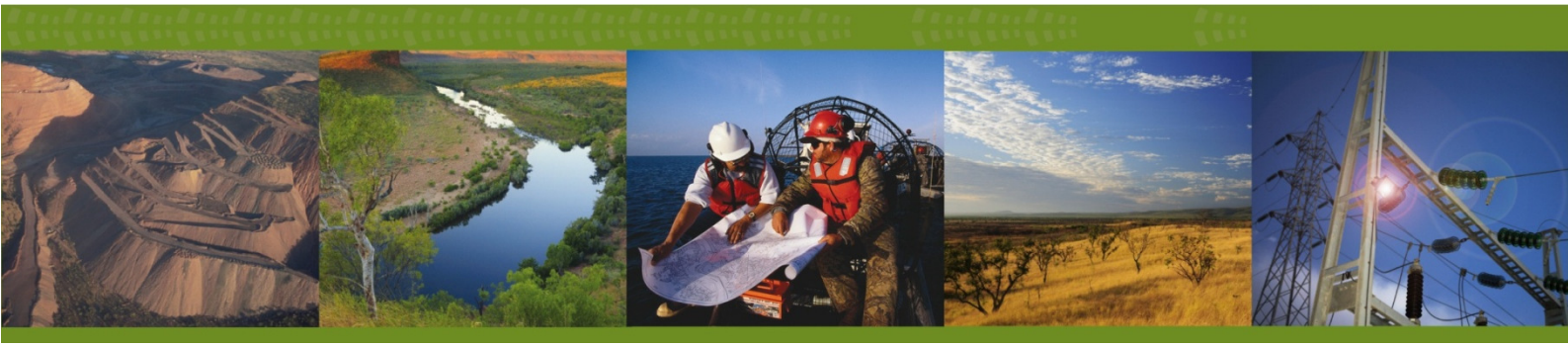

Mangles Bay Marina Based Tourist Precinct

Public Environmental Review

Prepared for
Cedar Woods Properties Ltd
by Strategen

February 2012

STRATEGEN
environmental consultants

Mangles Bay Marina Based Tourist Precinct

Public Environmental Review

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February 2012

Client: Cedar Woods Properties Ltd

Report Version	Revision No.	Purpose	Strategen author/reviewer	Submitted to Client	
				Form	Date
Preliminary Draft Report	A	Client review	TS/DN	Electronic / hard copy	30/9/2011
Preliminary Draft Report	B	Client review	AC/KT/DN	Electronic	7/10/11
Draft Report	0	EPA submission	DN/AC/KT/KO	Hardcopy	14/10/11
Final Draft Report	1	EPA submission	DN/KT/KO/ K Hillman	Electronic	27/01/12
Final Report	2	Public advertisement	Strategen/Cedar Woods	Hardcopy / Electronic	09/02/12

Filename: CED10088.01 Mangles Bay PER Rev 1 - 9 February 2012

Invitation to make a submission

Following referral of the Mangles Bay Marina Based Tourism Precinct to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and the Western Australian Environmental Protection Authority (EPA), it was determined the proposal should be formally assessed. In making the determination, the Commonwealth and State Governments have agreed to a coordinated bilateral environmental assessment process. The Public Environmental Review (PER) is in accordance with the DSEWPaC and EPA requirements as set out in the Environmental Scoping Document. This PER document intends to satisfy the requirements of each jurisdiction under the formal environmental impact assessment process.

Accordingly, DSEWPaC and the EPA invites people to make a submission on this proposal. The environmental impact assessment process is designed to be transparent and accountable, and includes specific points for public involvement, including opportunities for public review of environmental review documents. In releasing this document for public comment, DSEWPaC and the EPA advise that no decisions have been made to allow this proposal to be implemented.

Cedar Woods proposes to develop a tourist based marina development located in Mangles Bay, at the southern end of Cockburn Sound. In accordance with the *Environmental Protection Act 1986*, a PER has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of 10 weeks from 13 February 2012, closing on 23 April 2012.

Comments from government agencies and from the public will assist DSEWPaC and the EPA to prepare an assessment report in which it will make recommendations to government.

Where to get copies of this document

Printed and CD copies of this document may be obtained from Cedar Woods Properties Limited, Ground Floor, 50 Colin Street, West Perth, 6005 ((08) 9480 1500) at a cost of $10, consistent with formal proponent advertisement. Electronic versions of the document, on CD, can be obtained at no cost.

The document/s may also be accessed through the proponent's website at *www.manglesbaymarina.com.au*.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received will be acknowledged and electronic submissions will be acknowledged electronically. The proponent will be required to provide adequate responses to points raised in submissions. In preparing its assessment report for the Ministers for the Environment, DSEWPaC and the EPA will consider the information in submissions, the proponent's responses and other relevant information. Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the Freedom of Information Act 1992, and may be quoted in full or in part in each report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the PER or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific proposals in the PER:

- clearly state your point of view
- indicate the source of your information or argument if this is applicable
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful
- refer each point to the appropriate section, chapter or recommendation in the PER
- if you discuss different sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name
- address
- date
- whether you want your submission to be confidential.

The closing date for submissions is: 23 April 2012

DSEWPaC and the EPA prefers submissions to be made by email to submissions@epa.wa.gov.au.

Alternatively submissions can be posted to: Chairman, Environmental Protection Authority, Locked Bag 33, CLOISTERS SQUARE WA 6850, Attention: Leanne Thompson; or delivered to the Environmental Protection Authority, Level 4, The Atrium, 168 St Georges Terrace, Perth, Attention: Leanne Thompson.

If you have any questions on how to make a submission, please ring the EPA assessment officer, Leanne Thompson on 6467 5246.

Executive summary

Introduction

Western Australian Land Development Authority, LandCorp (Government Land Development Agency), has appointed Cedar Woods Properties Limited (Cedar Woods) as its private sector partner to progress this Proposal.

The Proponent, Cedar Woods proposes to develop a tourist based marina development located in Mangles Bay, at the southern end of Cockburn Sound. The Mangles Bay Marina Based Tourist Precinct (the Proposal) comprises a single entrance marina to accommodate up to 500 pens and moorings and a surrounding land development comprising tourism, accommodation, commercial, public open space (POS) and residential land uses.

This document is a Public Environmental Review (PER) for the Proposal and has been prepared in accordance with the Environmental Impact Assessment (Part IV Division 1) Administrative Procedures 2002 of the *Environmental Protection Act 1986* (EP Act).

Background

The Proposal (previously known as the Cape Peron Tourist Precinct Project) is a refinement of previous proposals that have been put forward since the early 1990s. Early project proposals were abandoned due to excessive costs, downturns in the real estate market or were rejected by the Environmental Protection Authority due to impacts on seagrass.

In response to community interest, the costs, benefits and constraints of Mangles Bay and other potential sites along the City of Rockingham coastline were reviewed. The review concluded that for a marina based development, when assessed against the project sustainability objectives, Mangles Bay presents the least constraints (not withstanding that the Mangles Bay site has some major environmental constraints) and the most opportunities when compared with other sections of the coastline in the City of Rockingham.

In 2006, a Strategic Environmental Review (SER) was prepared for the Proposal, for the consideration of the Environmental Protection Authority (EPA), to enable the EPA to give advice requested by the Minister for the Environment under section 16(e) of the *Environmental Protection Act 1986* (EP Act). The strategic assessment process enabled the EPA to examine (at the early stage in the Proposal development) the key environmental issues associated with the Proposal, including the provision of advice on potential key environmental items of the Proposal.

Under this strategic assessment process, in 2006, the EPA provided written and public advice to the Minister on the concept of an inland marina development at Mangles Bay. The EPA identified the following primary environmental issues:

- seagrass and water quality – direct loss through construction of the Proposal and indirect loss through changes in water quality, sand bypassing activities and coastal processes
- Lake Richmond – indirect impact on the lake and its key attributes (two threatened ecological communities [TECs]) through potential changes in hydrogeology thereby modifying the lake's water quality and water level and potentially threatening the TECs
- terrestrial vegetation – direct loss of vegetation and additional indirect loss through fragmentation, edge effects and changes in site hydrology.

Assessment process

The Proposal was referred to the EPA under section 38 of the EP Act on 25 August 2010. On 20 September 2010, the EPA set the level of assessment for the Proposal as a PER with a ten week public review period.

The Proposal was referred to the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) on 21 September 2010 for consideration under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). On 27 October 2010, DSEWPaC advised that the action was considered to be a 'controlled action' under the EPBC Act (EPBC Reference: 2010/5659).

As the Proposal has been deemed a controlled action, it will be assessed through the Bilateral Agreement. The Bilateral Agreement between the Commonwealth of Australia and the State of Western Australia provides for the accreditation of the Western Australian environmental impact assessment process to ensure an integrated and coordinated approach for actions requiring approval under both the EPBC Act and the EP Act.

The Proponent submitted a preliminary Environmental Scoping Document (ESD) to the EPA on 11 October 2010, which detailed the potential environmental impacts, their significance and possible management response, proposed scope of work to obtain information for the PER, key legislation, stakeholder consultation program, proposal and assessment schedule, study team and peer review mechanisms. The final ESD was approved by the EPA on 16 June 2011.

The proposal

is for a tourist based marina development comprising a single entrance marina to accommodate up to 500 pens and moorings and a surrounding land development comprising tourism, accommodation, commercial, POS and residential land uses.

The development will also incorporate local aquatic clubs.

The Proposal comprises the following elements:

- marina
- boating access channel
- provision and maintenance of service infrastructure
- land development area
- rehabilitation of degraded areas of surrounding vegetation in proximity to the Proposal area and seagrass transplantation to offset vegetation losses.

The key characteristics of the Proposal are included in Table ES 1.

Table ES 1 Key proposal characteristics

Proposal detail	Characteristics
Main activities	Construction activities to include clearing, wet excavation of the marina and dredging of the access channel. Operational activities include marina operation and maintenance dredging
Proposal area	Proposal area up to 77 ha Total land development area up to 49 ha Total vegetation clearing up to 40 ha Total marine disturbance (below current high water mark) to 6 ha
Marina	Total water area of marina up to 12 ha Deepest depth in marina up to -4.0 mAHD, shallowest -2.7 mAHD Excavation for marina up to 800,000 m^3 (Volume of material below 0.0m AHD is 364,000m^3)
Channel construction	Total channel length up to 550 m Total channel navigable width up to 30 m, including batters the channel has a width of 55 m Total channel area up to 3.4 ha (includes the footprint of 1:5 batters) Total channel depth up to -4.0 mAHD Total channel dredging of up to 50 000 m3 of spoil Dredged spoil material will be piped to the Proposal area, where it will be settled, the water infiltrated and solid material treated and disposed of off-site
Reclamation	Total reclamation area up to 1.36 ha Total breakwater length up to 290 m Total breakwater width up to 40 m includes breakwater batters of 1:5 Total breakwater area up to 1.1 ha
Area west of Garden Island causeway	Improvement works potentially including an upgrade to the car park, boat ramp and jetty platforms
Seagrass loss	Total seagrass removal up to 5.36 ha (includes breakwaters, reclamation areas, channel and batters) Total indirect loss of seagrass up to 0.3 ha (due to halo effects around infrastructure of approximately 15 m). Total marine footprint up to 5.66 ha
Water Corporation asset (considered part of 'service corridor')	Length of pipeline up to 1.6 km Width of the service corridor up to 45 m (includes batters, provision for a dual road and Water Corporation infrastructure) Pump station area to be cleared up to 0.2 ha
Department of Defence	Provision of a dual-lane road as part of the service corridor to accommodate traffic to Garden Island
Outfall	Relocation of Mangles Bay stormwater ocean outfall pipe to Hymus Street

Stakeholder consultation

This Proposal has built formal advice and community and specialised stakeholder input. Much of this input was generated during the 2005 – 2006 consultation for the Cape Peron SER (Strategen 2006).

The Cedar Woods stakeholder engagement program for this Proposal commenced in April 2010 and will continue throughout the Local Structure Planning process. Key stakeholders were identified through previous consultation programs undertaken during the many iterations of this Proposal. Government agencies have also provided recommendations on stakeholders that should be included within the program, with these recommendations adopted by Cedar Woods. The Proponent also established a Marina Working Group and a Stakeholder Reference Group to provide ongoing input into the Proposal plan.

A summary of the key stakeholder consultation undertaken to date is included in Table ES 2.

Table ES 2 Summary of key stakeholder consultations undertaken for the Proposal

Stakeholder	Outcome of consultation
City of Rockingham	Preliminary comments regarding marina design. Advice provided to the strategy for obtaining planning approval.
Department of Planning	MRS amendment to be initiated subsequent to the s.38 environmental approval process.
Department of Sports and Recreation	Inclusion of passive recreation opportunities within the development, consultation with existing lessees.
Department of Transport	Preliminary comments regarding marina design and suggestions for marina management.
Office of the EPA	Confirmation of the assessment process for the proposal.
Mangles Bay Fishing Club	Inclusion of the club's comments regarding marina planning and club site facility.
Rockingham Offshore Fishing Club	Inclusion of the club's comments regarding marina planning and club site facility.
The Cruising Yacht Club of WA	Inclusion of the club's comments regarding marina planning and club site facility.
Blue Lagoon Mussels	Inclusion of the club's comments regarding marina planning and club site facility.
Rockingham Volunteer Sea Rescue Group	Inclusion of the club's comments regarding marina planning and club site facility.
Retired Service League Rockingham	Realignment of Memorial Drive to retain the RSL Hall.
Cockburn Sound Management Council	Preliminary comments on Proposal and advice on marine water quality within Cockburn Sound.
Department of Water	Inclusion of comments to evaluate the environmental impact to the environmental values within, and adjacent to, the Proposal area.
Conservation Commission of Western Australia	Confirmation of the Proposal area and environmental assessment process.
Department of Sustainability, Environment, Water, Population and Communities	Inclusion of comments into addressing Matters of NES within the environmental assessment of the Proposal.
Department of Defence	Provision for a dual-lane road within the service corridor to accommodate future traffic movement to HMAS Stirling.
Water Corporation	Provision within the service corridor to accommodate current and future infrastructure requirements.

Environmental impact assessment and management

Environmental factors and required technical investigations relevant to this Proposal were identified through the scoping process and are presented in this document along with additional environmental considerations identified during the detailed assessment process. The technical investigations supporting this assessment provide adequate and accurate information describing the receiving environment. This assessment demonstrates that the environmental impacts upon environmental factors resulting from the Proposal (including cumulative impact) have been minimised, are not significant and can be acceptably managed.

Residual impacts are proposed to be offset. Residual impacts relate to the environmental factors of seagrass, Conservation Areas and associated vegetation. An offset package will be negotiated with relevant Agencies during the review process.

The key environmental factors that have been addressed in the PER are:

1. Terrestrial environment:
   - groundwater
   - surface water
   - flora and vegetation
   - terrestrial fauna
   - conservation areas (included in terrestrial vegetation and flora chapter for the purposes of scoping).
2. Marine environment:
   - water quality
   - coastal processes
   - benthic primary producer habitat (BPPH)
   - marine fauna.
3. Matters of National Environmental Significance.
4. Social surrounds:
   - recreation and public access
   - Aboriginal and European heritage
   - visual amenity.
5. Other Environmental Factors:
   - traffic
   - contaminated sites and acid sulfate soils (ASS)
   - construction impacts of dust, noise and waste.

Groundwater

The Proposal is expected to result in the following outcomes in relation to groundwater:

1. The groundwater levels around the marina fingers equilibrate, with a greater area around the marina experiencing groundwater levels less than 0.1 mAHD than is currently the case.
2. An estimated reduction in groundwater levels at Lake Richmond of 0.032 m (3.2cm) during construction and 0.038 m (3.8cm) during operation.
3. The saltwater interface is modelled as being located along the southern and eastern edge of the marina. There is also some additional intrusion to the northeast of the marina. Groundwater salinities under Lake Richmond are not expected to change.
4. No estimated impact to groundwater quality at Lake Richmond during construction or operation.
5. Limited impacts to bore users in the Rotary Park area will be managed through the implementation of mitigation measures in line with the proposed Groundwater Quality Management Plan.

Surface water

The Proposal is expected to result in the following outcomes in relation to surface water:

1. The Proposal is likely to result in a decrease of water levels in Lake Richmond of 0.032 m (3.2cm) during construction and 0.038 m (3.8cm) during operation.
2. The change in the location of the saltwater interface within the groundwater will not impact upon Lake Richmond during construction or operation of the Proposal.
3. The moving of the Lake Richmond Outlet Drain will not impact upon water levels in the lake.
4. Stormwater from the Proposal will not directly enter the lake and hence there will be no change in surface water quantities or quality entering the lake as a result of the Proposal.
5. The increased population in the Lake Richmond area as a result of the Proposal is not expected to significantly impact upon the lake.
6. The estimated changes to water levels are within the tolerance range of the Thrombolite community and are therefore assessed as not representing a risk to their ongoing survival.
7. The Proposal is not expected to significantly impact upon the flora, vegetation and fauna that exist within or utilise Lake Richmond.
8. As the 50 m buffer will generally be retained intact and rehabilitation will occur, the impact of the proposal upon the integrity of the buffer of Lake Richmond is considered to be minimal.
9. The Proposal will not impact upon lake water quality, and hence will not result in an increase in the frequency of algal blooms in the lake.
10. The Proposal is not expected to have an impact on the function and ecology of Lake Richmond.

Terrestrial flora and vegetation

The Proposal is expected to result in the following outcomes in relation to flora and vegetation:

1. Development will result in the clearing of up to 40 ha of remnant vegetation which has suffered varying degrees of disturbance, including extensive weed invasion.
2. No DRF or Priority Flora will be affected by the Proposal.
3. The Proposal will not result in any vegetation complexes being cleared to less than 10% of the original extent.
4. The Proposal will clear 1.93 ha of TEC FCT 30a. It is proposed to retain and consolidate TEC FCT 30a into a more sustainable shape of a remnant of approximately 3.95 ha, where the boundary to area ratio is improved when compared to the current configuration of the remnant. This will comprise the retention of 1.12 ha of Very Good condition vegetation, rehabilitation of 1.61 ha that currently does not support FCT 30a and 1.22 ha of FCT 30a that has been identified as being in Good – Degraded condition.
5. The proposal would result in the clearing of 34ha of SCP 29b (P3 PEC) - *Acacia* shrublands on taller dunes.
6. The proposal would result in the clearing of 0.5ha of SCP 30b (P3 PEC) - Quindalup *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands.
7. A community objective for the Proposal is to provide a sum of up to $5 000 000 to enhance the balance of Cape Peron outside the Proposal area. The funding will be provided for a range of activities including rehabilitation and the acquisition of land with comparable or greater conservation value to secure the land for conservation.

Terrestrial fauna

The Proposal is expected to result in the following outcomes in relation to terrestrial fauna:

1. Loss of 38.28 ha of viable fauna habitat, of which 35.2 ha is coastal heathland, 0.9 ha is shoreline and 2.18 ha is woodland.
2. A reduction in potential Quenda habitat within the Proposal area due to clearing of coastal heathland.
3. An increase in availability of coastal heathland and woodland, and improvements to the condition of existing habitat outside the Proposal area.
4. A small reduction in numbers of Perth lined skink, jewelled ctenotus and carpet python.
5. Unlikely to have any impact on SRE terrestrial invertebrate fauna.
6. Reduction in area of available GSM habitat, and potential impact on local population; however the viability of existing population is doubtful independent of the Proposal.
7. No significant impact to migratory species as the Proposal area does not support important habitat for migratory species and the Proposal will not have a significant impact on Lake Richmond.
8. No direct or indirect impact to the black cockatoo (Carnaby's and Forest Red-tailed) habitat.

Overall, there are likely to be some local reductions in fauna populations within the Proposal boundary; but the Proposal is unlikely to significantly affect the regional diversity or abundance as the habitats are well distributed locally and regionally.

Conservation areas

The Proposal is expected to result in the following outcomes in relation to conservation areas:

Bush Forever Site 355 – Cape Peron

The Proposal is not expected to impact the regional significance of the Cape Peron Bush Forever Site 355. The Proposal will not significantly impact the diversity of flora and fauna, however, it will disturb areas of mapped Threatened Ecological Community SCP 30a and Priority Ecological Communities SCP 29b and 30b. The Proposal will also impact some of the heritage values of the area. The changes to the hydrological regime have been assessed as not impacting the vegetation that will be retained adjacent to the Proposal area. The offset measures of the Bush Forever Site 355 will also mitigate the localised impacts to this Bush Forever Site. The offset package is also designed to meet the requirements of Statement of Planning Policy (SPP) 2.8, which addresses the protection and management of regionally significant bushland.

Bush Forever Site 358 – Lake Richmond

The Proposal is not expected to impact on the regional significance of the Lake Richmond Bush Forever Site 358. The Proposal will not be significantly impact the TECs, fish species within the lake, the diversity of flora and fauna nor will it disturb the heritage values of the area. The changes to the hydrological regime are considered acceptable as the changes are within the seasonal variations experienced at Lake Richmond, with the key environmental values of the lake not being significantly affected.

Rockingham Lakes Regional Park

The Proposal area represents less than 1% of the Rockingham Lakes Regional Park (RLRP) which covers an area of 4270 ha (DEC 2010).

The Proponent is committed to providing an environmental offset ratio of approximately 1.5:1 to rehabilitate the balance area within Cape Peron, with an emphasis on improving and maintaining linkages and providing management measures to mitigate the increased visitation. Endorsement of the offset package would ensure the project rehabilitates 54 ha of the Cape to improve the biodiversity of the area, consistent with the objectives of the RLRP.

The area where rehabilitation/restoration effort should be focussed will be selected in consultation with the DEC and other stakeholders.

This program will be achieved in partnership with the Regional Park land managers and has the potential to create a large and easily measurable improvement in vegetation condition and ecological diversity in the Proposal area.

Shoalwater Islands Marine Park

The Proposal is located to the east of the Garden Island Causeway and therefore will not impact directly on the Shoalwater Islands Marine Park (SIMP).

Marine water quality

The Proposal is expected to result in the following outcomes in relation to marine water quality:

1. The Proposal dredging program will generate minor, highly localised, and short-term impacts on turbidity in Mangles Bay. Turbidity generated during construction is not expected to cause any long-term impacts on seagrasses.
2. No adverse effects expected due to contaminant release during dredging and disposal, as contaminant levels in the sediments to be dredged meet all relevant ecological and human health guidelines.
3. Chlorophyll levels in the marina will be about twice that of Mangles Bay, but there will be little effect on water quality in Mangles Bay and adjacent waters in Cockburn Sound and the SIMP due to the effects of dilution once the marina waters disperse into Mangles Bay.
4. A proportion of groundwater nutrients that presently fuel epiphyte growth on the extensive seagrass meadows of Mangles Bay will instead be taken up by phytoplankton growth in marina waters.
5. Modelling further predicts that flushing should be sufficient to prevent any gradual build-up of the concentrations of nutrients or other contaminants over time.
6. Mangles Bay presently meets phytoplankton biomass EQC for moderate protection. EQC for seagrass health for high ecological protection are met in the shallow waters of Mangles Bay, as are sediment quality EQC and recreational EQC (faecal bacteria). It is considered that the Proposal will not result in any significant decrease in the water quality of Mangles Bay, and that EQC for those environmental indicators that are presently met will continue to be met.

Coastal processes

The Proposal is expected to result in the following outcomes in relation to coastal processes:

1. Reorientation of beach profiles at Mangles Bay, with sediment deposition on either side of the marina breakwater.
2. Minor seagrass accumulation in the dredge channel and harbour.
3. Minimal impact to development and foreshore area by sea level rise and storm events.

Benthic primary producer habitat

The Proposal is expected to result in the following outcomes in relation to benthic primary producer habitat:

1. The loss of approximately 5.66 ha of seagrass loss.
2. Rehabilitation of 6 ha of seagrass in Cockburn Sound with the objective of achieving a no net loss outcome. The Proposal will also consult with DoT and DEC to rehabilitate the swing mooring scars adjacent to the Proposal area, an area estimated at 3 ha.

Marine fauna

The Proposal is expected to result in the following outcomes in relation to marine fauna:

1. The loss of marine habitat (5.66 ha) and unvegetated sediment (1.69 ha) may potentially cause a temporary reduction in fish stocks due to egg loss and/or larval mortality until the seagrass loss is offset by the proposed rehabilitation.
2. Increased recreational fishing pressure due to the Proposal will constitute only a small proportion of that predicted due to population increase.
3. The proposed development will result in a small increase (1%) in the number of vessels able to access Cockburn Sound and the SIMP in the next 10–15 years (within the context of predicted increases of boat ownership; see above) and as such, it will also increase the amount of human-dolphin interaction that occurs.
4. Expected and potential increase in boat strike of marine fauna, particularly Little Penguins and potential disturbance of Little Penguin colonies. During breeding season it is estimated that n the medium-term the Proposal will result in about 14 large vessels/day versus 11 large vessels/day from population-driven increases alone and 14 vessels/day with or without the Proposal in the long-term.

Matters of National Environmental Significance

The Proposal is expected to result in the following outcomes in relation to matters of National Environmental Significance:

1. Reduction in area of available GSM habitat, offset by an improvement in local, adjacent habitat.
2. No significant impact to migratory species as the Proposal area does not support important habitat for migratory species and the Proposal will not have a significant impact on Lake Richmond.
3. No direct or indirect impact to the black cockatoo (Carnaby's and Forest Red-tailed) habitat.
4. No significant impacts to marine migratory species.

Overall, there are likely to be some local reductions in fauna populations within the Proposal boundary; however, the Proposal is unlikely to significantly affect regional diversity or abundance as the habitats are well distributed locally and regionally.

Recreation and public access

Overall the Proposal will provide positive outcomes increasing the recreation and tourism values for the Mangles Bay area and the wider Rockingham Region. The Proposal will be developed in accordance with the City of Rockingham's Strategic Plan (CoR 2007) and the targets and visions of the RLRP Management Plan (DEC 2010a).

Once operational, the Proposal should not restrict recreational fishing and yachting activities within Mangles Bay. During construction there may be some temporary disruption of recreational fishing due to dredge movements, and the turbidity and noise associated with dredging (although these are expected to be minimal). There will also be some temporary disruption of other recreational activities (land-based and water-based) due to restricted site access, and some temporary effects on the amenity of the area due to noise and turbidity.

Aboriginal and European heritage

The Proposal is expected to result in the following outcomes in relation to Aboriginal and European heritage:

1. Affect two identified Aboriginal heritage sites (Rotary Park and Mooribirdup Ceremonial Grounds). Approval will be sought to disturb the Aboriginal heritage sites under section 18 of the AH Act.
2. In consultation with the local Aboriginal community, an appropriate 'interpretative display' will be established to recognise the Aboriginal heritage values of the area. The European heritage site, Turtle Factory will require removal as part of the proposed development. Opportunities to relocate the building will be investigated.

Visual amenity

Visual amenity of the coastline and surrounding views is an aesthetic value that may be compromised following the implementation of Proposal, though the view sheds are currently broken by the existing infrastructure, industry and residential housing. This impact may be managed through using landscape location, orientation, materiality and height.

Traffic

The increased traffic flow generated by the Proposal will not have significant negative impacts on local road traffic. A Traffic Management Plan, outlining actions to minimise impacts to safety and amenity will be developed prior to the commencement of construction phase of the Proposal.

Contaminated sites and acid sulphate soils

The Proposal is expected to result in the following outcomes in relation to contaminated sites and acid sulphate soils:

1. The risk from contaminated sites within the Proposal area is considered negligible; however, further investigations will be conducted in the three small locations identified in the PSI as being potentially contaminated.
2. Analysis of the proposed dredge spoil (i.e. sediment in Mangles Bay) did not identify any potential contaminants; however, stockpiled dredge spoil will tested for various contaminants (metals, TBT etc) in collaboration with advice from the contaminated sites branch of the DEC, to determine the most appropriate management and disposal strategy.
3. The Proposal has the very low potential to produce monosulfidic black ooze (MBO) within the proposed marina and offshore access channel due to the low to no presence of sulfidic soils and organic materials, together with the high buffering capacity of the soils present within the soil and marine sediments.

Environmental management framework

In addition to implementing the requirements of specific environmental conditions set by the EPA if the Proposal is approved, the Proponent will minimise environmental impacts through:

- maintaining an Environmental Management System (EMS)
- implementing the CEMP for the Proposal (Appendix 1)
- regularly reviewing the performance of the EMS, CEMP and developing environmental improvement plans for priorities identified in the reviews
- continually updating construction (including ASS and dewatering) management plans and measuring success
- training staff and contractors in environmental requirements and considerations of their work
- ensuring that stakeholder views are sought, respected and considered
- regularly reporting to stakeholders on performance.

The proposed management of the key issues associated with the Proposal has been documented in the CEMP in order to manage specific environmental aspects of the Proposal. Implementation of the Proposal in accordance with the CEMP will ensure that the Proposal meets all respective environmental obligations including internal objectives, legislation, regulations and conditions of approval relating to operation of the Proposal.

The CEMP is comprised of management sub-plans that describe the specific environmental objectives and targets for each environmental factor; the management measures to be applied to avoid and minimise the environmental impact of the Proposal; monitoring measures to measure the performance of management against the targets; and, contingency measures to mitigate unavoidable or accidental impact. The sub-plans are as follows:

- groundwater management plan
- surface water management plan
- dredge spoil and dredge maintenance management plan
- terrestrial biodiversity and habitat management plan
- marine biodiversity and habitat management plan
- graceful sun-moth management plan
- dust management plan
- noise and vibration management plan
- fire management plan
- cultural heritage management plan
- hydrocarbon management plan
- waste management plan
- contaminated sites and ASS management plan
- public access and beach management plan
- rehabilitation management plan
- community issues management plan
- visual amenity management plan
- road traffic management plan.

The EMP will be regularly reviewed and revised as appropriate.

Impact assessment summary

Table ES 3 provides a summary of the potential impacts, proposed management commitments and environmental outcomes for each of the environmental factors assessed.

Table ES 3 Executive Summary of the Impacts and Proposed Management Commitments

Management objectives	Relevant standards and guidance documents	Existing environment	Potential impacts	Management strategies/proponent commitments	Predicted outcomes
Groundwater					
To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected. To ensure that emissions do not adversely affect environmental values or the health, welfare or amenity of people and land uses by meeting statutory requirements and acceptable standards.	• National Water Quality Management Strategy (ANZECC/ARMCANZ 2000) • Guidelines for Groundwater Protection in Australia (ANZECC/ARMCANZ 1995) • Guidelines on national water quality management - released by the Natural Resource Management Ministerial Council (NRMMC 2010) • Rights in Water and Irrigation Act 1914 • Rockingham – Stakehill Groundwater Management Plan (DoW 2008) • State Water Quality Management Strategy (Water and Rivers Commission 2001) • State Water Strategy (Government of Western Australia 2003) • Stormwater Management Manual (DoW 2004-2007) • Operational Policy 5.12 – Hydrogeological Reporting Associated with a Groundwater Well Licence • Operational Policy 1.02 Water Conservation/Efficiency Plans.	The key environmental value of groundwater in the area is in maintaining groundwater levels in Lake Richmond over the winter months. Groundwater in the area is used for irrigation of public open space and gardens. The superficial lithology in the Proposal area consists of two main superficial geological units (1) the Safety Bay Sand; and (2) the Tamala Limestone. The hydraulic conductivity (K) of the Safety Bay Sands is relatively high, with estimates ranging between 5 and 174 m/day (MWH 2011b). The hydraulic conductivity (K) of the Tamala Limestone is very high because of its' porous nature, with estimates ranging between 100 and 3000 m/day (MWH 2011b). Groundwater flow in the superficial aquifer in the Rockingham area is generally in a westerly direction, towards the Indian Ocean (Department of Environment 2004).	Changes to groundwater levels due to the presence of the marina allowing more interaction between local groundwater and the sea, resulting in: • lowering of water levels in nearby private garden bores • exposure of acid sulfate soils (if they exist) within the land development area. Saltwater intrusion caused by the inland movement of the saltwater-groundwater (fresh) interface due to the inland marina that may result in: • increasing salinity in local bores • salt entering the root zone of potentially salt sensitive native species.	Use of a wet construction method involving the use of excavators and dredges to construct the marina. Dewatering may not be required; however, if it is, it will be reduced in order to minimise groundwater drawdown. Limited dewatering may be required for the relocation of the SDOOL and construction of services such as sewers. This will be below the threshold required for a dewatering licence. Design modifications to reduce impacts to groundwater include reducing the length of the south eastern arm of the marina and reduction in depth of canals. The Proponent will develop a Groundwater Quality Management Plan to address potential changes in salinity on groundwater users, including measures to inform householders, investigating potential changes in locations for council irrigation bores and measures to mitigate impacts to affected households. This will be supported by a groundwater salinity monitoring program. A Local Water Management Strategy will be prepared to accompany the Local Structure Plan and will outline management measures for groundwater quality and quantity, and potable and non-potable water supplies (which would be initiated should these criteria be breached). Establishment of a contingency plan where domestic groundwater bore supply and quality be diminished. Using the construction methods advised by the Water Corporation, the construction of the SDOOL without the marina present resulted in a decrease in water levels at Lake Richmond of 0.24 m. With the marina being constructed at the same time, the decrease was 0.25 m. Thus cumulative impact of the two proposals on Lake Richmond is predominantly due to the construction of the SDOOL.	After mitigation measures as described, the proposal is expected to be able to: • result in a minimal reduction in groundwater levels at Lake Richmond of 0.032 m during construction and 0.038 m during operation • ensure no impact to groundwater quality at Lake Richmond during construction or operation • manage the limited impacts to bore users in the Rotary Park area through the implementation of mitigation measures in line with the proposed Groundwater Quality Management Plan. These impacts are considered to be acceptable as the key environmental values for groundwater surrounding the Proposal will not be significantly affected.
Surface water					
To maintain the integrity, ecological functions and environmental values of wetlands. To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected. To maintain biological diversity where that represents different plants, animals and micro-organisms, the genes they contain and the ecosystems they form, at the levels of genetic diversity, species diversity and ecosystem diversity.	• National Principles for the Provision of Water for Ecosystems (ANZECC/ARMCANZ 1996) • National Water Quality Management Strategy (ANZECC/ARMCANZ 2000) • State Water Quality Management Strategy 2001 (Waters and Rivers Commission 2001) • State Water Strategy (Government of Western Australia 2003) • Stormwater Management Manual (DoW 2004-2007) • Wetlands Conservation Policy for Western Australia (Government of Western Australia 1997) • Environmental Protection of Wetlands Preliminary Position Statement - Position Statement No. 4 (EPA 2004e) • Environmental Protection (Swan Coastal Plain Lakes) (EPA 1992) • Guideline for the Determination of Wetland Buffering Requirements (WAPC 2005b).	The soils of the Proposal area and surrounds are Safety Bay Sands, which are known for their high permeability (Gozzard 1983). Runoff is unlikely to occur, except perhaps during extreme events such as the 1 in 100 year rainfall event. Runoff from the Proposal area is not expected to enter Lake Richmond. Lake Richmond is a perennial, freshwater lake with an area of approximately 40 ha and a depth of approximately 14 m (MWH 2011a). The Lake Richmond Outlet Drain runs through the site, close to the southern and western boundaries of the Proposal area. Lake Richmond is a groundwater throughflow lake receiving groundwater from south and discharging water to the north towards Cockburn Sound (CALM 2003b). Water levels in the lake vary seasonally from between approximately 0.2 and 1.2 mAHD, with water levels generally peaking in spring and being lowest in summer/autumn, prior to the commencement of winter rainfall. Water quality in the lake is fresh, with values of between 400 mg/L and 1400 mg/L total dissolved salts (TDS) being recorded (MWH 2011a).	Construction and operation of the marina waterbody will lower regional groundwater levels which may lead to: • lowering of water levels in Lake Richmond • exposure of acid sulfate soils if they exist around Lake Richmond • saltwater intrusion caused by the inland movement of the saltwater-groundwater (fresh) interface due to the inland marina. Increased population as a result of development may increase indirect impacts on Lake Richmond through uncontrolled access, rubbish and domestic pets.	Minimising the amount of dewatering associated with the Proposal by adopting a wet construction method. Undertaking rehabilitation of areas not to be cleared within the Proposal area and within the Proposed Service Corridor. Installing best Management Practices that treat stormwater prior to infiltration or discharge in line with the Stormwater Management Manual (DoW 2004 - 2007). A Local Water Management Strategy will be submitted with the Local Structure Plan for the development outlining the details of the measures to be undertaken to manage stormwater quality and quantity within the Proposal area. Possible raising of the weir wall on the Lake Richmond Outlet Drain to decrease the amount of water leaving the lake as surface water each year. This measure will be considered in consultation with the City of Rockingham, Water Corporation, DEC, DOW and DSEWPaC.	The Proposal is likely to result in a decrease of water levels in Lake Richmond of 0.032 m during construction and 0.038 m during operation. This is not considered to significantly impact the lake ecology. The change in the location of the saltwater interface within the groundwater will not impact upon Lake Richmond during dewatering or following construction of the Proposal. The moving of the Lake Richmond Outlet Drain will not impact water levels in the lake. Stormwater from the proposal will not directly enter the lake and hence there will be no change in surface water quantities or quality entering the lake. The increased human population within the Lake Richmond area is not expected to significantly impact the lake. The Proposal is not expected to significantly impact upon the TECs present at Lake Richmond. As the 50 m buffer will generally be retained intact and rehabilitation will occur, the impact of the Proposal upon the integrity of the buffer of Lake Richmond is considered to be minimal. The Proposal will not impact upon lake water quality, and hence will not result in an increase in the frequency of algal blooms in the lake. The Proposal is not expected to have an impact on the function and ecology of Lake Richmond.

Terrestrial flora and vegetation					
To maintain the abundance, species diversity, geographic distribution and productivity of flora and fauna at species and ecosystems levels through the avoidance or management of adverse impacts and improvements in knowledge.	• EPA Position Statement No. 2 (EPA 2000a) • EPA Position Statement No. 3 (EPA 2002) • EPA Guidance Statement No. 33 (EPA 2008a) • EPA Guidance Statement No. 51 (EPA 2004b) • EPA Guidance Statement No. 10 (EPA 2006a) • *Wildlife Conservation Act 1950 (WA)* (WC Act) • *Environmental Protection Act 1986* (EP Act) • Conservation and Land Management Act 1984 (WA) • Bush Forever Policies, Principles and Processes • State Planning Policy 2.8 Bushland Policy for the Perth Metropolitan Region (WAPC 2005a) • *Environment Protection and Biodiversity Conservation Act 1999* (Australian Government) (EPBC Act).	Bennett (2005) recorded and described 25 different vegetation units as occurring in the Proposal area. Keating & Trudgen (1986) recorded 16 vegetation units, one of which was not recorded by Bennett (2005). Eight Floristic Community Types (FCTs) have been identified as occurring onsite (ENV 2010; Bennett 2005) and were mapped by ENV (2010). One TEC is located within the Proposal area and is in 'good' to 'degraded' condition. Two PECs occur within the Proposal area. Much of the Proposal area is located within the Bush Forever Site 355. Bush Forever Site 355 is 174.5 ha, of which approximately 107.1 ha is vegetated. A total of 54 vascular plant families, 112 genera and 132 taxa, of which 67 are endemic and 65 are weeds, were recorded by Bennett (2005) and/or ENV (2010). Four DRF and 15 Priority Flora species were identified from the DEC database as potentially occurring in the Cape Peron area (ENV 2010); however no Declared Rare Flora (DRF) or Priority Flora species were recorded during the Bennett (2005) or ENV (2010) survey.	• clearing of vegetation for the development will directly reduce the extent of vegetation communities with minimal disturbance expected to occur to threatened ecological communities (TECs) • creation of new saltwater interface as a result of the land based marina may affect saltwater/freshwater interface-dependent vegetation • increased human population as a result of development may increase indirect impacts on vegetation through uncontrolled access, rubbish and domestic pets • vehicle movements and earthworks have the potential to introduce and spread weed species • fragmentation of Bush Forever site 355 as a result of clearing for the development • dust generation due to earthworks and vehicle movements has the potential to smother vegetation • potential edge effects on surrounding vegetation from clearing and construction activities.	Clearing of vegetation will be minimised as far as practicable to allow construction and operation to be undertaken in a safe manner. Management strategies include a ground disturbance authorisation procedure, clear demarcation of areas approved for clearing and environmental awareness training to ensure all employees are aware of the requirement to minimise ground disturbance. Implementation of a rehabilitation program for the remnant vegetation of Cape Peron within the Bush Forever Protection Area including: • weed control program • planting and/or seeding disturbed areas with local provenance species where appropriate • consolidating and formalising walking tracks • fencing where required to protect vegetation • stabilisation of disturbed dune areas • establish a monitoring program to evaluate rehabilitation. Development of an offsets and rehabilitation package in consultation with DEC, OEPA, DoP and the City of Rockingham, to offset the vegetation loss and area excised from the RLRP and Bush Forever Site 355. The potential for the introduction of weeds will be managed through vehicle hygiene procedures for earth-moving equipment during the pre-construction and construction phases. Ongoing weed management will be undertaken through regular weed spraying programs. Dust will be managed through the use of water trucks or other dust suppression methods.	Development will result in the clearing of up to 40 ha of remnant vegetation which has been assessed as being of varying condition. FCT 30a near the corner of Memorial Drive and Safety Bay Road is 4.63 ha in area and is a an example of a TEC. The Proposal will clear 1.93 ha of TEC FCT 30a. It is proposed to retain and consolidate TEC FCT 30a into a more sustainable shape of a remnant of approximately 3.95 ha, where the boundary to area ratio is improved when compared to the current configuration of the remnant. This will comprise the retention of 1.12 ha of Very Good condition vegetation, rehabilitation of 1.61 ha that currently does not support FCT 30a and 1.22 ha of FCT 30a that has been identified as being in Good – Degraded condition. The consolidation of the area of FCT 30a will provide an area slightly less than the current mapped extent and an area of the occurrence which has a better area to boundary ratio. Confidence in the ability of the rehabilitation to improve the values of the remnant TEC occurrence is provided by the fact that the current occurrence of the TEC appears to have been an area of recolonisation / rehabilitation. The Proposal will not result in any vegetation complexes being cleared to less than 10% of the original extent. Approximately 48% of the pre-European extent Quindalup Vegetation Complex remains in the Metropolitan area. No DRF or Priority Flora will be affected by the Proposal. Changes in groundwater quality and levels are not anticipated to impact vegetation in the area The development will provide offsets in accordance with EPA Position Statement No 9.
Terrestrial fauna					
To maintain the abundance, diversity geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement of knowledge. To maintain biological diversity that represents the different plants, animals and microorganisms, the genes they contain and the ecosystems they form, at the levels of genetic diversity, species diversity and ecosystem diversity.	• *Wildlife Conservation Act 1950 (WA)* (WC Act) • *Conservation and Land Management Act 1984* • *Environment Protection and Biodiversity Conservation Act 1999* (Australian Government) (EPBC Act) • EPA Position Statement No. 3 (EPA 2002) • EPA Guidance Statement No. 56 (EPA 2004c) • EPA Guidance Statement No. 20 (EPA 2009a).	Bamford (2005) identified 187 non-marine species that either may potentially occur or have previously been recorded in the surveyed area. Surveys within and in the vicinity of the Proposal area recorded 17% of the native mammals, 52% of the birds, 45% of the reptiles and 71% of the amphibians potentially occurring. Six species of migratory birds were found in the survey area, but no other conservation listed species (ENV 2011a). One reptile of conservation significance has been recorded in the Proposal Area (ENV 2011a). Two other reptiles of conservation significance may occur within the Proposal area. No Priority or EPBC-listed mammals or amphibians are recorded as occurring in the Proposal area (ENV 2011a). No conservation significant scorpions, millipedes or land snails were found in the Proposal Area. Four terrestrial fauna habitats were identified within the Survey Area: • shoreline habitat • coastal heath habitat • woodland habitat • wetland habitat (ENV 2011a).	• clearing of vegetation for the Proposal will directly disturb fauna habitat, fragment fauna linkages and may result in the loss of individual terrestrial fauna • vehicle movements and construction activities in the Proposal area may result in the loss or disturbance of individual terrestrial fauna • predation on terrestrial fauna species from introduced domestic pets from the land development • indirect impacts from increase in population degrading habitat quality over time thereby reducing habitat quality for terrestrial fauna • indirect impacts from increase in saltwater interface as a result of the land-based marina impacting groundwater-dependent vegetation.	Management measures to minimise the impact of construction and operation of the Proposal on fauna include: • not undertaking clearing outside authorised areas • relocating mammals, reptiles and amphibians prior to clearing where practicable • conducting clearing in stages to allow for the movement of any remaining fauna • limiting noise and vibration that may disturb fauna during construction • restricting the time and length excavated trenches are opened/exposed • preventing vehicle access outside authorised areas during construction, and limiting vehicle speeds inside the construction area • providing suitable areas as conservation offsets • rehabilitating habitat areas in the vicinity of the Proposal area.	The loss of 38.28 ha of habitat, of which 35.2 ha is coastal heathland, 0.01 ha is shoreline, and 2.18 ha is woodland. The Proposal will result in a small reduction in potential Quenda habitat within the Proposal area due to clearing of coastal heathland. Rehabilitation will increase the availability of coastal heathland woodland, and improve the condition of existing habitat outside the Proposal area. The Proposal will result in a small impact to numbers of Perth Lined Skink, Jewelled Ctenotus and Carpet Python. The Proposal is considered unlikely to have an impact on short range endemic or subterranean fauna. The Proposal will result in the clearing of 32.6 ha of GSM habitat; however, the Proposal is unlikely to significantly impact upon GSM population due to the existing habitat fragmentation. The Proposal is not expected to result in significant impact to migratory species as the Proposal area does not support important habitat for these species. The Proposal will result in a significant impact to potential black cockatoo habitat (if present), with 1 ha of roosting habitat proposed to be cleared.

Marine water quality					
To maintain the integrity, ecological functions and environmental values of the seabed and coast. To ensure that emissions do not adversely affect environmental values or the health, welfare and amenity of people and land use by meeting statutory requirements and acceptable standards.	• State Environmental (Cockburn Sound) Policy 2005 (Cockburn Sound SEP) (Government of Western Australia 2005b) • Western Australian Planning Commission Policy Number DC1.8 (WAPC 1999) • National Health and Medical Research Council Guidelines (NHMRC 2008) • *Contaminated Sites Act 2003* (CS Act) • Department of Environment and Conservation Contaminated Sites Management Series (DEC 2010b) • National Assessment Guidelines for Dredging (NAGD; Commonwealth of Australia 2009) • SIMP Management Plan (DEC 2007).	Mangles Bay is sheltered by the Garden Island Causeway and Cape Peron, and is therefore relatively calm and poorly flushed by marine waters under most circumstances, but is exposed to storms from the north (Strategen 2006). **Nutrient enrichment** Chlorophyll-a levels in the shallows of Mangles Bay are generally higher than most other areas in Cockburn Sound, largely due to the reduction in flushing in Mangles Bay caused by the construction of the Garden Island Causeway. Baseline water quality surveys indicate chlorophyll-a levels in the shallows of Mangles Bay do not meet the phytoplankton biomass EQG or EQS set under the Cockburn Sound SEP for high ecological protection, or the EQG for moderate ecological protection (the EQS is met). Nutrient inputs into Mangles Bay come mainly from groundwater discharge and stormwater drainage, largely in organic forms available for plant growth. **Other contaminants** Studies for the Proposal have found low concentrations of metals in groundwater (MWH 2011a). Other contaminants sources include boat traffic and stormwater drainage (including faecal bacteria, metals, antifoulants, and fuels). Contaminant concentrations (metals, hydrocarbons, tributyltin) in sediments to be dredged for the Proposal access channel meet relevant guidelines (NAGD, and Cockburn Sound EQG), as do Mangles Bay sediments adjacent to the channel. Concentrations of ammonia in sediment elutriates also meet the toxicity guideline of the NAGD, and Cockburn Sound EQG for high ecological protection.	• changes to marine water quality (mainly turbidity) during construction may adversely affect marine ecology and function • outflow of marina waters into Mangles Bay may result in changes in turbidity, nutrients, and/or contaminants, which in turn may adversely affect marine ecology and function • changes in flushing of Mangles Bay may affect marine ecology and function • operational aspects with potential to impact on marine water quality include an increase in the number of boats in Mangles Bay and adjacent water, with the potential to release contaminants into the water.	• baseline and ongoing monitoring of water quality and seagrass health at agreed sites • agreed reporting requirements, management triggers for water quality and seagrass health, and required actions if management triggers are exceeded • post-construction monitoring of seagrass health. it is also proposed to include monitoring of water and sediments in the infiltration ponds used for temporary storage of dredged material, to confirm predictions that overall concentrations of contaminants (especially tributyltin) meet relevant EQG. Operational management plan will include: • fuel spill management plan • maintenance and management plan for marina facilities • codes of conduct for users of the marina • ongoing monitoring of water and sediment quality within the marina • monitoring of seagrass health • addition of sullage facilities. Best Management Practises for stormwater should ensure minimal Increases in stormwater runoff to Mangles Bay from the Proposal area. The realignment of the Lake Richmond drain will also redirect the single largest source of stormwater-borne contaminants into better flushed waters east of the Proposal.	The potential for contaminant release during dredging and disposal is considered very low, as contaminant concentrations in the sediments met NAGD screening levels (Commonwealth of Australia 2009). It is considered that the Proposal will not result in any significant decrease in the water quality of Mangles Bay, and that EQC for those environmental indicators that are presently met will continue to be met. Marina waters will also meet WAPC Policy No. DC1.8 guidelines for artificial waterways (WAPC 1999).
Coastal processes					
To maintain the integrity, ecological functions and environmental values of the seabed and coast.	• *Planning and Development Act 2005* • *Town Planning and Development Act 1928* • Statement of Planning Policy No. 2.6: State Coastal Planning Policy (SPP2.6) (WAPC 2006) • Sea Level Change in Western Australia – Application to Coastal Planning (DoT 2010).	The shallow sheltered waters of Cockburn Sound (and Mangles Bay) support extensive seagrass meadows and a wide range of marine fauna (Strategen 2010). Cockburn Sound is bound to the west by Garden Island and to the north by Parmelia Bank, resulting in the sound being relatively sheltered from swell energy. Limited swell does penetrate through from the northern entrance to the Sound. The local seas are dependent on wind conditions and basin dimensions. In the southern portion of Cockburn Sound, the locally generated seas have been found to come from the south or south west in summer, and from the west to northwest in winter. The coast where the Proposal is located, experiences diurnal microtidal conditions, with a maximum spring tidal range of 0.6 m. The beaches at Mangles Bay have been identified as low energy beaches. A number of shoreline structures have been constructed in the vicinity of the Proposal area since 1971, the most significant of which is the Garden Island Causeway. The coastline spanning the Proposal area is currently divided into distinct sub compartments by existing coastal structures.	• construction of the marina entrance breakwater and channel which may interrupt longshore sediment transport • construction of the breakwaters may result in the accumulation of seagrass wrack against the structure. In addition to consideration of the potential impacts of the Proposal on coastal processes, the effects of sea level rise and processes on coastal infrastructure need to be considered in the design of coastal structures.	Management, measures to protect the shore from erosion while ensuring that existing and planned recreation areas are not compromised include the installation of coastal defence structures, specifically: • two groynes located on either side of the marina breakwater entrance • buried sea wall adjacent to the development along the beaches within the Proposal area, exact location yet to be finalised • beach nourishment involving deposition of sediment along beaches at Mangles Bay to improve and protect social amenity and public access. The Proponent will undertake management and maintenance works until landscaping handover. The recommended coastal setback allowance calculation, as outlined in SPP 2.6 (WAPC 2003) is comprised of four distinct components, each of which have been addressed for the Proposal (JFA 2011). The calculated setback requirement for the Proposal also considered the management structures and beach nourishment activities which have been incorporated into the Proposal design.	• reorientation of beach profiles at Mangles Bay, with sediment deposition on either side of the marina breakwater • minor seagrass accumulation in the dredge channel and harbour • minimal impact to development and foreshore area by sea level rise and storm events.

Benthic primary producer habitats					
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.	• EPA Environmental Assessment Guideline No. 3 (EPA 2009b) • EPA Environmental Assessment Guideline No. 7 (EPA 2011) • Western Australian Government's Environmental Offsets Policy • EPA Position Statement No. 9 (EPA 2006c) • EPA Guidance Statement No. 19 (EPA 2008b) • State Environmental (Cockburn Sound) Policy 2005 (Government of Western Australia 2005b) • SIMP Management Plan 2007-2017 (DEC 2007).	Cockburn Sound has a history of poor water quality and large scale seagrass loss dating from the 1960s and 1970s. The shallow flats of Mangles Bay contain approximately 100 ha of seagrass. There has been an estimated 3 ha of seagrass loss within Mangles Bay due to mooring scars. Seagrass monitoring was undertaken in January 2010 at one reference site west of the Garden Island Causeway and one potential impact site east of the causeway in Mangles Bay. Shoot density counts were documented based on standard operating procedures established for Cockburn Sound. The median shoot density at the reference site met the 1 year shoot density EQS for high ecological protection but the potential impact site did not (Oceanica 2012) Seagrass monitoring in 2011 measured shoot density counts at four locations adjacent to the Proposal access channel. Three sites met the 1 year EQS for high ecological protection and one site did not, indicating considerable spatial variability in seagrass health (Oceanica 2012). Studies for the Proposal included seagrass transplant trials into mooring scars in Mangles Bay, where traditional moorings were replaced by seagrass-friendly designs. Results indicated regrowth of existing seagrass would achieve infilling of scars in about seven years, and a combination of transplanted seagrass and natural regrowth into the scars would reduce this time to around four to five years	The following aspects of the Proposal have the potential to affect BPPH values: • direct removal of seagrass to allow for the construction of the marina access channel and breakwaters • indirect impacts to seagrass meadows as altered patterns of sediment movement and water flow due to the breakwaters result in the erosion or smothering of seagrass, creating a 'halo' effect around breakwaters • indirect impacts to seagrass meadows as a result of alteration in water quality within Mangles Bay as a result of the creation of the marina.	The proposed dredging program has been designed to avoid or minimise impact on seagrass communities including: • dredging only between April and August when seagrasses are not actively growing • reduced period of dredging (3-4 months) • use of silt curtains to control turbidity release and dispersion. Seagrass health and water quality will be monitored during construction and contingency measures will be implemented, if necessary, to avoid impacts to seagrasses. Trained operators will be employed to operate machinery to ensure the loss of BPPH does not exceed the predicted footprint area. The number of swing moorings in the Mangles Bay area is proposed to be reduced, in turn reducing the damage to seagrass from these types of moorings. A CEMP will be prepared to identify the proposed breakwater and other construction methods and proposed management measures. After construction, seagrass will be monitored for two years through high resolution vertical digital imagery. The cessation of most boat launching activities across the beach adjacent to the Proposal area should reduce scouring damage to seagrass. The realignment of the Lake Richmond drain may also benefit seagrass. Any loss of seagrass will be offset by rehabilitation of at least an equal area of seagrass within Cockburn Sound. The proposed target for the total area of seagrass rehabilitation of 6 ha will exceed the total losses. A Seagrass Rehabilitation Plan will be developed identifying rehabilitation sites, species to be used, transplanting units and techniques, spacing of planting units and monitoring and management measures for transplanted seagrass. Development of an offsets and rehabilitation package for seagrass will be in consultation with OEPA, DEC and CSMC to offset the seagrass loss and area for replanting	The construction of the Proposal will potentially result in the loss of approximately 5.66 ha of direct and indirect seagrass loss. Approximately 1.7 ha of bare, unvegetated habitat (primarily mooring scars) will also be removed. No losses are expected due to turbidity generated during dredging, as this is expected to be minimal. The loss of seagrass will be offset by the rehabilitation of 6 ha of seagrass in Cockburn Sound, but this will probably target areas other than mooring scars. Transplant trials in mooring scars indicate that natural regrowth of existing seagrass should achieve infilling of scars in about seven years, once seagrass-friendly moorings are used (resulting in an estimated 3ha of seagrass). The Proposal is not expected to significantly impact on marine flora.
Marine fauna					
To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge. To maintain the integrity, ecological functions and environmental values of the seabed and coast. To conserve WA's marine environment by managing and reducing the impacts of introduced marine species and by preventing further introduction and spread.	• *Wildlife Conservation Act 1950* • *Conservation and Land Management Act 1984* • *Environmental Protection and Biodiversity Conservation Act 1999* • State Environmental (Cockburn Sound) Policy 2005 (Government of Western Australia 2005b) • SIMP Management Plan 2007-2017 (DEC 2007) • *Fisheries Resources Management Act 1994*.	Mangles bay provides significant habitat for a high fish diversity and abundance, in comparison to the broader Cockburn Sound area, most likely due to its sheltered waters, extensive seagrass meadows close to shore and high availability of food. It is also an important nursery for fish species targeted by fishers and baitfish. Marine invertebrate surveys in Mangles Bay have identified polychaetes, nematodes, amphipods (small crustaceans) and juvenile decapods (e.g. crabs, prawns). The blue swimmer crab, *Portunus pelagicus*, octopus, southern calamari squid and mussels are fished commercially within Cockburn Sound. Common bottlenose and Indo-Pacific bottlenose dolphins occur and forage within Mangles Bay. Leatherback and green turtles are seen occasionally in Cockburn Sound, being visitors brought southwards from tropical waters by storms and/or the southward flowing Leeuwin Current. Loggerhead turtles are more commonly seen. Australian sea lions use the islands of the SIMP as haul-out sites (males only) during the non-breeding season, and are often seen in waters around Garden Island (including Cockburn Sound). A colony of little penguins is found on Garden Island. The southern right whale is often seen in Perth coastal waters and may occasionally enter Cockburn Sound. The humpback whale is likely to occur offshore of Garden Island but is unlikely to enter Cockburn Sound.	The following aspects of the Proposal may affect marine fauna: • temporary changes in water quality during construction (turbidity, nutrient-related water quality, contaminants) due to dredging and the discharge of return water • ongoing changes in water quality due to outflow of lesser water quality from the marina into Mangles Bay • direct and indirect loss of habitat due to construction of the access channel and breakwaters of the marina • increased risk of introduced marine species due to increased numbers of large recreational vessels berthing in the marina • increased human access causing littering • increased vessel numbers causing increased fishing pressure and the potential for boat strike • increased interactions between humans and marine fauna.	Management measures to reduce potential impact of habitat loss on marine fauna include: • improvement of habitat value of seagrass meadows in Mangles Bay • seagrass transplantation in other areas of Cockburn Sound • no removal of sea wrack • establishment and enforcement of no-wake zones in shallow surface waters • promoting/displaying information on ecological values and appropriate behaviour, sustainable fishing practices, wildlife regulations, boat speeds • providing a base for surveillance, monitoring and research in the marine environment • provision of fishing line discard bins and information signs • patrolling of marina to remove line and other entanglement sources and to support clean up measures • prohibiting fishing within the marina • implementing strict environmental management standards for the marina • encouraging recreational and charter boat owners to participate in penguin monitoring program • encourage and promote best practice measures for refuelling, cleaning vessels, oil spills, bilge water, detergents, stormwater runoff • collaboration with department of fisheries to prevent and respond to incidents of introduced marine pests, or significant amounts of fouling organisms or sediment.	Construction of the Proposal will likely result in: • minor temporary turbidity and noise associated with dredging, with minimal effect on marine fauna • direct loss of 5.66 ha of seagrass meadow and 1.69 ha of bare sediment and offset of 6 ha of seagrass in Cockburn Sound. Operation of the Proposal will likely result in: • increased shore based recreational activity and increased recreational vessels and fishing pressure, which will be offset through management measures described.

Matters of National Environmental Significance					
To provide for the protection of the environment, especially matters of NES, promote ecologically sustainable development through the conservation and ecological sustainable use of natural resources and control of international movement of wildlife, wildlife specimens and products made or derived from wildlife.	• *Environment Protection and Biodiversity Conservation Act 1999* (Australian Government) (EPBC Act). • Matters of National Environmental Significance: Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999 (DEWHA 2009) • Japan Australia Migratory Bird Agreement (JAMBA) • China Australia Migratory Bird Agreement (CAMBA) • Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) • Ramsar Convention.	Based on previous surveys, databases and literature searches of the Proposal area and surrounds, one endangered terrestrial species and 32 migratory bird species listed under the EPBC Act may occur in the Proposal area. A search using the EPBC Protected Matters Database search identified a number of matters of NES that may occur within the Proposal area as follows: • 3 wetlands of international significance • 2 TECs • 21 threatened species • 23 migratory species • 38 marine species • 13 whales and other cetaceans. *Synemon gratiosa* (GSM) is an endangered day flying moth endemic to the area between Beekeepers National Park (10 km North of Leeman) and Preston Beach (Bishop *et al.* 2010). Two EPBC listed TECs occur within close proximity to the Proposal area.	• vegetation clearing for the development will result in clearing of fauna habitat • construction of a inland marina may result in the inland migration of the saltwater interface and changes to water quality, which may potentially impact fauna habitat and threatened ecological communities • construction of the access channel and breakwater of the marina may result in the direct and indirect loss of marine habitat • increased boat movements and berths may potentially impact fauna habitat and individual fauna species by increasing the risk of introduced marine species, increasing fishing pressure and the increasing the potential for boat strike of marine fauna • increased recreational access may potentially impact fauna habitat through littering • edge effects may potentially impact habitat at Lake Richmond.	Implementation of a CEMP will include management of dredge spoil, dust, GSM and noise and vibration. Measures to minimise impacts to matters of NES include: • no clearing outside authorised areas • clearing in stages to allow for fauna movement • planting/seeding of disturbed areas with local provenance species where appropriate • limiting noise/vibration • limiting time and length excavated trenches are open • no vehicle access outside authorised areas and vehicle speed limits imposed • fencing to protect vegetation where required • monitoring to evaluate rehabilitation • offset plan • rehabilitation of areas in vicinity of Proposal area • landscape median strips of Memorial Drive and Safety Bay Rd • designing proposal in water sensitive manner • strategic weed control program.	The Proposal is expected to have minimal impacts on matters of NES, as follows: • reduction in area of available GSM habitat through clearing of 32.6 ha • the Proposal will not result in a significant impact to the potential black cockatoo (Carnaby's and Forest Red-Tailed) habitat (1 ha cleared) or the population of black cockatoo species that may potential occur • terrestrial migratory species – the Proposal is not expected to result in significant impacts to these species • marine migratory species – the Proposal is not expected to result in significant impacts to these species. Overall, there are likely to be some local reductions in fauna populations within the Proposal boundary; but the Proposal is unlikely to significantly affect the regional diversity or abundance as the habitats are well distributed locally and regionally. With management and offsets, it is considered that the Proposal can meet EPA objectives, as well as other applicable policy and guidelines objectives.
Aboriginal and European heritage					
To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.	• Aboriginal Heritage Act 1972 • Native Title Act 1993 (Commonwealth) • EPA Guidance Statement No. 41, "Assessment of Aboriginal Heritage" (EPA 2004d) • Planning Policy 3.1.7 – Heritage Conservation and Development Policy.	Two 'Registered' sites are located within and/or adjacent to the Proposal area: • Lake Richmond (15974) • Rotary Park (3471). Two 'Other Heritage Places' are also included within the vicinity of the Proposal area: • Mooribirdup Ceremonial Ground (22888) • Lake Richmond (352). In April 2011, a detailed consultation program was undertaken to determine the significance of the sites located within / adjacent to the Proposal area. Sites / buildings of European heritage significance include: • Cape Peron Battery Complex • the Point Peron Recreation Camp buildings • the 'Turtle Factory' building.	As a result of the Proposal, one registered heritage site (Rotary Park) and one other heritage site (Mooribidup Ceremonial Grounds) will be affected through the following: • physical disturbance of the land surface during clearing and construction including removal of topsoil and overburden, and landform modification has the potential to disturb heritage sites and affect ethnographic values • presence of construction and operational personnel has the potential to disturb heritage sites, disrupt cultural association meetings and gatherings, and affect ethnographic values.	Where the Proposal may impact on any Aboriginal site, an application to disturb will be made under section 18 of the AH Act. Continue consultation and discussions with heritage site informants and the Native Title Claimants for the area throughout the planning, development and implementation stages of the Proposal. Install public art displays and signage to interpret and present the cultural and historical values held for the area, in close consultation with the Nyungar community. The Nyungar community will be given the opportunity to conduct appropriate proprietary rituals prior to ground disturbance associated with the sites mentioned above. Clearing is to be monitored by a qualified archaeologist and two Nyungar community members. Rehabilitation will be conducted utilising any indigenous seeds and plants are salvaged from the Proposal area. Employment opportunities for Nyungar people will be provided where possible throughout the construction phase of the Proposal. The Proponent will investigate the option for the former Sister Kate's Children's Home site to be leased to the Nyungar community. The site should also be registered with the DIA under the AH Act. Consideration will be given to relocating the Turtle Factory building; however, this may not be plausible given the building is constructed of asbestos material. The Proponent will consult with the relevant government heritage agencies, community groups and the City of Rockingham to determine the best outcome for this building.	The Proposal will potentially affect the cultural heritage values associated with the Cape Peron area, including two Aboriginal heritage sites (Rotary Park and Mooribirdup Ceremonial Grounds) and a European heritage site (the Turtle Factory). An appropriate 'interpretative site' will be established to recognise the Aboriginal heritage values of the area whilst providing for use by the local Aboriginal community as a meeting place. There are also other opportunities to recognise the Aboriginal connections with Cape Peron within the development (e.g. public art, information).

Recreation and public access impact assessment					
To ensure that existing and planned recreational uses are not compromised.	• Perth's Coastal Waters Position Paper (EPA 2000b) • Draft Perth Coastal Planning Strategy (DPI and WAPC 2008) • RLRP Management Plan (DEC 2010a) • City of Rockingham Strategic Plan 2006-2011 (CoR 2007).	The Mangles Bay foreshore comprises of sandy beaches backed by low sand dunes. A large proportion of this foreshore is presently occupied by the local yacht club, fishing club (with associated jetty and boat ramp) and chalet accommodation. The use of the land by these facilities currently restricts public access to these foreshore areas, although access along the beach is mostly unimpeded. The beach is not a popular swimming area, and beach-based recreation is more focussed on walking, and the launching of boats. Cape Peron is as a popular though neglected sightseeing destination, as well as providing for activities including fishing, walking, exercising dogs, diving, swimming, picnicking and windsurfing (DEC 2010a). Lake Richmond is an attractive expanse of water in an urban setting and is used for walking, bird watching and nature observation (DEC 2010a). Public facilities provided at Cape Peron include lookout points and an extensive walk trail.	• dredge movements may cause temporary disruption to yachting and recreational fishing activities • construction noise may affect recreational amenity • increased turbidity from dredging may affect local fish and crab behaviour and recreational swimming • direct removal of a small amount of beach due to the construction of the access channel and breakwaters to allow access to the marina • interruption of pedestrian traffic flow along the beach due to the access channel and breakwaters • increased traffic and use of both land and water based recreation areas • interruption of adjacent gazetted water-ski area and power craft area • construction of marina will reduce public access to the beach.	The proposed marina development is primarily a boating and tourist facility proposed to cope with the high demand for boating facilities in the City of Rockingham area. Within the Cape Peron and Lake Richmond area of the RLRP, it is proposed to: • improve recreational opportunities by providing hard walking and cycling paths without creating additional disturbance to the natural environment • formalise beach access points, provide parking and remove unnecessary paths to minimise dune erosion • recognise cultural heritage (Aboriginal and European) links with the area (e.g. providing interpretive signage at sites of significance and contributing to the maintenance of these sites) • contribute to research and educational opportunities through the provision of facilities within the marina and interpretative walk trails/signage The Proposal will provide new recreation facilities and funds to positively contribute to the management of the RLRP offset measure.	Overall the Proposal will provide positive outcomes increasing the recreation and tourism values for the Mangles Bay area and the wider Rockingham Region. The Proposal will be developed in accordance with the City of Rockingham's Strategic Plan (CoR 2007) and the RLRP Management Plan (DEC 2010a) targets and vision. Once operational, the Proposal will greatly enhance recreational fishing and yachting activities. There may be some temporary disruption of recreational fishing and yachting due to dredge movements, and effects on fishing movements due to turbidity and noise during construction. The Proposal will improve access to the beach, which is currently constrained by existing land uses.
Conservation areas					
To protect the environmental values of areas identified as having significant environmental attributes. To maintain the integrity, functions and environmental values. To maintain the integrity, ecological functions and environmental values of the seabed and coast.	• National Strategy for Ecologically Sustainable Development (Commonwealth of Australia 1992) • Australia's Biodiversity Conservation Strategy 2010-2030 (Natural Resource Management Ministerial Council 2010) • EPA Guidance Statement No. 10 (EPA 2006a) • Bushland Policy for the Perth Metropolitan Region, Statement of Planning Policy 2.8 (WAPC 2005a) • RLRP Management Plan (DEC 2010a) • SIMP Management Plan 2007–2017 (DEC 2007) • State Environmental (Cockburn Sound) Policy (SEP) (Government of Western Australia 2005b) • Japan Australia Migratory Bird Agreement (JAMBA) • China Australia Migratory Bird Agreement (CAMBA) • Republic of Korea Australia Migratory Bird Agreement (ROKAMBA).	All land within the Proposal area south of Point Peron Road is within Bush Forever Site 355 (Government of Western Australia 2000) and within the RLRP. The total area of Bush Forever Site 355 is 174.5 ha of which 106.1 ha is vegetated (Bennett 2005). The remaining 68.4 ha consists predominately of holiday cottages, the Water Corporation waste water treatment plant and recreational camps (Bennett 2005). The development will result in the clearing of approximately 40 ha of Bush Forever Site 355. The RLRP has significant conservation value owing to its geomorphic features, the presence of diverse wetland types, habitat, flora and fauna. The development will result in the clearing of approximately 37 ha within the RLRP or less than 1% of the total area of the RLRP, which covers an area of 4720 ha. The SIMP covers an area of approximately 6 658 ha and contains the chain of islands that run parallel to the coast between Cape Peron, Becher Point, the waters of Shoalwater Bay, Warnbro Sound and a part of Cockburn Sound off Cape Peron.	• decrease in the representation of regionally significant bushland in the Swan Coastal Plain portion of the Perth Metropolitan Region as a result of clearing and earthworks associated with the development • fragmentation of bushland as a result of clearing for the development which may disrupt recreational activities and the movement of terrestrial fauna • potential increase in recreational activity and opportunity to better manage recreation • potential loss of visual amenity associated with the natural coastal environment through the development; however, visual amenity may also be enhanced through rehabilitation measures.	An offset package has been formulated to compensate the impacts of the development. The package includes improving the quality of the surrounding Bush Forever Site and the RLRP, rather than buying land elsewhere. A Recreational Management Plan will be implemented with the primary aim of educating recreational users of the Mangles Bay and SIMP of the restrictions on use, to ensure that the conservation values of the SIMP are protected. Establishment of a Mangles Bay Heritage trail with informative signs and displays illustrating the heritage values of the area.	The Proposal is not expected to impact the regional significance of Cape Peron Bush Forever Site 355 or Lake Richmond Bush Forever Site 358, including TECs, fish species, flora and fauna and hydrological regimes of these sites. The proposed rehabilitation within Cape Peron is predicted to improve the biodiversity of the area, consistent with the objectives of the RLRP. The Proposal will not impact directly on the SIMP.

Visual amenity					
To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable. To maintain the integrity, ecological functions and environmental values of landscapes and landforms.	• EPA Guidance Statement No. 33 (EPA 2008a) • Visual Landscape Planning in Western Australia manual (WAPC 2007) • State Planning Policy No. 2 (WAPC 2003).	The vantage points of the proposed development were classified into three zones for assessment including: • zone 1 – perimeter • zone 2 – coastline • zone 3 – vantage points. Two primary vantage points were located, including Battery Hill within Cape Peron and the dunal ridge along Shoalwater Bay. The Proposal area will not be visible from John Point in Point Peron which is used frequently by the public.	• clearing vegetation will alter the appearance of the natural environment which may be visible from identified significant sites • physical attributes of significant infrastructure that may obstruct or change views of existing natural features considered aesthetically significant. The infrastructure may, in itself, be aesthetically displeasing.	Existing visual amenity values within, and surrounding the Proposal area will be maintained as far as practicable through the implementation of the following measures: • retaining vegetation associated with areas of public open space • the shore disturbance required for the Proposal is concentrated in the area of existing yacht club activity • aligning roads on existing contours where practicable • avoiding interruption of the natural ridgeline • contributing to rehabilitation and management works in adjacent RLRP • connecting the new development with the existing residential and commercial areas through pedestrian access ways • guiding building height and distribution to provide diversity, permeability and limit mass • developing design guidelines that specify architectural designs, colours and materials that blends well with the natural landscape and are visually sensitive to the area • developing a Local Structure Plan that maintains key view corridors • maintaining a landscape buffer around Proposal area that minimizes visual impact on the area • maintaining a landscape buffer along the coastline.	Visual amenity of the coastline and surrounding views is an aesthetic value that may be compromised following the implementation of Proposal, though the view sheds are currently broken by the existing infrastructure, industry and residential housing.
Road traffic					
To ensure that the increase in traffic resulting from the Proposal does not adversely impact on the amenity of social surroundings or increase the risk to local public safety.	Main Roads Western Australia (MRWA) Road Hierarchy Criteria (MRWA 2011) Western Australian Restricted Access Vehicles Network City of Rockingham Infrastructure Guidelines (City of Rockingham 2011)	The road network within and adjacent to the Proposal area consists of local access, local distributor and distributor roads that service the area. These existing roads provide access to Garden Island and direct access to residential, retail, commercial and recreational areas. Key roads connected to the Proposal area: • Point Peron Road • Naval access road • Memorial Drive • Lease Road • Boundary Road • Parkin Street • Rae Road • Safety Bay Road.	• public safety issues (e.g. road traffic and pedestrian safety) • reduction in amenity (e.g. increase in noise emissions from vehicles).	The increased volume of traffic created by both the construction and operation phases of the Proposal may potentially increase public safety issues and / or reduce amenity of the area (e.g. increased noise emissions). In order to mitigate these impacts the following management measures will be incorporated into the Local Structure Plan preparation and design phase: • design of roads according to the City of Rockingham standards • routing of construction traffic to avoid existing high volume and/or residential areas • upgrade of Memorial Drive (Section 21.5.2) to cater for increased demand, including the installation of appropriate intersection controls. A Traffic Management Plan, outlining actions to minimise impacts to safety and amenity will be developed prior to the commencement of construction phase of the Proposal.	It is not anticipated that the increased traffic flow generated by the Proposal will have significant negative impacts on local road traffic. The Proposal will generate increased traffic on the road network in the vicinity of Cape Peron, during both the construction and operation phases. Memorial Drive will be realigned and upgraded to improve traffic flow with multiple road connections to Mangles Bay and the marina. The service corridor will have provision for a dual road to accommodate increased traffic volumes to HMAS Stirling.
Contaminated sites and acid sulfate soils					
To ensure that emissions do not adversely affect environment values or the health, welfare, and amenity of people and land uses by meeting statutory requirements and acceptable standards. To ensure that rehabilitation achieves an acceptable standard compatible with the intended land use and consistent with appropriate criteria.	• Contaminated Sites Act 2003 (WA) • Contaminated Sites Regulations 2006 • Environmental Protection Act (EP Act) • Contaminated Sites Management Series (developed by the DEC) • Acid Sulfate Soils Guideline Series (developed by the DEC) • Australian New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000) • National Ocean Disposal Guidelines for Dredged Material (Commonwealth of Australia 2002) • National Assessment Guidelines for Dredging (Commonwealth of Australia 2009).	A search of the ASS Swan Coastal Plain risk map (DEC 2003) indicated the site was within an area of "low to no risk of ASS occurring within 3 m of the natural soil surface. Results of geotechnical investigations suggest the majority of soil samples contain neutral to alkaline soils with a significant amount of acid neutralising capacity. Concentrations of metals within the sediments to be dredged did not exceed, EILs, HILs or EQGs), indicating that there was a low risk of adverse ecological effects due to dredging or disposal, and that the material was suitable for use on land. Concentrations of ammonia in elutriates of Mangles Bay sediments did not exceed the toxicity guideline of the NAGD or Cockburn Sound EQG for high ecological protection. The median TBT concentration at baseline sediment sampling sites also met the EQG.	• earthworks (excavation and dewatering) have the potential to disturb and expose contaminated soil, sediment and/or water if contamination exists on site • excavation onsite or along service infrastructure corridors has the potential to disturb ASS if they occur on the site • exposure of contaminated sediments during the dredging of the marina access channel.	Management measures will be implemented by the Proponent and include: • undertaking due diligence onshore ASS investigations as part of a dewatering management program • undertaking due diligence ASS monitoring of the access channel during the dredge program • undertaking due diligence ASS monitoring of the dredge spoil from construction of the access channel • stockpiled dredge spoil will be tested for contaminants (such as metals and TBT) on advice from DEC Contaminated Sites Branch • establish a monitoring program encompassing the marina and access channel sediments to monitor the potential for Monosulfidic black ooze formation. • conducting further investigations at three small localised locations of potential contamination, • maintaining an up to date contaminated sites inventory. Any areas of contaminated land within the Proposal area will be identified, remediated and managed by the Proponent for clearance by the DEC prior to the cessation of the construction period and the use of the potential contaminated land by the public and/or residents. The Proponent will maintain a contaminated sites register throughout the pre-construction and construction period at the Proposal area as required by the *Contaminated Sites Act 2003* (WA).	Contaminant levels in the sediment to be excavated are such that ecological values in the vicinity of the Proposal area will not be affected as no EILs or HILs are exceeded, no marine guidelines for sediment are exceeded. Elutriate testing of sediments in the breakwater footprints meet marine water quality guidelines. The risk of ASS (sediments and soil) for this Proposal is negligible and contaminated sites within the Proposal area are unlikely to cause any environmental impacts.

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1. Introduction

1.1 Proposal overview

1.1.1 Background

The proposed Mangles Bay Marina Based Tourist Precinct (the Proposal) is a refinement of previous proposals that have been put forward since the early 1990s. Early project proposals were abandoned due to high costs and downturns in the real estate market. In response to community interest, the costs, benefits and constraints of Mangles Bay and other potential sites along the City of Rockingham coastline were reviewed.

The review concluded that for a marina based development, when assessed against the project sustainability objectives, Mangles Bay presents the least constraints (not withstanding that the Mangles Bay site has some major environmental constraints) and most opportunities when compared with other sections of the coastline in the City of Rockingham (Strategen 2006).

This Proposal has been designed to address the physical, environmental and social opportunities and constraints that have been identified during the development and assessment of these previous proposals.

In 2006, a Strategic Environmental Review (SER) was prepared for the Mangles Bay Marina Based Tourist Precinct (previously known as the Cape Peron Tourist Precinct Project), for the consideration of the Environmental Protection Authority (EPA) to enable the EPA to give advice requested by the Minister for the Environment under section 16(e) of the *Environmental Protection Act 1986* (EP Act). The strategic assessment process enabled the EPA to examine (at the early stage in the Proposal development) the key environmental issues associated with the Proposal, including the provision of advice on potential fatal flaws of the Proposal.

Under this strategic assessment process, in 2006, the EPA provided written and public advice to the Minister on the concept of an inland marina development at Mangles Bay. The EPA identified the following primary environmental issues:

- seagrass and water quality – direct loss through construction of the Proposal and indirect loss through changes in water quality, sand bypassing activities and coastal processes
- Lake Richmond – indirect impact on the lake and its key attributes (two threatened ecological communities [TECs]) through potential changes in hydrogeology thereby modifying the lake's water quality and water level and potentially threatening the TECs
- terrestrial vegetation – direct loss of vegetation and additional indirect loss through fragmentation, edge effects and changes in site hydrology.

The Proposal was referred to the EPA under section 38 of the EP Act on 25 August 2010. The level of assessment for the Proposal was advertised on 20 September 2010 as a Public Environmental Review (PER) with a ten week public review period and a two week public review of the ESD.

This PER will describe the studies and investigations that have been conducted by the Proponent that are in addition to the existing information resources regarding the aforementioned environmental issues, as well as those identified through consultation and screening processes. The objective of the reviews and additional studies and investigations will be to ensure that the full environmental effects of the proposal are properly understood, thus guiding the development and timely implementation of optimal management controls and enabling a reliable and knowledge-based environmental impact assessment to be conducted.

1.1.2 Location

The Proposal is located within the Perth Metropolitan Area, on the Swan Coastal Plain approximately 40 km south southwest of Perth within the City of Rockingham, Western Australia (Figure 1). The proposed development is at the southern end of Cockburn Sound, immediately east of the Garden Island Causeway and bounded by Hymus Street/Safety Bay Road to the east (Figure 2).

1.1.3 Description

This Proposal is for a tourist based inland marina development comprising a single entry marina to accommodate up to 500 pens and moorings and a surrounding land development comprising tourism, accommodation, commercial, POS and residential land uses. The development will also incorporate local aquatic clubs.

The Proposal comprises the following elements:

- marina
- boating access channel
- provision and maintenance of service infrastructure
- land development area
- rehabilitation of degraded areas of vegetation in proximity to the Proposal area and seagrass transplantation to offset vegetation losses.

The Proposal will provide much needed protected boating facilities in Mangles Bay, enhance public access to Mangles Bay and create a vibrant tourist district that will attract visitors to the region and create employment opportunities for Rockingham and the surrounding area. The Proposal will also include rehabilitation of bushland in the Cape Peron region and provide additional passive recreation facilities such as walkways and information. The design objectives are included in Appendix 2.

A detailed description of the Proposal is outlined in Section 3, with Figure 6 and Figure 7 illustrating the indicative layout of marina, access channel, breakwaters and land development. The final layout of the Proposal, especially the marina, channel and breakwaters, is still subject to amendment on the basis of stakeholder consultation, environmental investigations and engineering investigations.

Source: Imagery supplied by Landgate (2010)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F001.dgn

Regional location of the Proposal

Figure No: 1

Source: Imagery supplied by Landgate (2010)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F002.dgn

Location of Proposal area

Figure No: **2**

1.2 The Proponent

The Western Australian Government endorsed the progression of the Proposal. Subsequently, the Western Australian Land Development Authority, LandCorp (State Government's Land Development Agency), appointed Cedar Woods Properties Limited (Cedar Woods) as its private sector partner to progress this Proposal. Cedar Woods is the Proponent for this Proposal. The nominated contact for the Proponent is:

Marcus Deshon
Development Manager
Cedar Woods Properties Limited
50 Colin Street
West Perth, WA 6005
PO Box 788 West Perth WA 6872
Email: Marcus.deshon@cedarwoods.com.au

1.3 Purpose and scope of this document

The purpose of this document is to present an environmental review of the Proposal, including a detailed description of the key components, environmental impacts and proposed environmental management measures for relevant environmental aspects identified by the ESD.

This PER includes:

- a description of the existing environment (Section 2)
- a detailed description of the Proposal (Section 3)
- a description of the stakeholder engagement and consultation process undertaken for the Proposal (Section 4)
- a factor-by-factor assessment of the environmental impact of the Proposal (Section 6 to Section 21)
- a description of key environmental management measures and controls (Section 22).

1.4 Rationale for Proposal

1.4.1 Requirement for marina development

The need for boating and marine facilities in the south of Cockburn Sound has been identified in several tourism and recreational studies of the area (LandCorp 1998).

Cockburn Sound is an important destination for boating, providing a large area of water for yachting and powerboat use. Its shoreline currently supports both yacht and power boat clubs. There are approximately 600 (legal and illegal) swing moorings in Mangles Bay, which provide little protection for vessels in winter storms that approach from the northwest. Damage to boats and moorings is regularly sustained during these storms, and provision of a marina would provide an alternate option for mooring these vessels. Swing moorings have also caused seagrass loss in Mangles Bay. Furthermore potentially contaminating activities such as re-fuelling, rubbish and sullage disposal are difficult to manage in this area.

In February 2010 the Port Rockingham Marina (approximately 5 km from the Proposal site) attained environmental approval. If this marina is built, it will provide pens for up to 500 boats. However, as the population increases, these additional marina facilities will not satisfy demand for boating facilities in the area. Rockingham is one of the fastest growing areas in the south west corridor and levels of disposable

income have increased with expanded employment opportunities and comparatively lower housing mortgage rates.

The population increase for the Cockburn, Kwinana and Rockingham areas between 1996 and 2011 is estimated at 138 800 to 216 530, an increase of 56%. The primary source of demand for moorings in the proposed Mangles Bay marina will be from the local Rockingham region and this demand will increase with population growth. The availability of pens will also allow current boat owners to upgrade beyond trailerable vessels. Boat owners from other areas of Metropolitan Perth will add to the demand as mooring space in existing metropolitan clubs and marinas reach capacity. Room for expansion of existing metropolitan facilities is limited, resulting in extended waiting periods for pens.

1.4.2 Social and economic benefits of the Proposal

Social benefits

The Proposal is expected to provide the following social benefits:

- provision of a range of public recreation and tourist facilities to enhance Cape Peron as a destination for local and international visitors
- improved public access to both Shoalwater Bay and Mangles Bay and pedestrian and cycle linkages between Rockingham Beach, Cape Peron and Shoalwater Bay
- provision of a secure marina area specifically designed for commercial and recreational boating and yachting clubs
- increased facilities for management and regulation of boating activity with associated improvements in public safety
- increased management presence, lighting and increased public use of Cape Peron will help discourage anti-social behaviour
- effective traffic management in the local area
- increase in housing supply and diversity
- provision of a site for a Marine Science Centre
- provision of low cost, family holiday accommodation for a wide cross section of the community.

Economic benefits

A detailed analysis of the economic impacts of the Proposal will be undertaken during the planning phase of the Proposal. It is envisaged that the construction and operation of the Proposal would generate significant economic revenue within Rockingham with flow-on effects for local industries.

The development is expected to include retail, tourist (including a hotel) and commercial businesses that will all create long-term employment opportunities within Rockingham. There will also be flow-on effects in employment opportunities.

The Proposal will comprise a major construction project and will also create employment for the duration of construction.

1.5 Environmental approvals

1.5.1 Western Australian Environmental Impact Assessment Process

The Proposal was referred to the EPA under section 38 of the EP Act on 25 August 2010. On 20 September 2010, the EPA set the level of assessment for the Proposal as a PER with a ten week public review period.

The Proponent submitted a preliminary ESD on 11 October 2010, which detailed the potential environmental impacts, their significance and possible management response, as well as outlining the proposed scope of work to obtain information for the PER, key legislation, stakeholder consultation program, proposal and assessment schedule, study team and peer review mechanisms. The final ESD was approved by the EPA on 16 June 2011.

The PER has been prepared in accordance with the Environmental Impact Assessment (Part IV Division 1) Administrative Procedures 2010 for environmental assessment prescribed under the EP Act. The purpose of the PER is to present an Environmental Impact Assessment of the key environmental aspects of the Proposal in accordance with the approved ESD (a table showing commitments made in the ESD, and how these have been addressed in the PER is included as Appendix 3). The Environmental Impact Assessment process is based on conformance with various relevant EPA Position Statements and Guidance Statements in order to determine the significance of the environmental effects of the Proposal

Following a ten week public review, the EPA will provide the Proponent with copies of any submissions received. The Proponent will be required to prepare a summary of the key issues and matters raised in the submissions and respond to these, to the satisfaction of the EPA.

The EPA will assess the PER document, submissions, Proponent response to submissions, and obtain advice from any other persons it considers appropriate and submit its assessment report to the Minister for the Environment.

The Minister will publish the EPA report as soon as the Minister is reasonably able to do so after receiving it. As provided for under section 100(1)(d) of the EP Act, any person may lodge an appeal to the Minister for the Environment against the findings or recommendations of the EPA assessment report within 14 days of the publication of the report. Subsequent to the determination of appeals (if any), the Minister will then decide whether or not the Proposal should be implemented and if so, under what conditions.

The procedure for a PER level of assessment is outlined in Figure 3.

1.5.2 Australian Government Environmental Impact Assessment Process

The Proposal was referred to the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) on 21 September 2010 for consideration under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). On 27 October 2010, DSEWPaC advised that the action was considered to be a 'controlled action' under the EPBC Act (EPBC Reference: 2010/5659).

As the Proposal has been deemed a controlled action, it will be assessed through the Bilateral Agreement. The Bilateral Agreement between the Commonwealth of Australia and the State of Western Australia provides for the accreditation of the Western Australian environmental impact assessment process to ensure an integrated and coordinated approach for actions requiring approval under both the EPBC Act and the EP Act.

1.5.3 Other Environmental Approvals

Additional environmental-related approvals required are outlined in Table 1.

Table 1 Other environmental approvals required

Decision Making Authority	Approval Required	Legislation
Department of Water	26D License to construct wells for dewatering and injection 5C License to take water	*Rights in Water and Irrigation Act 1914*

1.6 Planning approvals

The proposed Precinct area is not currently zoned for residential development under the Metropolitan Region Scheme (MRS) or City of Rockingham's Town Planning Scheme (TPS) No. 2. As such, amendments to both the MRS and TPS and a Local Structure Plan (LSP) will be required prior to the commencement of development.

These processes allow for input from stakeholders and State and Local Government to ensure that the development meets social, economic and environmental needs. The MRS rezoning will be initiated following environmental approval of the Proposal. The LSP will require the preparation of an Environmental Review document and a Local Water Management Strategy (LWMS) to ensure that the Proposal adequately addresses environmental and water issues. The LWMS will provide details regarding water management in the Precinct and will be required to be approved by City of Rockingham and Department of Water (DoW) prior to the Proposal progressing.

After the rezoning and LSP have been approved, the land may then be developed and subdivided. At the subdivision stage, State and Local Government regulators may set conditions for subdivision that must be signed off by the regulators prior to the developer receiving Certificates of Title and being able to sell the lots. This includes environmental conditions, such as the preparation of a Construction Environmental Management Plan (CEMP) and Urban Water Management Plan.

The environmental and water management documents developed at the LSP and subdivision stage will comply with the commitments made in the PER and provide additional details regarding the implementation of these commitments.

1.7 Operational management framework

Policy No. DC 1.8 of Canal Estates and Other Artificial Waterways Developments require waterways to be transferred at no cost to the Department of Land Administration for subsequent vesting.

DC 1.8 stipulates the need for a Deed of Agreement to be finalised by Cedar Woods as the Proponent, prior to the City of Rockingham endorsing a Scheme Amendment for the proposal. It is not intended to pursue a scheme amendment until such time as the PER has been approved. Accordingly, preparation of a management agreement is considered premature until the environmental approval process has been completed. A draft Development Agreement will then be prepared as part of the future planning of the Proposal which will ultimately assist in determining the ongoing management and maintenance costs of the marina.

Pursuant to Clause 2.2.4, the Deed of Agreement is required to identify and provide the role and responsibility of the waterway manager to:

- monitor and manage the water quality and sediment to specified requirements
- construction, monitoring and maintenance of specific artificial waterways and channel (including entrance dredging, monitoring erosion or accretion associated with the development).

The maintenance period with which Cedar Woods, as the Proponent, will be responsible to undertake the maintenance works of the marina will also be included within the Deed.

Proposal referred and accepted by the EPA

↓

EPA decides to assess the proposal at the PER level and publishes the level of assessment and decision on:

- the length of public review (4-12 weeks)
- whether the EPA or proponent will prepare the Environmental Scoping Document (ESD)
- whether the ESD would require public review

↓

Proponent prepares ESD

↓

Proponent prepares and submits an ESD acceptable to the EPA

↓

EPA may require public review (2 weeks) of the ESD

↓

EPA approves the ESD as basis for the PER document

↓

Proponent prepares and submits a PER document acceptable to the EPA

↓

EPA authorises release of the PER document for public review (4-12 weeks)

↓

EPA provides a copy of all the submissions and a summary of the submissions on the PER document to the proponent

↓

Proponent submits a response to the summary of the submissions that is acceptable to the EPA

↓

EPA assesses the proposal and seeks comment from the proponent and key government agencies on the draft recommended conditions

↓

EPA submits the EPA Report to the Minister and publishes the Report

2. Overview of existing environment

2.1 Bio-physical setting

The region experiences a warm Mediterranean climate which is characterised by hot dry summers and mild wet winters. The nearest Bureau of Meteorology (BoM) weather station is located at Garden Island, approximately 5 km north of the Proposal area. The nearest long-term average weather station is located at Kwinana BP Refinery, approximately 8 km to the northwest of the Proposal area.

The Rockingham area experiences an average maximum summer temperature of 28.4°C and an average minimum winter temperature of 10.9°C. The average annual rainfall for the region is 748.9mm, with the majority of precipitation occurring in winter (BoM 2011).

Mangles Bay is at the southern end of Cockburn Sound and is part of the shoreline leading to the Garden Island Causeway and Point Peron. This area is known as Cape Peron.

2.1.1 Terrestrial environment

Geology

Cape Peron is a cuspate (sharp headland with adjacent smooth shoreline) foreland, formed where sand has been trapped and deposited in the lee of offshore islands, including Garden Island. Cape Peron was once an island that became connected to the mainland due to sand accumulation.

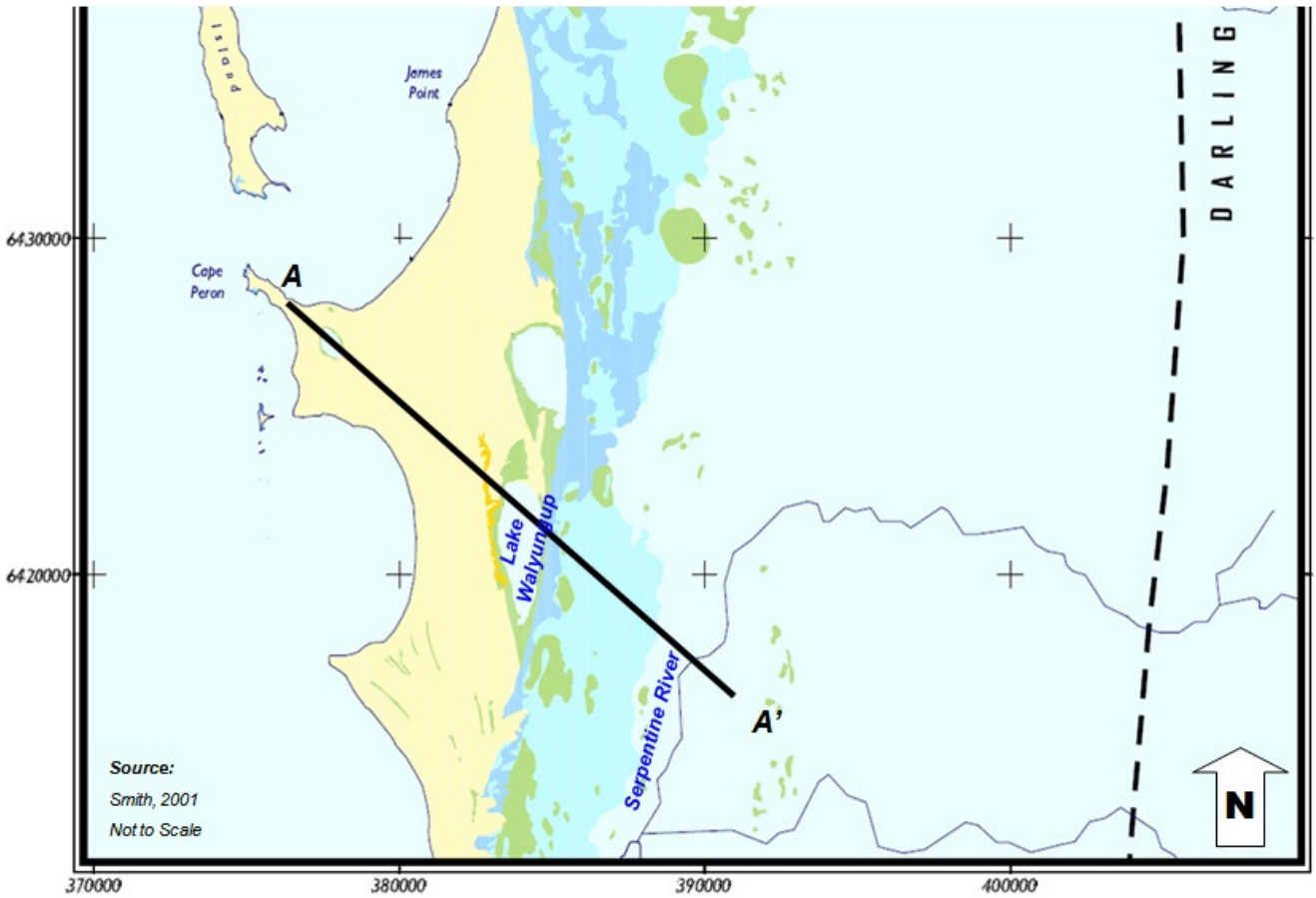
The site is underlain by approximately 30 m of superficial formations, comprising Safety Bay Sands and Tamala Limestone. These formations are in turn underlain by an approximately 100 m thick sequence of Rockingham Sand (WorleyParsons 2005).

The Safety Bay Sand formation which blankets the surface of the Cape Peron area overlies Tamala Limestone, which consists of cream, unlithified, calcareous fine-grained to medium-grained quartz sand and shell fragments.

The Tamala Limestone unit is a calcareous eolianite (rock formed by cementation of calcareous dune sands) that unconformably overlies the deeper Rockingham Sand formation. It contains various proportions of quartz sand, fine-grained to medium-grained shell fragments and minor clay lenses. The limestone typically exhibits secondary porosity in the form of numerous solution voids, channels and cavities. The average base elevation of the Tamala Limestone in the Proposal area is estimated to be 30 mAHD (metres Australian Height Datum) (Strategen 2006).

The Rockingham Sand formation occupies what is thought to be a palaeo-channel (erosional channel) incised into the bedrock Cretaceous sediments, which extends offshore from Rockingham to beneath the southern end of Garden Island. The unit mainly comprises slightly silty, medium-grained to coarse-grained sand of shallow marine origin. The maximum thickness of the Rockingham Sand is approximately 110 m at the southern end of Cockburn Sound in the Rockingham area.

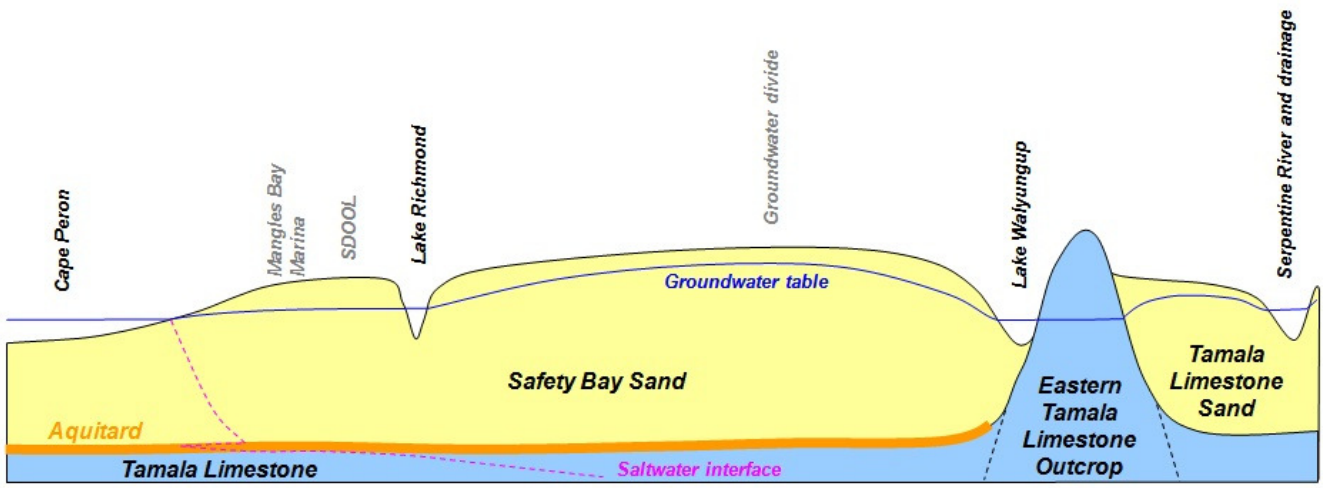
Geological units are shown on Figure 4.



Data Sources:
1:50,000 Environmental Geology Series (DOME)

LEGEND

Environmental Geology
- Safety Bay Sand
- Limestone (Safety Bay Sand)
- Tamala Limestone
- Sand (Tamala Limestone)
- Sand (alluvium)
- Swamp deposit



Note:
Based on Smith, 2001
Not to Scale

STRATEGEN	Mangles Bay Marina Based Tourist Precinct Regional hydrogeological of the Proposal area	Figure 4

strategen
Sep-2011

Hydrogeology

Groundwater occurs in two main aquifer systems at the Cape Peron Proposal area:

- superficial aquifer: collectively made up of the Safety Bay Sands and Tamala Limestone
- underlying Rockingham aquifer: made up of the Rockingham Sand formation.

Groundwater in the superficial aquifer (top 30 m of profile) generally flows in a westerly direction. Being the surface aquifer, it is relatively shallow with flows tending to discharge to the near shore marine environment along the coastline.

The flow in the underlying Rockingham aquifer is generally in a westerly direction and discharges freshwater directly into the ocean below sea level. The aquifer extends to a depth of about -65mAHD, and the top 40 m contains groundwater of salinity less than 1000 mg/L (MWH 2011b).

The hydrogeology is described in further detail in Section 6.

Flora and fauna

The vegetation of the Proposal area consists mostly of coastal shrublands dominated by common species of Swan Coastal Plain areas over a series of low lying dunes between the rocky headland of Cape Peron and Lake Richmond (Keating & Trudgen 1986). There are no wetland vegetation communities within the Proposal area; Lake Richmond is to the south east of the Proposal area.

The site is mapped as containing the Quindalup Vegetation Complex: Coastal dune complex mainly consisting of two alliances – the standard foredune alliance and the mobile and stable dune alliance. Local variations include the low closed forest of *Melaleuca lanceolata – Callitris preissii* and the closed scrub of *Acacia rostellifera* (ENV 2010).

The majority of the Proposal area is classified as coastal heath with a moderate value as fauna habitat. Other fauna habitat types in the Proposal area are woodland and shoreline habitats; also with a moderate value as fauna habitat (ENV 2011a).

Surveys conducted in and around the Proposal area recorded five amphibian, 19 reptilian, 66 avian and six mammalian species (including three introduced mammals) (ENV 2011a).

All land within the Proposal area south of Point Peron Road is within Bush Forever Site 355 (Government of Western Australia 2000) and within the RLRP.

Flora and fauna are described in further detail in Section 8 and 9 respectively.

Lake Richmond

The most significant surface water feature in the vicinity of the Proposal is Lake Richmond, located to the southeast of the Proposal area and separated from it by Safety Bay Road. Lake Richmond is a perennial freshwater lake occupying approximately 40 ha and is approximately 0.6 m above sea level (spill level of outlet drain) and up to 14.4 m deep (MWH 2011d). Currently, there are three main drains into Lake Richmond and one outlet that discharges to Mangles Bay (this drain traverses the Proposal area).

Lake Richmond is described in further detail in Section 6.1.

2.1.2 Marine environment

The Cape Peron headland extends westward into the Indian Ocean and defines the southern extent of Cockburn Sound. The Mangles Bay foreshore (within Cockburn Sound) forms most of the northern shoreline of the Cape while the Shoalwater Bay foreshore forms most of the southern shoreline of the Cape (Figure 2). The Cape Peron shoreline consists of sandy beaches and limestone rocky shores and headlands while the seabed comprises extensive sandy areas and limestone reefs.

The SIMP (Figure 2) comprises the chain of islands that run parallel to the coastline between Cape Peron and Becher Point (to the south). The SIMP borders Mangles Bay at the Garden Island causeway and contains the waters of Shoalwater Bay and Warnbro Sound. The islands are important for a diversity of wildlife, particularly the little penguin, other sea birds and the Australian sea-lion. The islands also make a significant contribution to the conservation value of Western Australia's islands estate.

Cockburn Sound is the most intensively used marine embayment in Western Australia. Historically, water quality at Mangles Bay has been of concern due to the effects of reduced flushing on nutrients loads, contamination from industrial uses, organic matter, and human health-related quality of the water, sediments and biota (EPA 2006b). With increasing improvements to industrial practice in the region, discharge of contaminants has decreased substantially. Subsequently, water quality has improved considerably since the 1970s but still remains the focus of current management attention.

Mangles Bay is sheltered by the Garden Island Causeway and Cape Peron, and is therefore relatively calm and poorly 'flushed' by marine waters under most circumstances. Natural patterns of sediment movement have been disrupted by the Causeway and the Cape Peron boat ramp, which has resulted in minor sediment accumulation and erosion along the Mangles Bay foreshore area adjoining the Proposal area. The waters in Mangles Bay within and adjacent to the Proposal area have been declared an Environmentally Sensitive Area, as per the Environmental Protection (Environmentally Sensitive Areas) Notice 2005 (Government of Western Australia 2005a). The shallow sheltered waters of Cockburn Sound (and Mangles Bay) support extensive seagrass meadows. Widespread loss of seagrass on the eastern margin of the Sound occurred during the 1970s; the loss attributed to shading caused by nutrient-stimulated growth of epiphytes (algae that grow on seagrass leaves) and phytoplankton (microscopic algae in the water).

The seagrass meadows in Mangles Bay show evidence of nutrient enrichment in the form of heavy epiphyte loads in summer while some areas of seagrass are partially exposed at low tide and experience desiccation and heat stress. The seagrass meadows are generally dense, but have patches of localised loss due to numerous mooring scars. Although the seagrass meadows in Mangles Bay are patchy due to the loss of habitat from mooring scars, the shallow, sheltered, slightly nutrient-enriched waters of Mangles Bay are recognised as an important fish nursery habitat.

Cockburn Sound supports a wide range of fauna and has significant fauna values because of its utilisation by dolphins, a large range of seabirds, protected migratory birds, and little penguins. The whole of Cockburn Sound is considered significant as a fish nursery/habitat. About 130 species of fish and 14 large crustacean and mollusc species are estimated to exist in Cockburn Sound. Accordingly, the Sound is a significant fisheries resource.

The marine biota of Cockburn Sound (and Mangles Bay) is further described in the following sections:

- marine water quality (Section 10)
- benthic primary producer habitats (BPPH) (Section 12)
- marine fauna (Section 13).

2.2 Socio-economic setting

2.2.1 City of Rockingham

The Proposal is located within the City of Rockingham, which has a population of greater than 100 000 residents. Historically, Rockingham was a seaside holiday town; however it is now one of fastest growing cities in Western Australia. Rockingham has undergone significant development, with increased industry, large residential developments (e.g. Port Kennedy and Secret Harbour) and redevelopment of the old Rockingham town centre foreshore and surrounds as well as the Rockingham City centre. Rockingham is also one of the most popular coastal destinations south of Perth.

The Royal Australian Navy has a strong presence in the area, with its base on Garden Island and a significant amount of residential requirement being filled in and around Rockingham.

Main industries and employment sectors in the City of Rockingham (NIEIR 2011) include:

- public administration and safety (including defence)
- retail trade (including food retail)
- construction
- education and training
- health care and social assistance
- accommodation and food services
- manufacturing
- transport, postal and warehousing.

2.2.2 Land tenure and zoning

The Proposal area south of Point Peron Road is vested in the Conservation Commission and is managed by Department of Environment and Conservation (DEC). The boating facilities are operating within a monthly leasehold arrangement vested with the Minister for Transport, Western Australia. The Water Corporation also hold an existing Crown Reserve within the Proposal. The details of land tenure are shown in Figure 5.

The area to the south of Point Peron Road is zoned 'Parks and Recreation' with the area to the north of Point Peron Road, along the Mangles Bay foreshore, being zoned 'Port Installations' under the MRS. There are other small areas within the Proposal area that are reserved for parking, drainage, special use (e.g. wastewater treatment plant) and a possible future road connection to the Garden Island Causeway.

2.2.3 Land use

The Proposal area and surrounds is the focus for the pursuit of many recreational activities, including:

- water-based activities: boating, swimming, snorkelling, fishing and crabbing
- land-based activities: walking, fishing and nature appreciation.

A large proportion of the Mangles Bay foreshore is currently occupied by the local yacht club, fishing club (with associated jetty and boat ramp) and chalet accommodation. The use of land by these facilities means that public access to the area is restricted.

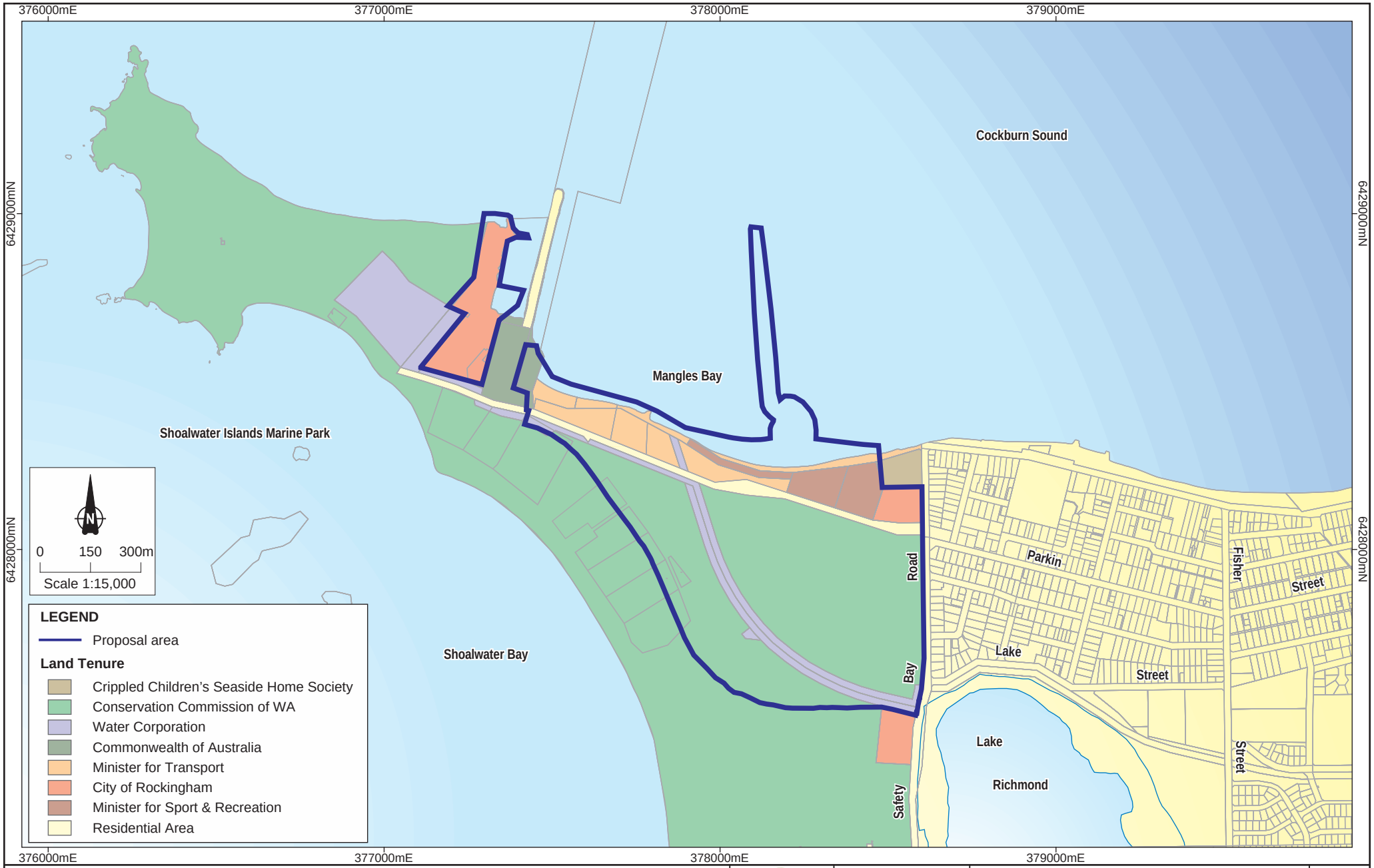
Other facilities within the Mangles Bay area include day-use car parks for accessing beaches and lookouts, and a public boat ramp directly to the west of the Garden Island Causeway. The City of Rockingham is currently undertaking minor upgrade works to the existing boat ramp facilities west of the Causeway. The development will look to build upon this infrastructure and improve facilities for the community.

Most of the Mangles Bay foreshore and some of the Shoalwater Bay foreshore are designated dog beaches. An area directly to the east of the Garden Island Causeway is designated a power water craft and water ski area. Visitor facilities on Cape Peron include 10 recreation camps, mainly located to the west of Memorial Drive along the Shoalwater Bay foreshore, which are managed by DEC and leased to private groups. DEC also manages one educational camp lease (leased by the Department of Education), which is located to the west of the Garden Island Causeway.

The Naragebup Rockingham Regional Environment Centre is located on the southwest corner of the Memorial Drive/Safety Bay Road intersection, opposite Lake Richmond. The centre is a community-run non-profit organisation that is actively involved in conservation activities in the Rockingham area and also provides a role in environmental education.

The Water Corporation Point Peron Wastewater Treatment Plant is located to the west of the Garden Island Causeway and the Water Corporation's infrastructure drain dissects the landscape from Lake Richmond to Mangles Bay.

Residential areas are located immediately to the east and south of the Proposal area.



Source:
Cadastral data supplied by Landgate
Tenure data supplied by MAPS
Coordinate System: MGA94 Zone 50
Date: 12/10/2011

NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F003.dgn

Land tenure of the Proposal area

Figure No: **5**

2.3 Key conservation values

2.3.1 Bush Forever

All land within the Proposal area south of Point Peron Road is within Bush Forever Site 355 (Government of Western Australia 2000). The purpose of Bush Forever is to provide protection for representative vegetation complexes and communities within the Perth Metropolitan Area. Lake Richmond, which is located to the south east of the Proposal area, is also identified as Bush Forever Site 358. Sections 8 (terrestrial flora and vegetation) and Section 17 (conservation areas) contain more detailed descriptions of Bush Forever Site 355 and Bush Forever Site 358.

2.3.2 Regional Park

In 1997 the State Government announced that Rockingham Lakes would be established as a regional park. Cape Peron and Lake Richmond are within the boundaries of the RLRP.

Regional parks are areas of regional open space that have been identified through planning processes as having regionally significant conservation, landscape and recreation values (CALM 2003a). The RLRP is one of eight regional parks in the Perth Metropolitan area.

The RLRP covers an area of 4270 ha, which consists of coastal areas, wetlands, remnant bushland areas, private leases and recreation areas. The RLRP is valued for its natural environment, recreation, cultural heritage, landscape, and research and education values. The *Rockingham Lakes Regional Park Proposed Final Management Plan* provides a broad direction for the protection and enhancement of these values (DEC 2010a).

Further details are provided in Section 17.

2.3.3 Shoalwater Islands Marine Park

The SIMP covers an area of approximately 6545 ha and comprises the waters of Shoalwater Bay, Warnbro Sound and a portion of Cockburn Sound off Cape Peron, approximately 400 m from the Proposal area.

The park is vested to the Marine Parks and Reserves Authority (MPRA), and managed by the DEC, apart from recreational fishing which is managed by the Department of Fisheries (DoF) in close cooperation with DEC. The Shoalwater Islands (i.e. the terrestrial portion) are managed under the 1992 Shoalwater Islands Management Plan.

The SIMP Management Plan 2007–2017 (the management plan) was formally approved by the Minister for the Environment in August 2007 (DEC 2007). The management plan sets out, among other things, a zoning scheme and a ‘best practice’ model for managing the identified ecological and social values of the SIMP. The zoning scheme proposes that the area to the north of Cape Peron (to the west of the Causeway) be within a ‘General Use Zone’.

Shoalwater Bay (on the southern side of Cape Peron) is a recommended ‘Special Purpose Zone’ for wildlife conservation, and further south are two sanctuary zones (at Second Rock, and Becher Point). A ‘Special Purpose Zone’ for scientific reference is at Murray Reef.

Further details are provided in Section 17

2.3.4 Lake Richmond

Lake Richmond has national conservation significance due to the presence of TECs (thrombolites and sedgelands [in Holocene dune swales and Woodlands over sedgelands in Holocene dune swales]), and Bush Forever status (Bush Forever Site 358). Lake Richmond also has iconic value to the Rockingham Community. It is a perennial freshwater lake occupying approximately 40 ha and is approximately 0.6 m above sea level (spill level of outlet drain) and up to 14.4 m deep (MWH 2011d). The lake receives the majority of water from stormwater drains but is also connected to groundwater.

Lake Richmond was isolated from the sea when part of the marine portion of Cockburn Sound was in-filled during the last 4000 years (English *et al.* 2003). Cape Peron, to the northwest, was once an island that became connected to the mainland as sand accumulated on the leeward side. Lake Richmond was cut off from the marine environment by this process (CALM 2003b).

The lake is located outside, but in proximity to the Proposal area.

Further details are provided in the following sections:

- surface water impact assessment (Section 6.1)
- matters of national environmental significance (NES) impact assessment (Section 14)
- conservation areas impact assessment (Section 17).

3. Description of Proposal

3.1 Development overview and key characteristics of Proposal

3.1.1 History of the Proposal

The redevelopment of the Mangles Bay area has been the subject of a number of previous proposals since the 1970s that have included both sea-based and inland marina options. A water-based marina proposal in 1993 estimated a loss of about 30 ha of seagrass, this loss was considered unacceptable by the EPA, especially as seagrass rehabilitation was not a proven technique at the time. In 1998, another marina concept for the development of an inland marina in Mangles Bay was developed. The Proposal was never formally assessed but advice from the EPA indicated that the proposal would not be environmentally acceptable due to seagrass losses. Processes for seagrass rehabilitation were not considered reliable at the time. A summary of the proposal for a marina development at Mangles Bay, Rockingham, is provided below:

- 1971: The Fremantle Port Authority adopted a plan for the development of a container port in Mangles Bay.
- 1975: The MRS was amended to provide for the connection of the site to the regional road and rail network.
- 1982: A Cabinet Sub-Committee and Departmental Technical Committee were established to review the Mangles Bay site and compare it with other sites.
- 1984: The proposed container port facility for the area was rejected on the basis that Catherine Point and North Mole would be more suitable and cheaper alternative sites for a port.
- 1985: The John Holland Group put forward a proposal for a small marina built outwards from Mangles Bay, which was found to be environmentally acceptable. The proposal was never pursued due to the downturn in the real estate market.
- 1992: The Department of Marine and Harbours proposed a 500 pen marine-based marina built outwards from Mangles Bay, close to the Garden Island causeway. The proposal was formally assessed by the EPA at the level of a PER. The EPA identified the main environmental factor as the significant impact on the remaining seagrass in the Mangles Bay area and the ecological significance of preserving the small amount of seagrass that remained in Cockburn Sound. The EPA in its report and recommendations (Bulletin 693) recommended against the proposal primarily due to seagrass loss. At this time, seagrass rehabilitation was not considered feasible. The Minister for the Environment did not issue a Statement that the Proposal could be implemented and hence the proposal could not proceed. The Mangles Bay Steering Committee was established to consider potential options, taking into account the environmental issues associated with the area.
- 1998: Following a request by Cabinet in May 1997, the Mangles Bay Boat Harbour Steering Committee developed a concept plan for the development of an inland marina in Mangles Bay. The concept plan was never formally assessed. Most recent reports indicate the seagrass meadows are under similar pressures as in 1998, if not increased.

Seagrass in Mangles Bay continue to compare poorly with other sites in Cockburn Sound. The direct loss of seagrass therefore remains a primary issue for any proposal to develop the Mangles Bay Boat Harbour. The protection of Lake Richmond (recognised for its conservation value) and nutrient inflow and pollutants from the Lake Richmond drain on the waters of Mangles Bay are also of concern.

In 2005, concept plans were prepared for a marina development at the site following a comprehensive community consultation process. A SER on the proposal was undertaken by the EPA in 2006. The process undertaken was in accordance with section 16(e) of the EP Act. The purpose of reviewing the Proposal under section 16(e) of the EP Act was to identify key environmental issues associated with the proposal and to gather, at a strategic level, information on those environmental issues.

The SER was released for public comment on the 7 March 2006 for a four week period and received approximately 440 submissions. Following the public comment, and EPA review period, the EPA provided advice in October 2006 as Bulletin 1237 recommending major and minor environmental factors that should be evaluated in detail for any future proposal.

3.1.2 Key components of the Proposal

Land development area

The total land development area is estimated to be up to 77 ha (Figure 7). The land development area will encompass various land uses including: tourist-based commercial uses; an aquatic club area; short-term accommodation; POS; and residential uses. The distribution and density of residential land uses will be defined during the structure planning process of the Proposal. The development will however, comprise a variety of lot sizes and residential densities to provide a diverse mix of buildings.

It is intended that the marina will provide a focal point for the local community and a tourist destination. It is the Proponent's vision to provide the community with a gathering place from which locals and tourists will embark to explore the Cape and its surrounds. Memorial Drive, a local access road within the Proposal area that connects to Safety Bay Road will be realigned as part of the Proposal development. The road will be redesigned to meet current urban road standards and increased traffic volumes resulting from the Proposal.

Marina

The total water area of the single entrance marina is estimated to be up to 12 ha (Figure 7). The marina will be able to accommodate pens for up to 500 craft, ranging from 8 m to 25 m in length.

The marina will be constructed using wet excavation methods. Construction methods will include vinyl edge sheet piling, steel reinforcing and concrete anchors to provide support to canal walls and edges, which will provide structural integrity to allow for wet excavation.

Access channel

The Proposal includes a dredged access channel to allow large (up to 25 m) power and sail craft to access the marina. The channel will extend approximately 550 m north from the breakwaters at the entry of the marina, towards deeper waters in Cockburn Sound. The channel will be within Mangles Bay east of the Garden Island Causeway.

The channel will be dredged using a 'cutter suction dredge', with dredged material piped back to the mainland. The dredged material (spoil) will be placed in settlement and infiltration basins located within the Proposal area adjacent to the coast, where the seawater will infiltrate into the shallow groundwater system (which discharges to Mangles Bay) and solid material will be treated and disposed offsite, where necessary.

Key infrastructure

A Crown Reserve of the Water Corporation is located within the Proposal area (Figure 7). It is understood that the Water Corporation proposes to upgrade and duplicate the infrastructure within this reserve in the future. Through an agreement with Water Corporation, the Proponent proposes to realign the existing infrastructure within a service corridor along the southern Proposal boundary. The service corridor has been defined to accommodate the Sepia Depression Ocean Outlet Landline (SDOOL) and future Water Corporation service requirements including:

- realignment of the existing 1400 mm SDOOL 1
- realignment of the existing 2 x 450 mm Garden Island Wastewater Pressure Main
- realignment of the existing 450 mm Garden Island Water Reticulation
- duplication of the SDOOL, with the 1400 mm SDOOL 2
- future provision for the 1400 mm SDOOL 3
- future 1600 mm Brine Water Pipe.

The Water Corporation has indicated it seeks within the next 5 years to replace the existing SDOOL 1 and duplicate the service with the construction of SDOOL 2. SDOOL 3 and the Brine Water Pipe are provisional items for the Water Corporations strategic planning.

In consultation with the Water Corporation a conceptual design for the Service Corridor was developed indicating approximately 25 m of the 45 m width is required to accommodate existing and future infrastructure.

The realignment of the existing service infrastructure and the SDOOL duplication (SDOOL 2) requires approximately a 15 m width within the Service Corridor. A further 10 m width has been provided to accommodate the future infrastructure of the Water Corporation.

The requirement for SDOOL replacement and duplication is independent of the Proposal. The intersection between the two projects involves only the alignment of the infrastructure. Although the Water Corporation recognises that this Proposal will seek to realign the existing infrastructure, a separate proposal is also being progressed by Water Corporation to upgrade and duplicate the pipeline in the event where the Cedar Woods Proposal does not proceed. Only one of these proposals will be implemented.

An ocean outfall pipe carrying stormwater overflow from Lake Richmond to Mangles Bay (near the Mangles Bay Fishing Club jetty) is located within the Proposal area (Figure 2). The Proposal includes the relocation of this ocean outfall pipe to the end of Hymus Street with the pipeline infrastructure to be contained within the Safety Bay Road/Hymus Street road reserve.

The 45 m Service Corridor will also provide for a dual-lane road from Safety Bay Road to the Garden Island Causeway. The Department of Defence has forecasted traffic volumes that require that provision be made within the Service Corridor to accommodate a dual-lane road to Garden Island.

Area west of the Garden Island Causeway

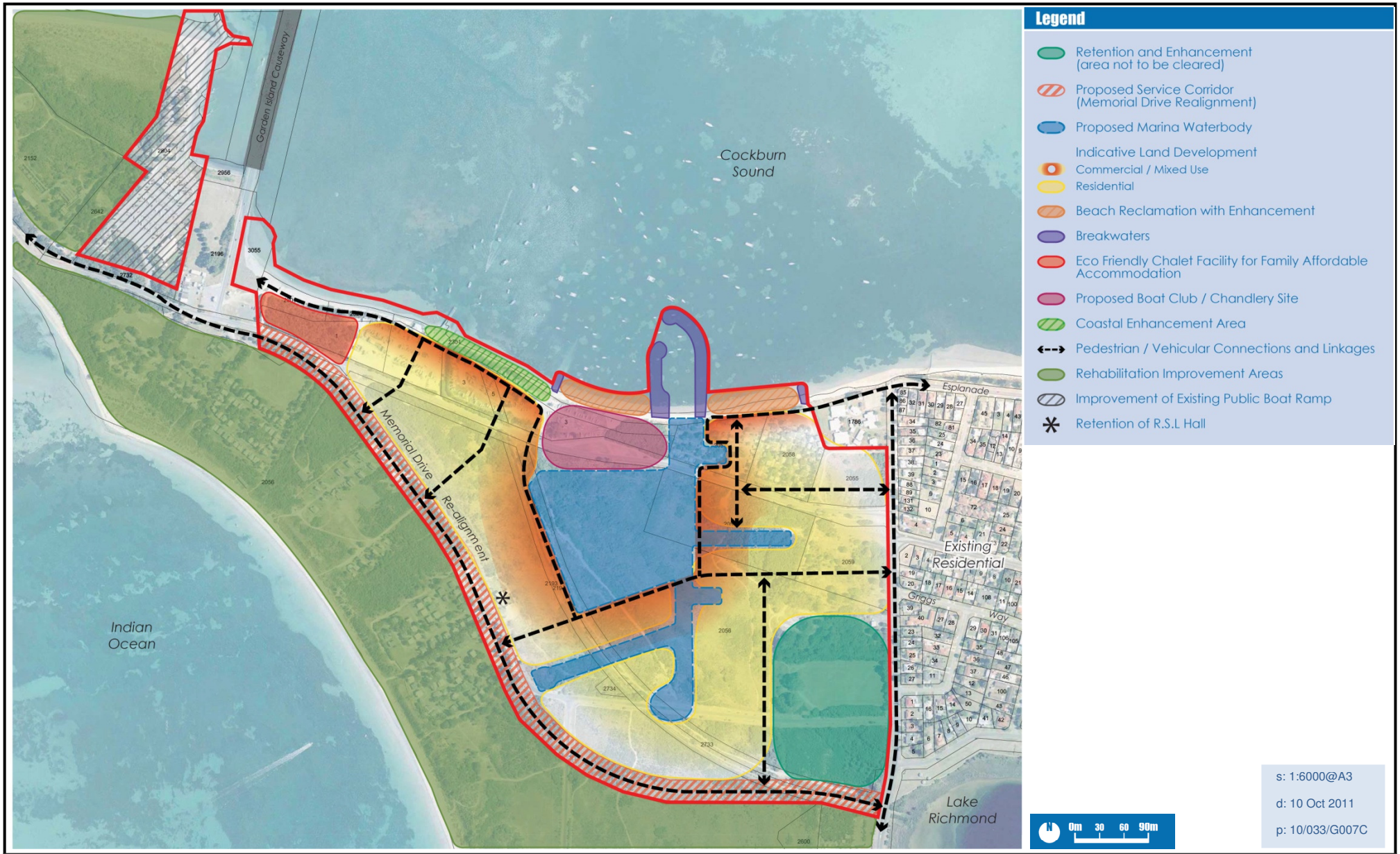
The Proposal boundary includes the existing car park and boat launching facility west of the Garden Island Causeway. Improvement works to the facility including an upgrade to the car park, boat ramp and jetty platforms will be considered as part of the Proposal. These improvement works will be limited to upgrading the amenity value of these facilities with works such as pile driving and dredging no longer proposed in this area.

Other elements of this Proposal

Other elements of this Proposal include:

- road improvements to cater for additional traffic
- improved beach access to the public
- remediation and enhancement works outside the proposed action including revegetation of degraded areas around Cape Peron, dune restoration, seagrass transplantation and improved walkways with educational signage with regard to the history and natural values of Cape Peron
- construction of a dual-use path along the length of the beachfront to the causeway
- affordable family holiday accommodation with beachfront access
- a site for the Boating Clubs, on a non-commercial leasehold basis, with marina frontage and beach access
- a seabed lease within the marina and adjoining the boating clubs site in which the clubs can build pens and lease them to members
- commercial pens to be provided in the public tourist area for commercial charter operators
- a tourism hub including restaurants, cafes and short-term serviced accommodation
- a site for a Marine Science Centre
- retention of the Returned and Services League (RSL) hall.

An indicative conceptual layout of the Proposal is outlined in Figure 6. This conceptual layout of the Proposal will be subject to the planning process should environmental approval of the Proposal be obtained.



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Mangles Bay Marina Based Tourist Precinct

Proposal conceptual layout (Source: TBB 2011)

FIGURE 6

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Oct-2011

3.1.3 Key Proposal characteristics

The key characteristics of the Proposal are included in Table 2.

Table 2 Key Proposal characteristics

Proposal detail	Characteristics
Main activities	Construction activities to include clearing, wet excavation of the marina and dredging of the access channel Operational activities include marina operation and maintenance dredging
Proposal area	Proposal area up to 77 ha Total land development area up to 49 ha Total vegetation clearing up to 40 ha Total marine disturbance (below current high water mark) to 6 ha
Marina	Total water area of marina up to 12 ha Deepest depth in marina up to -4.0 mAHD, shallowest -2.7 mAHD Excavation for marina up to 800 000 m^3
Channel construction	Total channel length up to 550 m Total channel navigable width up to 30 m (including batters the channel has a width of 55 m) Total channel area up to 3.4 ha (includes the footprint of 1:5 batters) Total channel depth up to -4.0 mAHD Total channel dredging of up to 50 000 m^3 of spoil Dredged spoil material will be piped to the Proposal area, where it will be settled, the water infiltrated and solid material treated and disposed of offsite
Reclamation	Total reclamation area up to 1.36 ha Total breakwater length up to 290 m Total breakwater width up to 40 m includes breakwater batters of 1:5 Total breakwater area up to 1.1 ha
Area west of Garden Island causeway	Improvement works potentially including an upgrade to the car park, boat ramp and jetty platforms
Seagrass loss	Total seagrass removal up to 5.36 ha (includes breakwaters, reclamation areas, channel and batters) Total indirect loss of seagrass up to 0.3 ha (due to halo effects around infrastructure of approximately 15 m) Total marine footprint up to 5.66 ha
Water Corporation asset (considered part of 'service corridor')	Length of pipeline up to 1.6 km Width of construction corridor up to 45 ha (includes batters and laydown areas) Pump station area to be cleared up to 0.2 ha
Department of Defence	Provision of a dual-lane road as part of the service corridor to accommodate traffic to Garden Island
Stormwater outfall	Relocation of Mangles Bay stormwater ocean outfall pipe to Hymus Street

Source:
Cadastral Data supplied by Landgate
Coordinate System: MGA94 Zone 50
Date: 10/1/2012
NB: Potential errors may occur in some areas

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Key characteristics of the Proposal

Figure No:
7

3.2 Exclusions from the Proposal

This Proposal only covers the environmental aspects of the proposed works and seeks approval for an environmental impact only. The Proponent will submit a separate application to the Western Australian Planning Commission (WAPC) and the City of Rockingham for regional and local scheme amendments.

3.3 Consideration of options/alternatives

The Proposals primary aim is to meet the high demand for boating facilities in the Rockingham area. Cockburn Sound is an important destination for boating, providing a large area of protected water for yachting and powerboat use. Rockingham is one of the fastest growing population centres in the southwest corridor. As a result, boat ownership and the demand for boating facilities are also rapidly increasing in the area.

Currently, boats unable to fit on trailers are confined to moorings in Mangles Bay, which provide little protection to vessels from winter storms that approach from the northwest. The existing swing moorings in Mangles Bay have also removed seagrass, resulting in mooring scars visible in Figure 2.

In 2005, a high level review of the costs, benefits and constraints of Mangles Bay and other potential sites along the City of Rockingham coastline was undertaken. The review concluded that Mangles Bay presented the least constraints and the most opportunities for a combined marina and land development, when compared with the other sections of the coastline in the City of Rockingham.

Alternative design concepts have been considered in consultation with the community during the 2005 and 2006 process and during the development of the current Proposal. All options involved an inland marina; however each differed with respect to layout and the extent of land footprint. An offshore marina option in Mangles Bay was considered unlikely to provide the project benefits of a mixed-use tourism precinct; would involve the loss of a substantial proportion of seagrass in Mangles Bay; and, would be unlikely to be found environmentally acceptable, even with rehabilitation of seagrass.

The details of the 2005/6 process and community and stakeholder involvement in developing the concept and project objectives are provided in Appendix 4 (as part of the SER).

The current Proposal being developed takes into account previous community and regulatory agency consultation and the EPA advice provided within Bulletin 1237 in October 2006. The configuration design of the marina and breakwaters has been thoroughly tested and scrutinised with detailed hydrogeological and hydrodynamic investigations and modelling undertaken for the development.

The development footprint has been reduced from the original design(s) presented in 1998 and 2006 to reduce the amount of native vegetation clearing; avoid disturbance to most of the TEC (Floristic Community Type [FCT] 30a: *Callitris preissii* forest and woodlands); to allow a greater buffer distance between the development and Lake Richmond; and, to reduce impacts on the SIMP.

3.4 Description of development process

Section 3.4.1 and Section 3.4.2 identify the types of infrastructure (marine and terrestrial) to be constructed as part of the Proposal. Once the project is established, the nominated structures (buildings, roads and fences) will be demolished and the nominated areas cleared as required for each stage of the development. Vegetative waste will be mulched and recycled for landscaping purposes on and offsite. Demolition and construction waste will be categorised, recycled where possible and transported offsite to landfill.

3.4.1 Marina and canal construction

Construction of the marina will be undertaken in stages over a seven to nine year period. The construction of the marina will be undertaken in wet conditions, such that no to very little dewatering required for the development of the inland marina. Construction methods will include vinyl edge sheet piling, steel reinforcing and concrete anchors to provide structural integrity to allow for wet excavation. Small amounts of localised dewatering will be required in wet excavation to allow concrete beams to form and cure.

The excavation of the inland marina will be undertaken, following the construction of canal edge walls. Long reach excavators will be used to gradually lower the earth material from between the vinyl sheet piled edges which would excavate down to the finished canal floor level. The material would be dry above groundwater level (approximately 0.0-0.5 mAHD) with all material excavated below this level to be wet.

The sand material excavated from below the water table will be placed in infiltration basins to allow for dissipation of the water. The material would then be double-handled and loaded onto trucks for either relocation on site, or exported to an appropriate facility offsite. In some instances where the required finished floor level of the marina cannot be achieved through long reach excavators, a dredge will be mobilised to complete final excavations in the wet, with no dewatering required to trim the base level of the marina and canal bodies.

The marina will be staged so that the canals in each stage are excavated as required. Consequently, temporary canal edge protection will be required along the existing batters which form the stage boundary. Filter fabric with rock material may be placed over temporary waterway edges, with a concrete revetment providing additional erosion protection if required, without the requirement for dewatering.

At the entrance of the marina between the rock breakwaters, excavation in wet conditions will proceed behind the existing beach, with an informal temporary bund resulting from the excavation. The marina body for Stage 1 will be excavated, separating the ocean from the internal water body until the 'bund' is removed as a final act of wet excavation on the completion of internal excavation for Stage 1.

Similarly, in future stages of the development, excavation may proceed behind stage boundaries, with a temporary edge protection forming a bund between stages, until the excavated water bodies are connected on removal of natural earth bunds.

The access channel will be constructed as part of the first stage of construction, along with a small section of the marina. Relocation of Water Corporation infrastructure will occur during Stage 1 and 2. Subsequent sections of the marina will be developed based on demand for land and boat pens. Marina construction may therefore be discontinuous, with periods of no construction occurring between marina construction stages. An indicative development schedule is outlined in Table 3 and Figure 8.

Table 3 Indicative development schedule of construction

Stage	Construction	Cumulative duration (months)
1	Wet excavation, sheet piling, temporary wall installation (shoreline, between Stage 1 and Stage 1.5 and between Stage 1 and Stage 2), and shoreline removal at end of Stage 1.	1 – 18
1.5	Wet excavation, sheet piling, temporary wall installation (between Stage 1 and Stage 4) and temporary wall (between Stage 1 and Stage 1.5), removal at end of Stage 1.5.	18 – 30
Break	No wet construction required.	31 – 37
2	Wet excavation, sheet piling and temporary wall removal (between Stage 1 and Stage 2) at end of Stage 2.	38 – 59
Break	No wet construction required.	60 – 66
3	No wet construction required.	67 – 79
Break	No wet construction required.	80 – 86
4	Wet excavation, sheet piling and temporary wall removal (between Stage 1 and Stage 4) at end of Stage 4.	68 – 101

In total, up to 800 000 cubic metres (m^3) of surplus material (which won't be used as fill on site) will be excavated during the construction of the marina and canals. The material will be good quality sand and will be recycled for use as fill at a number of project sites. This material will be transported offsite by road trucks in accordance with Traffic Management Plans to be submitted to, and approved by, the City of Rockingham.

3.4.2 Marina access channel construction

A boat entrance channel from Mangles Bay to the proposed inland marina and canals will be required to be in service coincidentally with the provision of mooring space in the marina. A dredging program is proposed for the access channel which will take place at the same time as the marina construction program.

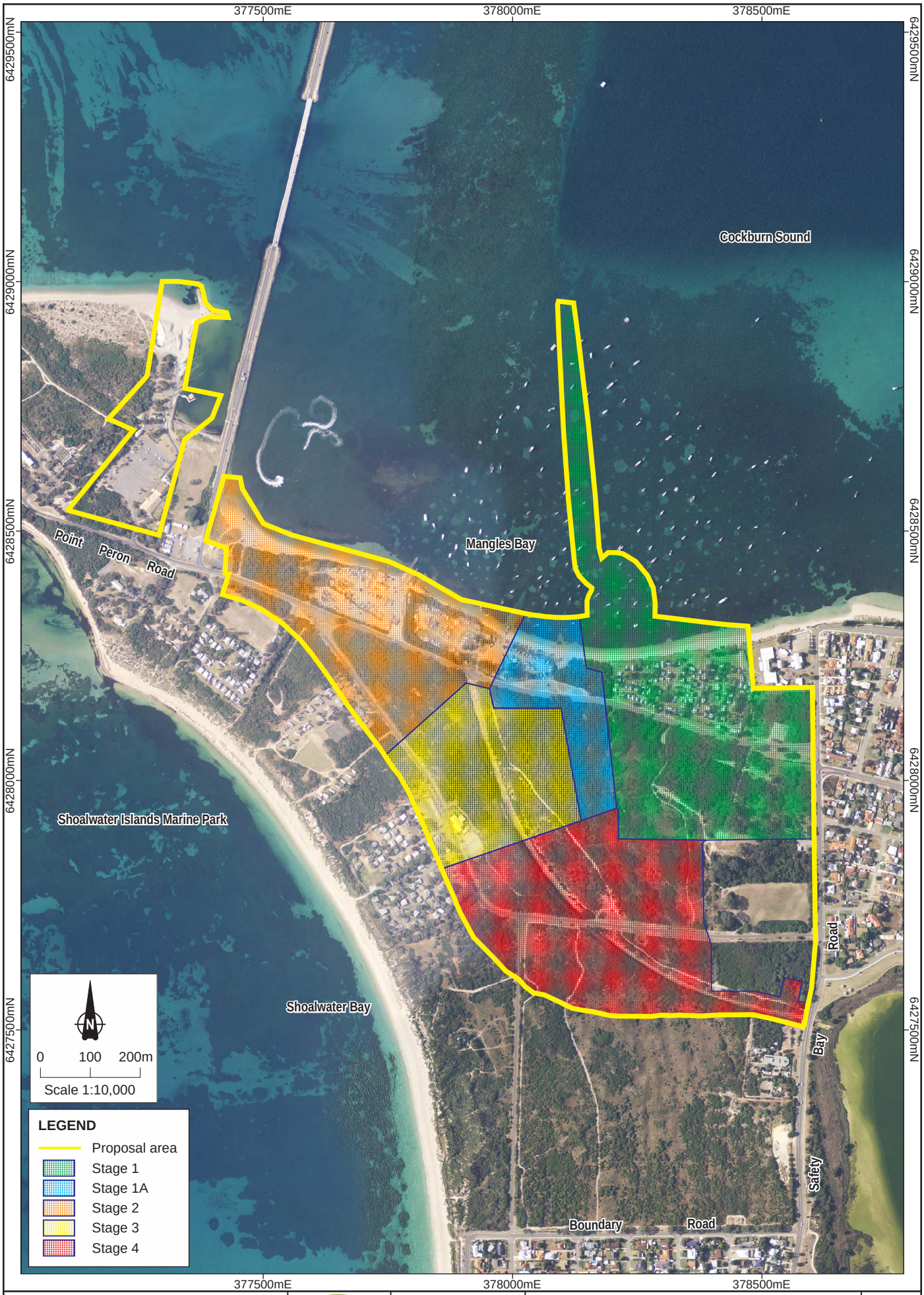
The channel will be 55 m wide (including batters), up to 550 m in length, up to -4.0 mAHD deep with stable batters in medium dense sand and will cover an area of up to 3.4 ha. Up to 50 000 m^3 of material will be dredged during the construction of the access channel. A small cutter suction dredge will be used which displaces the sand by cutter action whilst drawing it into the dredge pump before pumping the dredge slurry onshore via a pipeline. This method of dredging is commonplace in Western Australia, being used annually at a number of Marine Facilities.

At least two settlement basins will be constructed to receive the pumped dredge spoil to remove sediments from the excess water before it is released back to the environment. This will ensure that the turbidity of the sea water in the Mangles Bay area does not exceed set trigger levels due to the dredging program. The settlement basins will be located close to the coast to ensure maximum distance from Lake Richmond and nearby TECs; and this is shown in Figure 9. The solid spoil will be treated on site, and used as fill at other locations.

It is expected that the dredging works will be completed within a 12 – 15 week timeframe during the winter months of the bulk earthworks program.

3.4.3 Other infrastructure

Roads and service (electricity, water, sewerage, communication, gas) infrastructure will be constructed or installed during the marina construction period. Minor dewatering may be required for trenching to install some services.



Source:
Imagery supplied by Landgate (2010)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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Preliminary construction stages

Figure No:
8

Source: Imagery supplied by Landgate (2010)
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Date: 12/10/2011
NB: Potential errors may occur in some areas

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Indicative locations of settlement basins

Figure No: **9**

4. Stakeholder Consultation

This Proposal has built on the outcomes of formal advice and inputs from the community and specialised stakeholders. Much of this input was generated during the 2005 – 2006 consultation for the Cape Peron SER (Strategen 2006).

In the development of the current Proposal, the Proponent has undertaken consultation with a number of government agencies, including the EPA, and has also commenced discussions with local fishing and boating clubs.

The following section summarises the consultation and outcomes to date, including consultation undertaken as part of the 2006 SER, due to its relevance to the current Proposal.

4.1 Stakeholder engagement process

4.1.1 Previous consultation

The consultation process for the development of a concept plan for a marina-based tourist precinct in 2005 and 2006 focussed on an active community engagement approach to developing concept options. A high level of interest was shown in the concept plan with more than 800 community members from a broad range of stakeholder groups participating in the process. The consultation process included public forums, establishment of a Stakeholder Reference Group (SRG), public advertising, project website, information hotline and various individual stakeholder meetings including Aboriginal representatives.

The outcomes of the stakeholder consultation process are summarised in the SER (Strategen 2006) (Appendix 4) and the Response to Submissions included as an appendix of Bulletin 1237.

Key agencies, non-government organisations and other stakeholder groups consulted at that time included:

- Royal Australian Navy and Corporate Support Infrastructure Group
- Environmental Protection Authority Services Unit
- Department of Environment
- Department of Conservation and Land Management
- Cockburn Sound Management Council (CSMC)
- Department for Planning and Infrastructure and the WA Planning Commission
- Public Transport Authority
- Main Roads WA
- Water Corporation
- City of Rockingham
- Naragebup Rockingham Regional Environment Centre
- Recreation camp leasees (e.g. Returned and Services League, Apex)
- Mangles Bay foreshore user groups (e.g. Mangles Bay Fishing Club)
- Aboriginal groups
- Local residents and interest groups
- Local business operators
- Local sport and recreation groups
- Boat owners and mooring owners
- Recreational beach users.

As described in Section 4.1.1, the Proponent has used the outcomes of the previous consultation to identify and help identify the relevant environmental factors for assessment in the PER.

4.1.2 Recent consultation

In September 2009, Premier Colin Barnett announced that the State Government would progress the marina project at Mangles Bay and commence the environmental impact assessment process. Once Cedar Woods was appointed as the Proponent for the Proposal, consultation commenced with the City of Rockingham and key government agencies including the Office of the Environmental Protection Authority (OEPA) and the Department of Planning. The Proponent also established a Marina Working Group and a SRG to provide ongoing input into the project plan.

In July 2010 the Mangles Bay Information Line was established to provide the public with an opportunity to ask questions and be informed about the development. In conjunction to the phone line, the Proposals objectives, deliverables and key documents were provided on the Cedar Woods website.

Furthermore local press advertorials and media statements have been used to communicate information and encourage further enquires to the dedicated information line.

A summary of the key stakeholder consultation undertaken to date for this is included in Table 4.

Table 4 Summary of key stakeholder consultation undertaken for this Proposal to date

Stakeholder	Outcome of consultation
City of Rockingham	Preliminary comments regarding marina design. Advice provided to the strategy for obtaining planning approval.
Department of Planning	MRS amendment to be initiated subsequent to the s.38 environmental approval process.
Department of Sports and Recreation	Inclusion of passive recreation opportunities within the development, consultation with existing lessees.
Department of Transport	Preliminary comments regarding marina design and suggestions for marina management.
Office of the EPA	Confirmation of the assessment process for the proposal.
Mangles Bay Fishing Club	Inclusion of the club's comments regarding marina planning and club site facility.
Rockingham Offshore Fishing Club	Inclusion of the club's comments regarding marina planning and club site facility.
The Cruising Yacht Club of WA	Inclusion of the club's comments regarding marina planning and club site facility.
Blue Lagoon Mussels	Inclusion of the club's comments regarding marina planning and club site facility.
Rockingham Volunteer Sea Rescue Group	Inclusion of the club's comments regarding marina planning and club site facility.
Retired Service League Rockingham	Realignment of Memorial Drive to retain the RSL Hall.
Cockburn Sound Management Council	Preliminary comments on Proposal and advice on marine water quality within Cockburn Sound.
Department of Water	Inclusion of comments to evaluate the environmental impact to the environmental values within, and adjacent to, the Proposal area.
Conservation Commission of Western Australia	Confirmation of the Proposal area and environmental assessment process.
Department of Sustainability, Environment, Water, Population and Communities	Inclusion of comments into addressing Matters of NES within the environmental assessment of the Proposal.
Department of Defence	Provision for a dual-lane road within the service corridor to accommodate future traffic movement to HMAS Stirling.
Water Corporation	Provision within the service corridor to accommodate current and future infrastructure requirements.

4.2 Stakeholder comments and proponent responses

The Cedar Woods stakeholder engagement program for this Proposal commenced in April 2010 and will continue throughout the Local Structure Planning process. Key stakeholders were identified through previous consultation programs undertaken during the many iterations of this Proposal. Government agencies have also provided recommendations on stakeholders that should be included within the program, with these recommendations adopted by Cedar Woods.

The program included three SRG meetings (including boating users, adjacent leaseholders and community groups) to provide input to prepare the marina design.

The consultation activities undertaken to date and the issues raised are summarised in Table 5.

Table 5 Summary of consultation undertaken to date and key topics raised regarding Proposal

Date	Stakeholder	Purpose	Topics Raised	Proponent Response
21 November 2010	Rockingham Fair patrons	To better inform the public of the Proposal.	• environmental impacts • consolidation of boating clubs • public boat ramp west of the Garden Causeway • traffic management • project partnering.	Environmental approvals to be undertaken in accordance with the statutory environmental assessment process. The public will have an opportunity to make a submission during the advertising of the Proponent's environmental impact assessment report. Proposal to upgrade the public car park facility and boat ramp West of the Garden Island Causeway. Proposal to provide a 3.5 ha site to the consolidated boating club with marina and ocean access. The Proposal is in partnership with LandCorp, the State's land development agency.
26 October 2010 24 November 2010	Stakeholder Reference Group	To provide design input to the master plan for the development.	• public access • potential impacts to SIMP • environmental Impacts to Lake Richmond, seagrass and vegetation • traffic impacts to HMAS Stirling • land uses and density of the Proposal • consolidation of boating clubs • impacts to existing leaseholders along Mangles Bay • realignment of the existing Water Corporation infrastructure • land use types within the Proposal area.	Provide a plan with improved public access to the Mangles Bay foreshore. Provide a pedestrian path along the length of the marina edge with connections to Mangles Bay. Environmental impacts to be assessed through the PER process, being assessed by the EPA. Proposal to undertake a traffic assessment to determine the service requirements for the Water Corporation and Department of Defence. Proposal to provide a 3.5ha site to the consolidated boating club with marina and ocean access. A family-affordable chalet facility to be provided along Mangles Bay. Land use types to be refined through the planning process.
9 December 2010 4 March 2011 25 March 2011 9 June 2011	Water Corporation	To determine an appropriate alignment and service corridor width to accommodate the existing and future infrastructure.	• existing infrastructure • future infrastructure provisions • environmental approval for the realigned service corridor.	A service corridor has been designed along the southern Proposal boundary to realign the existing, and to make provision for, the future Water Corporation infrastructure.
11 April 2011	Conservation Commission	To present the proposals and the environmental studies being undertaken to assess the environmental impact.	• reduce the number of swing moorings within Mangles Bay • impact to fauna • environmental offsets for development within RLRP and Bush Forever Site.	The Proposal seeks to reduce the number of swing moorings by providing boats with a safe protected anchorage. Fauna impacts from the development will be assessed in both local and regional context. An offset package has been prepared for consideration and comment from DEC.

Date	Stakeholder	Purpose	Topics Raised	Proponent Response
11 October 2010 19 October 2010 11 June 2011	Department of Environment and Conservation, Cockburn Sound Management Council	To inform DEC and representatives of CSMC of the Proposal and seek comments to the proposed environmental studies to be undertaken.	• require an understating of the environmental impacts of the Proposal • environmental offsets considered by the Proponent for the Proposal • environmental studies to be undertaken.	Additional environmental studies to be included within the ESD. Environmental impacts to be assessed within PER.
1 December 2010 28 January 2011 23 May 2011	Department of Environment and Conservation – Regional Parks	To familiarise DEC with the Proposal, the likely impacts to Bush Forever and RLRP.	• require an understating of the environmental impacts of the Proposal • environmental offsets considered by the Proponent for the Proposal.	Environmental offsets will be considered for the Proposal, with consultation with the relevant government agencies. Environmental aspects and mitigation strategies will be presented within the PER document. Relevant WAPC, DEC and EPA guidelines and statements will be considered and addressed when presenting the offsets package.
10 February 2011	Department of Water	To inform DoW of the proposal and seek comments prior to the commencement of the groundwater modelling.	• peer reviewer to be appointed for the conceptual and numerical modelling • climate change factors to be included within groundwater modelling • assessments required determining the impacts from dewatering during and post construction • monitoring data timeframes and parameters.	The conceptual and numerical groundwater model will be formulated in consultation with a peer reviewer. Environmental impacts to be assessed from the results on the modelling.
9 July 2010 1 October 2010 15 November 2010 2 December 2010 17 March 2011	City of Rockingham	To inform on the planning of the current marina footprint plan included within the ESD.	• environmental opportunities and constraints for the planning for the marina footprint design • the retention versus realignment of existing Water Corporation services • marina management following construction.	Structure planning will commence following the lodgement of the PER. The retention of the Water Corporation infrastructure on marina footprint plan will be unsuccessful in activating the marina edge. The management of the marina will be determined as part of the Project business case for funding.
14 October 2010 26 May 2011	Environmental Protection Authority	To inform EPA for finalising the ESD.	• need for consultation with the Water Corporation on the realignment of the existing services • Public Environmental Review (PER) to assess cumulative impacts between the Proposal and the Water Corporation SDOOL project • reduce the number of swing moorings within Mangles Bay.	The existing Proposal is a reduced environmental footprint from the 2006 concepts which were assessed under a SER. Environmental studies are being undertaken in accordance with the ESD. The PER will provide an assessment of the environmental impacts and how they are to be managed.
2 August 2010 9 November 2010 14 April 2011	Department of Transport	To inform the Department of Transport of the Proposal and marina design.	• marina design and boat capacity • management of the marina • swing moorings within Mangles Bay.	The marina is to accommodate up to 500 boats. Management of the marina to be determined during the planning. Swing moorings to be reduced on Proposal approval.

Date	Stakeholder	Purpose	Topics Raised	Proponent Response
27 October 2010	Department of Sustainability, Environment, Water, Populations and Communities	To familiarise the Department of SEWPaC with the existing environment, studies and management of the environmental disturbances.	• beneficial outcomes to the environment are to be considered for the Proposal • Proponent will need to demonstrate that no impacts will occur on listed marine species • offsets will need to be considered where relevant and developed in conjunction with the relevant government agencies • Proponent will need to demonstrate that there will be no hydrogeological interaction (no threat) between the marina and the Beecher Point Wetlands • Proponent will need to demonstrate the potential effects of the Proposal to thrombolites at Lake Richmond.	Environmental offsets will be considered within the Proposal with consultation with the relevant government agencies. Environmental aspects and mitigation strategies of the identified environmental impacts to the environment will be presented within the PER document.
15 February 2011	South West Aboriginal Land Council (SWALC)	To inform and determine a representative for the Aboriginal heritage consultations.	• compensation • reflecting Aboriginal values within the area.	Native Title is extinguished with no requirement to provide compensation. Consultation is being undertaken to determine the significance of the heritage values and what can be undertaken for the development to occur.
20 April 2011 21 April 2011 10 May 2011	Aboriginal Heritage consultations	To consult with Indigenous groups on the Proposal comprising representatives from the SWALC and site informants from Department of Indigenous Affairs. To formalise recommendations for inclusion into the ethnographic report.	• the site contains three Aboriginal heritage sites • the former Sister Kate's site on the South of Memorial drive and outside of the Proposal area is considered to be significant • the majority of the Indigenous groups supported the proposal subject to the recommendations being implemented.	The Proponent commits to adhere to the recommendations of the ethnographic report.
8 December 2010 21 September 2011	Technical Working Group (Office of EPA, City of Rockingham, Department of Transport, LandCorp, Cedar Woods, Cockburn Sound Management Council)	To inform the technical working group of the project objectives and commitments. Identify issues within environment, planning, engineering, management.	• project program. • environmental approval process • marina management • realignment of the Water Corporation infrastructure.	The project program has assumed timeframes contained within the draft Environmental Impact Assessment Guidelines. The Proposal will be assessed by the EPA as a PER. Management of the marina to be determined through the planning process. The realigned service corridor is required to accommodate the Water Corporation Infrastructure and a dual-lane road.

Date	Stakeholder	Purpose	Topics Raised	Proponent Response
16th August 2010 4th October 2010 30th November 2010 14th December 2010	Marina Working Group (Rockingham Sea Search and Rescue, Mangles Bay Fishing Club, The Cruising Yacht Club)	To provide input the consolidated club site facility.	• Site area and design for club facility. • Tenure. • Consolidation of the clubs. • Commercial viability.	Business case to be prepared to determine the operating viability of the consolidated club. Club site and improvements to be provided in accordance with the Proposal objectives.

4.3 Ongoing consultation

The Proponent is commencing a broader stakeholder engagement process with a SRG formed to include local user groups, community groups and adjacent leaseholders.

Following the ongoing consultation completed to date, it is important to continue this discourse with key stakeholders throughout, and beyond, the environmental approval process.

Ongoing communication and consultation with relevant Local, State and Federal Government representatives, business and industry leaders, local community groups, and existing Cape Peron users and tenants will continue in order to provide critical information to feed into the refinement of the Structure Plan and to identify communication issues that will need to be addressed during the process.

5. Framework for environmental impact assessment of Proposal

5.1 Identification of key factors and their significance

The key environmental factors were identified through the scoping process and an ESD was prepared in accordance with the Environmental Impact Assessment (Part IV Division I) Administrative Procedures 2010. The scoping process included:

- review of the outcomes of EPA Bulletin 1237 that was issued by the EPA in response to the s16(e) strategic environmental review process undertaken in 2005 and 2006
- stakeholder consultation for the SER and scoping process
- results of environmental investigations
- ESD assessment and approval by the EPA.

This process identified the key environmental factors listed in Section 5.2. These factors are addressed in detail in this PER in accordance with the requirements of the ESD.

The results of the stakeholder consultation process and EPA advice have provided a sound basis for the identification of the key environmental issues associated with this Proposal. Key environmental issues are considered to be: and are considered to be:

- loss of seagrass in Mangles Bay
- potential changes to water quality in Mangles Bay
- potential for indirect impacts on Lake Richmond from hydrological changes or increased use
- clearing of vegetation and fauna habitat within the predominantly cleared Metropolitan area
- the excision of the Proposal area from the RLRP and the Bush Forever Site 355
- continued and enhanced public access to Mangles Bay and Cape Peron.

5.2 Relevant factors

The environmental factors considered likely to be impacted by the Proposal are:

1. Terrestrial environment:
   - groundwater
   - surface water
   - flora and vegetation
   - terrestrial fauna
   - conservation areas (included in terrestrial vegetation and flora chapter for the purposes of scoping).
2. Marine environment:
   - water quality
   - coastal processes
   - benthic primary producer habitat (BPPH)
   - marine fauna.
3. Matters of National Environmental Significance.
4. Social surrounds:
   - recreation and public access
   - Aboriginal and European heritage.

5. Other Environmental Factors:
   - traffic
   - contaminated sites and acid sulfate soils (ASS)
   - construction impacts of dust, noise and waste.

5.3 Consistency with environmental principles

The Proposal has been developed with consideration of the principles of environmental protection (EPA 2004a). A summary of how the environmental principles have been incorporated into the Proposal is included in Table 6.

Table 6 Principles of environmental protection, as they apply to the Proposal

Principle	Applicability to this Proposal
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.	The Proposal is the culmination of a series of development options for a marina at Mangles Bay. The Proposal has been designed to avoid, as far as practicable, harm to the area's recognised environmental values, including Lake Richmond and Cockburn Sound/Mangles Bay. The potential effects to the environment have been studied rigorously, in order to ensure predictions of environmental outcomes are reliable. Mitigation measures have been developed from extensive consultation and review and will be finalised through the environmental impact assessment process.
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.	The Proposal will improve the social amenity of the area by addressing an increasing need for safe boat anchorage and improving recreation assets. The Proposal will derive long-term environmental improvements to the area through mitigation measures, including the facility to relocate open moorings to the marina, rehabilitation of seagrass and terrestrial vegetation, while improving knowledge of the area's environment. The provision of facilities for passive recreation will ensure that the environment is protected from increased pressure from both the development and surrounding areas.
3. The principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	The Proposal has been designed to maximise the separation distance to Lake Richmond. The Proposal will also minimise impacts to seagrass and terrestrial vegetation in the short-term while seeking to enhance conservation in the long-term. The Proposal involves loss of vegetation but the rehabilitation of the remainder of vegetation on Cape Peron is expected to enhance ecological integrity of this area. Additionally, the potential to offset the loss of conservation estate by a financial contribution toward land to be purchased is being considered in consultation with DEC.

Principle	Applicability to this Proposal
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 maximise benefits and/or minimise costs to develop their own solution and responses to environmental problems.	Cost estimates of potential offsets have been incorporated into the cost estimates for the Proposal. Contribution will be made for management of adjacent environmental values in anticipation of increased utilisation and pressure on the area. The management of the marina, including water quality monitoring, marina regulation and maintenance of POS, will be funded by the development.
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.	Owing to its nature, the Proposal is expected to generate a minimal amount of waste. Any wastes will be managed consistent with the waste hierarchy.

5.4 Consistency with expectations of EPA for environmental impact assessment

Table 7 sets out the EPA expectations for environmental impact assessment of proposals, with a summary of how these matters are considered in this environmental impact assessment, together with a cross reference to the relevant sections.

Table 7 Statement of expectation for environmental impact assessment

Expectations	Consideration Given in Proposal	Relevant Sections in Document
a) Proponents will use best practicable measures and genuine evaluation of options or alternatives in siting, planning and designing their proposals to avoid, and where this is not possible, to minimise impacts on the environment.	Options and alternatives have been evaluated for each proposed marina design.	Section 3.3
b) The onus is with the proponents to describe the environmental impacts of their proposals, and to use their best endeavours to demonstrate that the unavoidable impacts are environmentally acceptable, taking into account cumulative impacts in the region.	Environmental impacts have been described for each factor under the relevant section. Instances of unavoidable impact have been studied and demonstrated to be environmentally acceptable. Cumulative impacts have been addressed for each factor.	Section 6, 6.1, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21
c) Proponents will use best practicable measures and mitigation to manage adverse environmental impacts.	Best practicable measures and mitigation have been evaluated for each factor under the relevant section. Mitigation measures for each factor outline how potential impacts will be mitigated through consideration of the EPA mitigation sequence: avoid, minimise, reduce, rectify and offset.	Section 6, 6.1, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21.

Expectations	Consideration Given in Proposal	Relevant Sections in Document
d) Proposals will meet relevant environmental objectives and standards.	The Proposal has been assessed against relevant environmental objectives and standards, and this assessment has been described in each factor section.	Section 6, 6.1, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21
e) In all EIA, there will be opportunities for effective stakeholder consultation, including engagement with the local community during the assessment of the proposal. Proponents should adequately engage in consultation with stakeholders who may be interested in, or affected by their proposals, early in the EIA process.	Stakeholder consultation has been undertaken and is described in the relevant section.	Section 4
f) Assessment will be based on sound science and documented information. It is essential that proponents allow adequate time and resources to carry out the necessary surveys and investigations as part of the EIA.	This PER has been written based on the results of extensive assessment of hydrology, vegetation, flora, fauna, contamination potential, marine environment, coastal processes, BPPH, heritage, and public access within the Proposal area and surrounds. Relevant documentation is included in appendices and the reference list.	Appendix 5 and References (Section 23)
g) Proponents will identify management measures for all key environmental factors during the assessment, to demonstrate whether the proposal can be implemented to meet the EPA's environmental objectives.	Environmental measures and controls have been described throughout the PER. An associated CEMP including management of: groundwater, surface water, dredge spoil, terrestrial biodiversity and habitat, marine biodiversity and habitat, GSM, dust, noise and vibration, fire, heritage, hydrocarbons, waste, contaminated sites and ASS, public access, rehabilitation, community issues, visual amenity, and road traffic has been included as an appendix to the PER.	Section 22, Appendix 1
h) In all EIA, performance standards will be established, communicated and agreed at the beginning of the EIA process, and these will be monitored, reviewed and reported against.	Performance standards are included as part of the management plan for the Proposal.	Appendix 1
i) Proponents will implement continuous improvement in environmental performance and will apply best practicable measures for environmental management in implementing their proposals.	Best practicable measures for environmental management will be implemented through the Proposal. Objectives, standards, actions, monitoring and contingencies to achieve successful management are included in the CEMP. The Proponent is also supporting research into seagrass rehabilitation and GSM conservation.	Section22, Appendix 1

6. Groundwater impact assessment

6.1 Relevant environmental objectives, policies, guidelines, standards and procedures

6.1.1 EPA objectives

The EPA applies the following objectives in assessing proposals that may affect groundwater:

To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected.

To ensure that emissions do not adversely affect environmental values or the health, welfare or amenity of people and land uses by meeting statutory requirements and acceptable standards.

6.1.2 Legislation, policy and guidance

National legislation and policy

Water quality guidelines for the protection of marine and freshwater ecosystems have been released under the auspices of the National Water Quality Management Strategy (ANZECC/ARMCANZ 2000). The guidelines provide a comprehensive list of recommended low-risk trigger values for physical and chemical stressors in water bodies, and are applied to five geographical regions across Australia and New Zealand. The National Water Quality Management Strategy is supported by the Guidelines for Groundwater Protection in Australia (ANZECC/ARMCANZ 1995), which outlines a framework for protecting groundwater in Australia. The Guidelines require the identification of beneficial uses for groundwater in aquifers, and a policy to manage these issues.

A series of guidelines on national water quality management has also been released by the Natural Resource Management Ministerial Council (NRMMC) and, in some cases, in collaboration with the National Health and Medical Research Council (NHMRC) and the Australian Health Ministers Conference. These guidelines address a range of issues including policies and processes for water quality management, water quality benchmarks, groundwater management, diffuse and point sources, guidelines for sewerage systems, effluent management and water recycling.

State legislation

The *Rights in Water and Irrigation Act 1914* (RiWI Act) makes provision for the regulation, management, use and protection of water resources, to provide for irrigation schemes, and for related purposes. The Proposal area is located within the RiWI Act proclaimed Rockingham Groundwater area, Warnbro Groundwater subarea.

Licences issued by the DoW under the RiWI Act are required for works associated with groundwater abstraction (including for dewatering purposes, if the volume exceeds the maximum volume and duration criteria) within the Rockingham Groundwater Area. Groundwater licences specify the maximum abstraction rate from aquifers and includes conditions for monitoring. Groundwater licenses may require the submission of supporting documentation outlining the local hydrogeology, operating strategies and management and water conservation measures in line with the DoW's Operational Policies.

Stormwater management, surface water discharges and potentially polluting activities are managed under an environmental licence issued under Part V of the EP Act. These activities are addressed in Section 7.

State Policy and water resources strategies

Rockingham – Stakehill Groundwater Management Plan

The Rockingham – Stakehill Groundwater Management Plan (DoW 2008) guides groundwater licence assessments and allocations within the Rockingham and Stakehill groundwater areas. The plan provides the objectives, policies, principles and strategies used to manage the groundwater resources of the plan area with the long-term objective to achieve sustainable use of the groundwater resources within the groundwater areas. Groundwater abstraction licences submitted to the DoW will be assessed in accordance with the groundwater objectives set in this plan.

State Water Strategy

The Government of Western Australia developed the State Water Strategy in 2003 with the objective of achieving a sustainable water future for all Western Australians by:

- improving water use efficiency in all sectors
- achieving significant advances in water reuse
- fostering innovation and research
- planning and development of a new source of water in a timely manner
- protecting the value of our water resources (Government of Western Australia 2003).

Stormwater Management Manual

The Stormwater Management Manual was developed by the Government of Western Australia to provide a consistent approach to stormwater management, while considering a variety of stormwater management options to be considered by land developments across Western Australia. The manual provides case studies and planning approaches for the consideration of stormwater management at the early planning stages of a land development, with an emphasis on source controls, regulation and education.

The Stormwater Management Manual provides the minimum best management practice to be applied for the management of stormwater to land developments. The manual focuses on the need to integrate a range of stormwater management measures, including urban design principles to be considered within the framework of 'Water Sensitive Urban Design' that maximise local retention, reuse of stormwater and management of 'non-point source' pollutants.

State Water Quality Management Strategy

The Government of Western Australia developed the State Water Quality Management Strategy in 2001 (Waters and Rivers Commission 2001) with the objective 'to achieve sustainable use of the Nation's water resources by protecting and enhancing their quality while maintaining economic and social development'.

The State Water Quality Management Strategy requires that a Water Conservation Plan be developed before a water allocation licence is issued or renewed. A water allocation license would be required for the Proposal if broad-scale dewatering is to occur or if groundwater is to be allocated for irrigation of POS. The Water Conservation Plan must outline water efficiency objectives and timeframes. Licence conditions require implementation of the Water Conservation Plan to an agreed schedule. This Water Conservation Plan is usually included within an 'Operating Strategy' which is prepared to support a water allocation application.

Operational policies

The DoW has prepared a range of 'operational policies' to assist proponents in the application of licences to take water and the associated reporting and management requirements associated with a water licence.

Two relevant operational policies, *Operational Policy 5.12 – Hydrogeological reporting associated with a groundwater well licence* and *Operational Policy 1.02 Water conservation/efficiency plans*, may be applicable to this Proposal.

Operational Policy 5.12 provides guidance to proponents on the hydrogeological assessment and groundwater monitoring reports required and the information they should contain when applying for a water licence. This information would form part of the water licence assessment that would be undertaken by the DoW prior to applying for a license to install a groundwater well for POS irrigation or dewatering.

Operational Policy 1.02 provides guidance on the preparation of conservation/efficiency plans to ensure the efficient use of a proponent's water entitlement. A water conservation/efficiency plan may be part of the hydrogeological assessment and groundwater monitoring report submitted as part of water licence application or a standalone document, which details the water conservation/efficiency measures considered and those to be implemented as part of the water entitlement.

The preparation of either or both of these reporting requirements, are listed as a licence condition, to ensure their implementation for the duration of the licence.

6.2 Findings of surveys and investigations

6.2.1 Existing groundwater use and values

The Guidelines for Protection of Groundwater Quality in Australia (ANZECC/ARMCANZ 1995) provide a framework to protect beneficial uses and values of groundwater throughout Australia. The key beneficial use of groundwater in the Proposal area is for the irrigation of POS and gardens. The key environmental values of groundwater in the area are:

- maintaining groundwater levels in Lake Richmond over the summer months, as discussed in Section 6.2.4
- providing a water source for vegetation, including the TECs FCT 30a *Callitris preissii* (or *Melaleuca lanceolata*) forest and woodlands and FCT 19 (Sedgelands in Holocene dune swales), as described in Section 8.2.1.

Groundwater in the area is used for irrigation of POS and gardens. Domestic bores for properties less than 2000 m^2 in area are not required to be licensed. As these bores are unlicensed, it is not possible to accurately determine the numbers in the area. Groundwater within the Rockingham area is mainly used for irrigation water for POS and recreational areas (DoW 2008). The Rockingham area has the greatest percentage of domestic garden bores in the Perth Metropolitan area (DoW 2008). A 1995 bore-ownership survey of 16 133 households indicated that 76% of properties in the Rockingham area had garden bores, compared with the average of 36% in the Perth region (DoW 2008).

Garden bores in the area are expected to be comparatively shallow, and would be expected to abstract water from the Safety Bay Sands. Groundwater in the Tamala Limestone in the area is mostly saline and is therefore unsuitable for beneficial uses such as irrigation and drinking water. Based on DoW guidance, groundwater with less than 1 000 mg/L total dissolved salts (TDS) is considered suitable for irrigation, with 1 000 to 2 000 mg/L being suitable for 'irrigation with caution' (Mayer *et al*. 2005).

Licenses are required for non-domestic bores that irrigate POS or private land. The DoW's WIN database includes 42 licenses within a 2 km radius of the Proposal area (ERM 2011). Licensees include the City of Rockingham (including a license for irrigation of Rotary Park approximately 300 m east of the proposal boundary), Rockingham Beach Primary School and various community groups in the Cape Peron area. Non-domestic bores that may be potentially impacted by the proposal are shown in Figure 10.

6.2.2 Regional geology and hydrogeology

The regional geology of the proposal area consists of layers of regolith deposited during the Late Tertiary and into the Quaternary. The superficial lithology in the Proposal area consists of two main superficial

geological units (1) the Safety Bay Sand; and (2) the Tamala Limestone. The Safety Bay Sand unconformably overlies the Tamala Limestone, which then overlies the Rockingham Sands.

The Safety Bay Sand consists primarily of shell fragments and variable amounts of white calcareous fine to medium-grained quartz sand with traces of fine-grained black, heavy minerals (Davidson 1995). The depth of Safety Bay Sand found in the investigation area was between 20 and 24 m, extending to approximately -20 mAHD (ERM 2011, Appendix 5). The hydraulic conductivity (K) of the Safety Bay Sands is relatively high, with estimates ranging between 5 and 174 m/day (MWH 2011b). A thin layer of clay (0.5 to 2 m thick) lies at the base of the Safety Bay Sands in the Proposal area and acts as an aquiclude, effectively limiting water movement between the Safety Bay Sands and the Tamala Limestone (ERM 2011). At Cape Peron, the Tamala Limestone is exposed above the water table.

The Tamala Limestone unconformably overlies the Rockingham Sand formation and has been described as a creamy-white to yellow or light grey limestone (Playford *et al.* 1976). The Tamala Limestone consists largely of coarse to medium grained shell fragments and variable amounts of fine to coarse-grained quartz and minor clayey lenses (Davidson 1995).

The limestone exhibits areas of secondary porosity due to cavities, channels and in some locations, karst structures. The Tamala Limestone extends to approximately -23 mAHD in the Proposal area (ERM 2011). The hydraulic conductivity (K) of the Tamala Limestone is very high because of its' porous nature, with estimates ranging between 100 and 3 000 m/day (MWH 2011b).

Groundwater flow in the superficial aquifer in the Rockingham area is generally in a westerly direction, towards the Indian Ocean with summer groundwater levels varying between 3 m AHD at Ennis Avenue to approximately 0 m AHD at the coast (Department of Environment 2004). The coastal strip of the superficial aquifer is generally characterised by relatively flat hydraulic gradients (1 in 1000 to 1 in 2000), due mainly to the hydraulic effects of the porous nature of the Tamala Limestone (Worley Parsons 2005).

6.2.3 Groundwater investigations

A groundwater investigation program was undertaken between March 2010 and August 2011 to support the development of the PER and groundwater modelling. Monitoring will continue until October 2011. The investigations were undertaken by MWH and included:

- drilling and construction of 16 monitoring bores at 14 locations throughout the Proposal area and geological logging, with one barometric datalogger to allow water level readings to be corrected for barometric pressure
- twelve months' collection of real time water level data in six bores using data loggers
- monthly water level and surveying of salinity to determine the presence and depth of any changes in salinity associated with saltwater wedges
- monthly collection of water samples from all bores for chemical analysis for general water chemistry, nutrients and heavy metals including:
  - general water chemistry (total dissolved solids [TDS], pH, electrical conductivity [EC[1]] cations, anions, Ca, Cl, Na, K, Mg, Fe, sulphate, nitrate, carbonate/bicarbonate)
  - eight standard metals (As, Cd, Cu, Cr, Hg, Pb, Ni and Zn)
  - nutrients (total nitrogen [TN], total kjeldahl nitrogen [TKN], nitrate, nitrite, TP and phosphate)
  - redox potential (E_h) (post February 2011)
  - monthly downhole monitoring of EC, pH, dissolved oxygen (DO) and temperature surveys at 1 m depth intervals.

The majority of bores were installed in March 2010 to between 8 and 30 m depth. The shallower bores, MB02, MB04, MB06, MB08, MB09S[2], MB13 and MB14S were installed within the Safety Bay Sands. The

[1] [1] Electrical conductivity is used as a stand in measure for salinity (total dissolved salts) by hydrologists. In the Rockingham Area, an EC of 1 mS/cm is approximately equivalent to 600 mg/L total dissolved salts.

remainder of the bores intercepted both geological units. Three additional bores, MB14S, MB14D and PS1 were installed in February 2011 to assist in testing for hydraulic conductivity (pump testing).

Pump testing was also undertaken in the bores MB09S and the specially drilled production bore PB1 to determine aquifer properties for the model, including hydraulic conductivity and the interaction between the Tamala Limestone and Safety Bay Sand layers.

Groundwater monitoring locations are shown in Figure 10. Further details of the investigations can be found in Appendix 5.

It is noted that 2010 was a particularly dry year in the Rockingham area. Average rainfall for the Kwinana BP Refinery between 1955 and 2010 is 748.9 mm/yr (MWH 2011a). During the one year monitoring period, only 419.6 mm of rainfall was recorded. In the southwest of WA, 2010 had the lowest annual and winter rainfall on record (BoM 2011). Because of this, groundwater and surface water levels were lower than what would be expected in an average year. As an example, water levels in Lake Richmond varied between approximately -0.1 and 0.85 mAHD over the monitoring period, as compared to an average range of 0.2 to 1.2 mAHD (MWH 2011b).

Groundwater monitoring in the area is being continued by the Proponent.

Groundwater Reporting

Groundwater results were initially reported through MWH's *Cape Peron Groundwater Study* (2011a) (provided in Appendix 5). This report and additional work by ERM including downhole gamma logging and construction of additional bores was used to develop an understanding of the conceptual site hydrology, as presented in the *Mangles Bay Marina Groundwater Modelling: Revised Conceptual Site Model Report* (Conceptual Site Model) (ERM 2011, provided in Appendix 5). The PER reflects the understanding of the Proposal area hydrology presented in the Conceptual Site Model.

[2] Where multiple bores were installed at the same location, the letters 'S' and 'D' are added at the end to distinguish between them. 'S' refers to the shallower one and 'D' to the deeper one.

Source:
Imagery supplied by Landgate
Water Monitoring Sites supplied by ERM (2010)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011

NB: Potential errors may occur in some areas

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Groundwater monitoring locations

Figure No:
10

6.2.4 Local groundwater system

The groundwater monitoring program indicates there is little connection between the Safety Bay Sands and Tamala Limestone in the Cape Peron area due to the presence of a clayey aquiclude, which acts to limit the movement of water between the two layers (Figure 11). The Safety Bay Sands and the Tamala Limestone have therefore been considered to be two separate aquifers for the purpose of this investigation. This concept is supported by the head (pressure) difference between the two aquifers, with higher heads occurring in the Tamala Limestone than the Safety Bay Sand (ERM 2011) and gamma logging indicates the presence of a clay layer at the base of the Safety Bay Sands (MWH 2011c).

Neither the proposed marina nor Lake Richmond are deep enough to intercept the Tamala Limestone aquifer (Figure 11). As such, the proposal is not considered to impact upon the Tamala Limestone aquifer. Because of this, the focus of the PER has been on the Safety Bay Sands Aquifer.

Additional information regarding the local groundwater system can be found in Appendix 5.

Groundwater levels

Groundwater levels recorded manually during the study period varied between 0.05 and 0.95 mAHD (MWH 2011a). This is similar to the -0.1 and 0.85 mAHD water levels measured in Lake Richmond over the same period (MWH 2011a).

In the Safety Bay Sands, groundwater flow is generally in a northerly and westerly direction, towards the coast (ERM 2011). Groundwater in the Safety Bay Sands shows two different types of fluctuations, depending on the location of the bores. Groundwater in the Safety Bay Sands within approximately 500 m of the coast experiences tidal variations, with groundwater levels rising and falling with the tide (Figure 12). Further from the coast, groundwater levels respond directly to rainfall with groundwater levels peaking in August/September 2010 and at their lowest in April 2011, before the commencement of winter rains (Figure 13).

Groundwater levels in the Tamala Limestone Aquifer showed significant tidal variation throughout the groundwater monitoring area, supporting the concept that the Tamala Limestone and Safety Bay Sands are two separate aquifers (ERM 2011, Figure 14). This difference is because of the higher hydraulic conductivity (and hence lower resistance to water movement) in the Tamala Limestone as compared to the Safety Bay Sands. This allows tidal signals to move more easily through the limestone than the sand.

Groundwater flow directions and surface water interactions

The interaction between Lake Richmond and local groundwater varies over the year. Lake Richmond interacts with the groundwater and also receives surface water from an extensive catchment to the east of the lake (Section 7.2.2). The Lake Richmond Outlet Drain discharges water from the lake into Cockburn Sound when the water level exceeds the weir height of 0.58 mAHD. In an average year, the water level in the lake varies from less than 0.2 mAHD to 1.2 mAHD, with a mean water level of 0.74 mAHD (MWH 2011b).

In the winter months, the input of surface water causes lake water levels to rise and the water level in the lake rises. During this period, the lake acts as a recharge zone with surface water from the lake entering groundwater to the east and west of the lake (Figure 15). At this time of year, water levels within the proposal area vary from less than 0.2 mAHD to approximately 0.8 mAHD near Lake Richmond. Groundwater levels at the lake were modelled as approximately 1.1 mAHD.

As rainfall decreases during the spring months, the water level of the lake drops, the lake no longer acts as a recharge area, and groundwater flows into the lake in the south and east (discharging to the north) (Figure 16). At this time of year, water levels within the Proposal area vary from 0.2 mAHD to approximately 0.6 mAHD near Lake Richmond. Groundwater levels at the lake were modelled as approximately 0.74 mAHD.

The flow direction in the Safety Bay Sands changes during the drier parts of the year (late summer and autumn). Groundwater levels within the area modelled fall due to water use by vegetation and

groundwater users and also due to evaporation from Lake Richmond. The drop in water levels in Lake Richmond causes some groundwater to the north and east to flow towards the lake (Figure 17). At this time of year, water levels within the proposal area are between 0.2 and 0. mAHD. Groundwater levels at the lake were modelled as approximately 0.01 mAHD. This is a common pattern of lake behaviour on the Swan Coastal Plain (Townley *et al.* 1993).

Water Quality

Groundwater in the Safety Bay Sands in the study area generally has total dissolved salts (TDS) less than 1000 mg/L (Figure 18). Salinities greater than 2000 mg/L generally only occur within 200 m of the coast and at Cape Peron, which is bounded by seawater on both sides (Figure 18). Close to the coast, salinity increases with depth because saltwater is denser (and hence heavier) than freshwater, and thus sinks to the bottom of the aquifer. Because of this, the salinities of near-coast groundwater increase with depth in the Safety Bay Sands (Figure 19 at depths less than and including -20 mAHD). The exception is a zone of brackish groundwater with a salinity of 2000 to 3000 mg/L associated with Lake Richmond (Figure 18). Historically, Lake Richmond was a brackish water body (Passmore 1970), and this residual salinity in the groundwater is considered to be a remnant of the former state (ERM 2011).

Groundwater within the Tamala Limestone is generally saline (MWH 2011b) (refer to cross sections at -24 mAHD and below in Figure 19). The proposed marina and any associated dewatering will only occur in the Safety Bay Sands Aquifer, and will not intercept the Tamala Limestone. Therefore, this section of the report focuses on the properties of the Safety Bay Sands aquifer.

Within the Safety Bay Sands, all bores were slightly alkaline, with mean pH values between 7.3 and 8.2 (MWH 2011b). This is similar, but slightly less alkaline than the ranges of pH 7.6 to pH 9 recorded in Lake Richmond during the study period. Additional information regarding both aquifers and the bores can be found in Appendix 5.

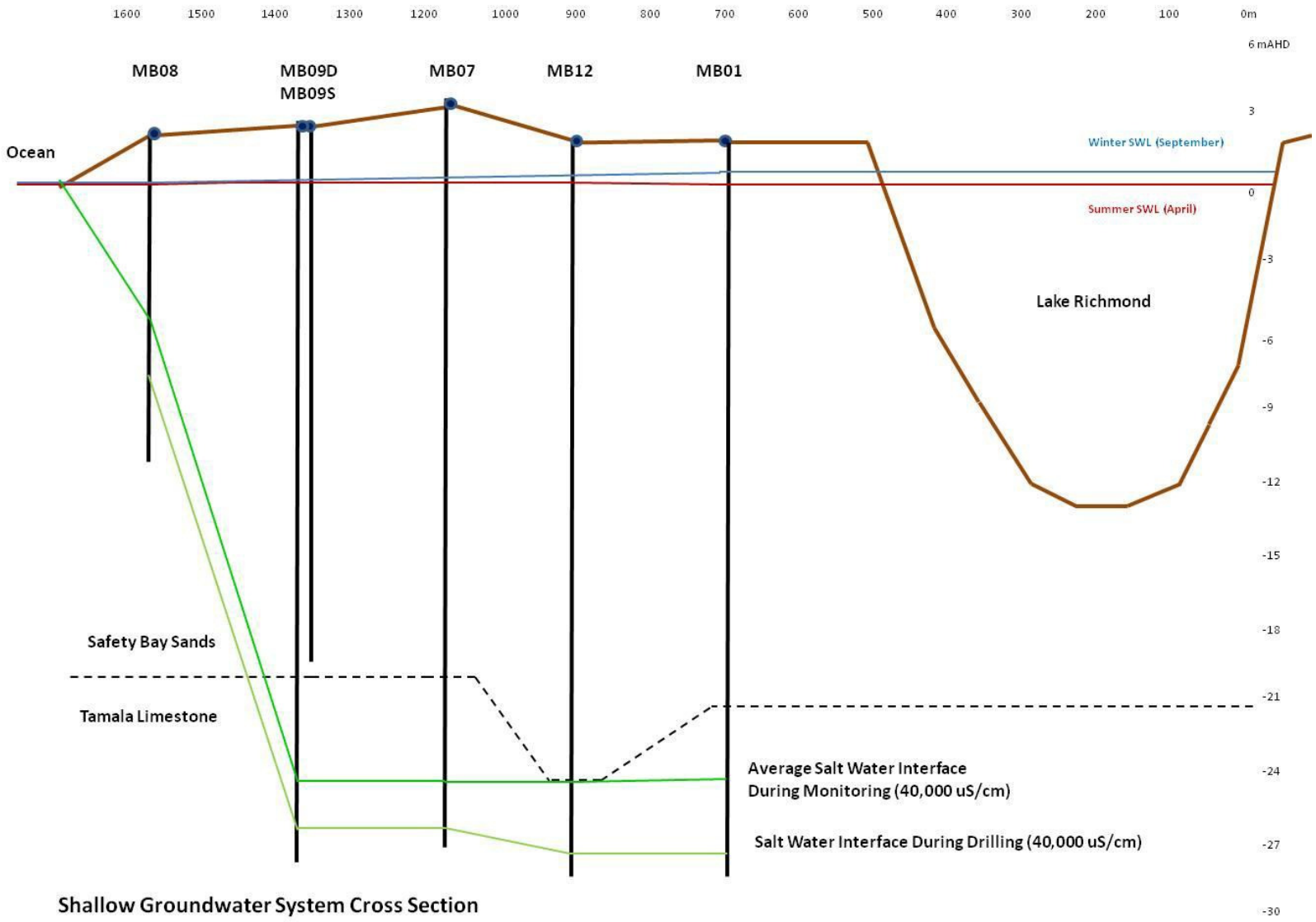
Nitrogen and phosphorus are important nutrients that influence biological growth in fresh and marine waters. TN and TP concentrations in the Safety Bay Sands bores were compared to water quality guidelines for the protection of marine and freshwater ecosystems released under the auspices of the National Water Quality Management Strategy (ANZECC/ARMCANZ 2000). Average TN and TP results for these bores were compared to the guidelines for slightly disturbed ecosystems in southwest Australia (ANZECC/ARMCANZ 2000). Values were also compared to the average and maximum concentrations observed in Lake Richmond (MWH 2011d).

Table 8 ANZECC/ARMCANZ 2000 guidelines for water quality in slightly disturbed ecosystems in south west Australia compared to water quality in study area

Item	Freshwater lake guideline (mg/L)	Wetland guideline (mg/L)	Marine, inshore guideline (mg/L)	Lake Richmond (average and maximum) (mg/L)	Range of average values for Safety Bay Sands bores (mg/L)
Total Phosphorus (TP)	0.01	0.06	0.02	0.02 0.03	0.038 – 0.18
Total Nitrogen (TN)	0.35	1.5	0.23	0.92 1.9	0.85 – 6

For TP, the average values for all seven bores were above the 0.01 and 0.02 mg/L guidelines set for freshwater lakes and inshore marine waters (Table 8). The average phosphorus concentrations at the three coastal bores, MNB02, MB06 and MB08, met the wetland water quality guidelines (Table 8). In terms of TN, none of the bores met the guidelines set for freshwater lakes and inshore marine waters (Table 8). The average TN concentration at bores MB04, MB06, MB08, and MB09S met the wetland guidelines (Table 8). Groundwater exhibited higher average phosphorus concentrations and generally higher average nitrogen concentrations than the lake (Table 8).

The values found in groundwater are similar to the average value of 0.24 mg/L TP and 2.64 mg/L TN for superficial bores in rural and vegetated areas in the nearby Murray catchment (DoW 2011).



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Hydrogeological cross section of the Proposal area

Figure 11

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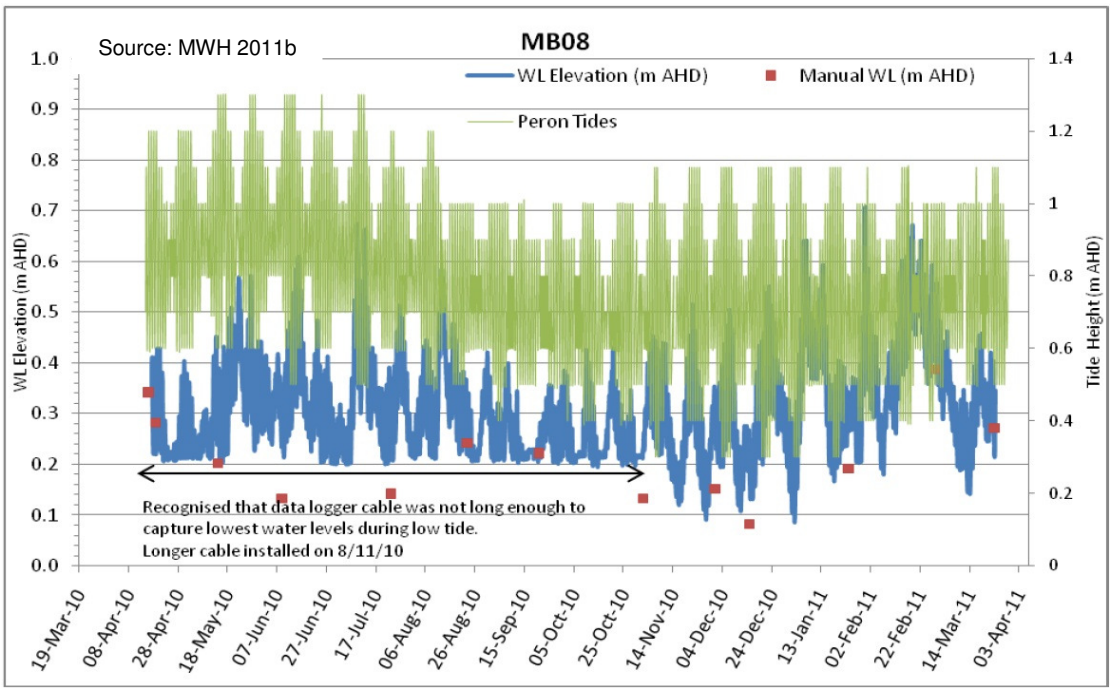

Figure 12 Groundwater levels in Safety Bay Sands aquifer, bore MB08 compared to tide levels

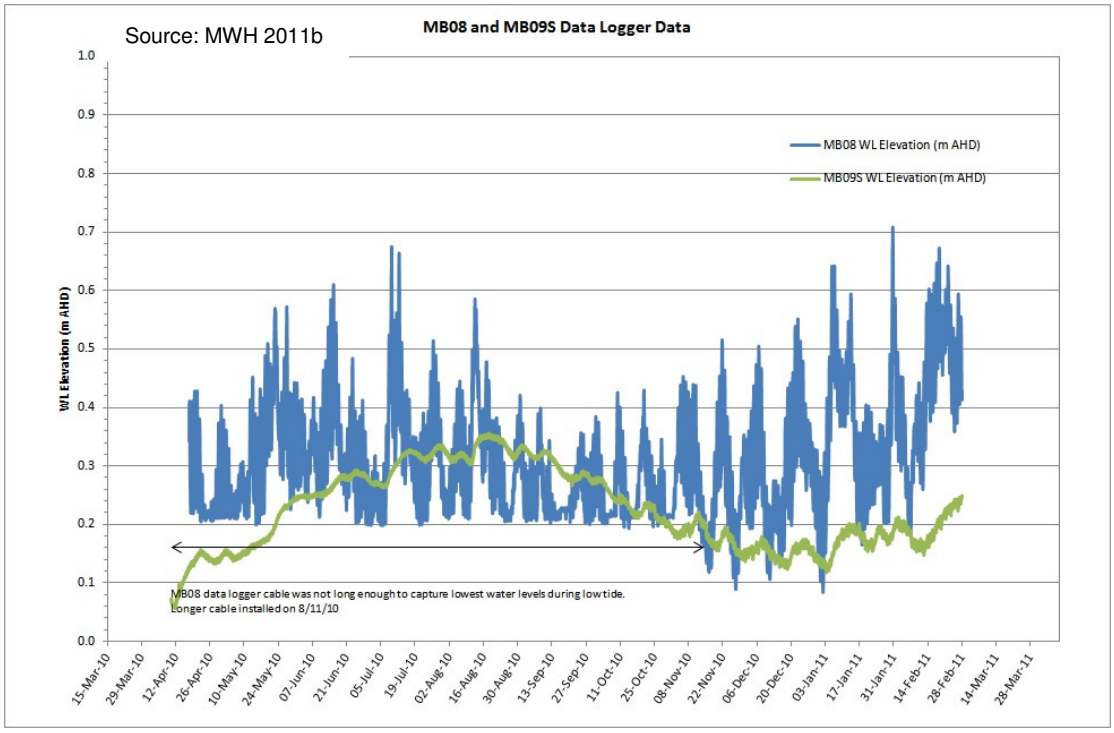

Figure 13 Groundwater levels in Safety Bay Sands aquifer, bore MB09S compared to rainfall

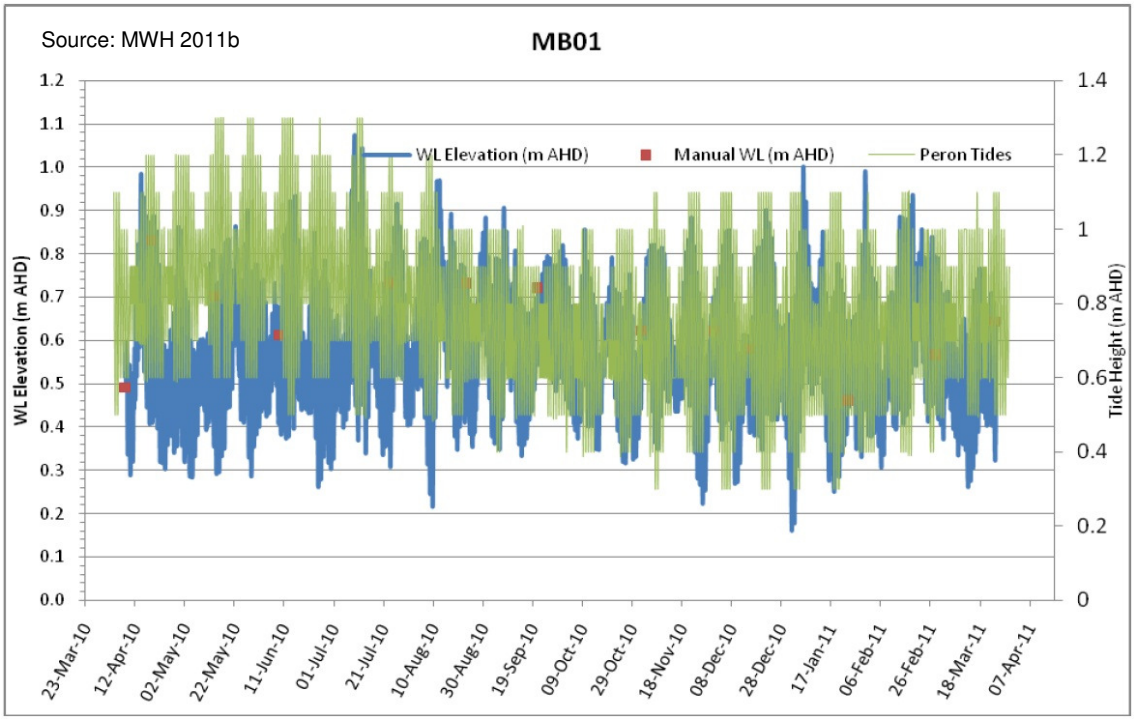

Figure 14 Groundwater levels in Tamala Limestone Aquifer bore MB01 compared to tide levels

Source: Cadastral data supplied by Landgate (2010)
Groundwater Contours supplied by ERM (2011)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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Modelled groundwater contours - existing high water levels

Figure No:
15

Source: Cadastral data supplied by Landgate (2010)
Groundwater Contours supplied by ERM (2011)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F054.dgn

Modelled groundwater contours - existing mean water levels

Figure No: **16**

Source: Cadastral data supplied by Landgate (2010)
Groundwater Contours supplied by ERM (2011)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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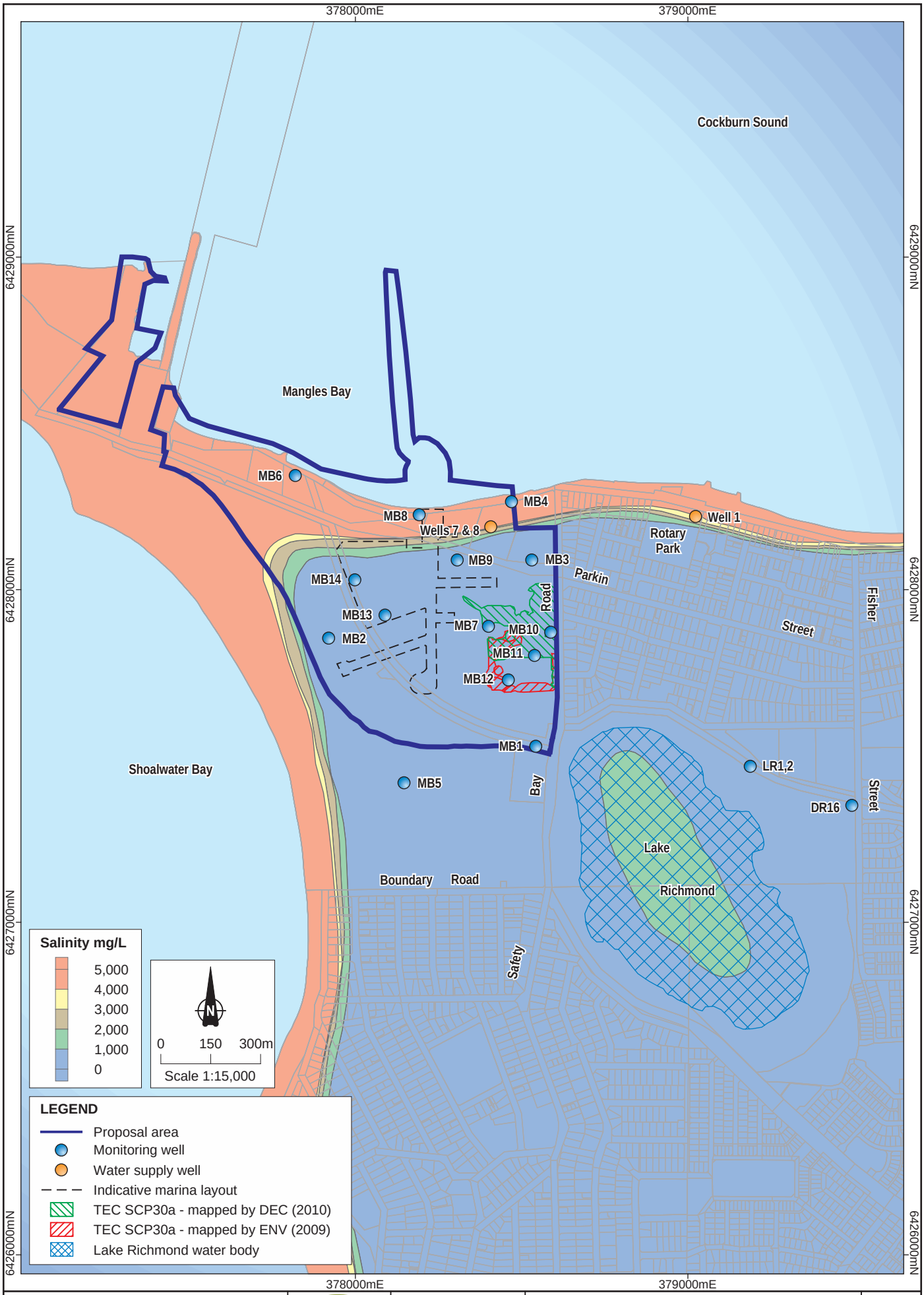
Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F040.dgn

Modelled groundwater contours - existing low water levels

Figure No: **17**



Source: Cadastral data supplied by Landgate (2010)
Modelled salinity supplied by ERM (2011)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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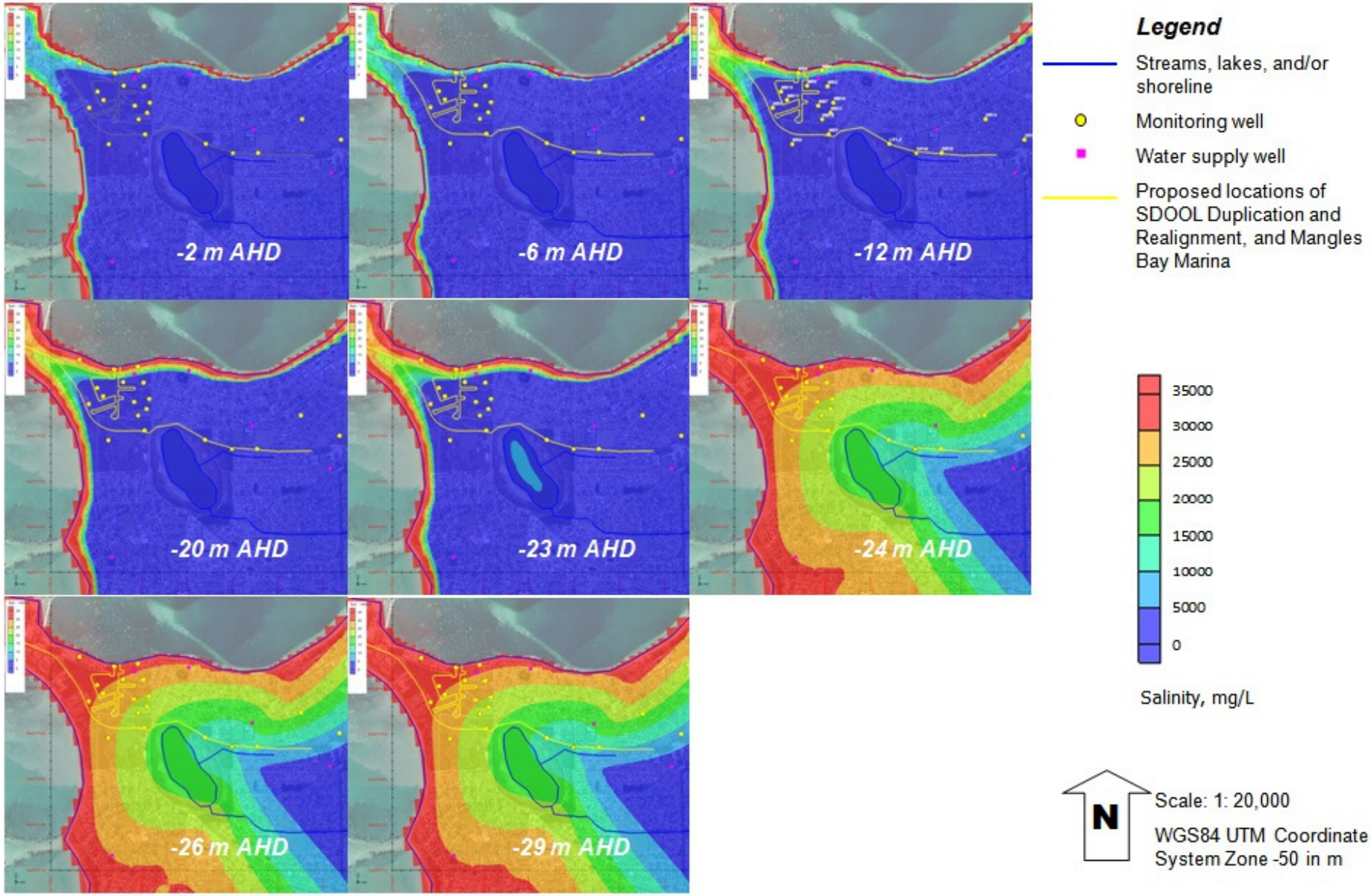
Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F036.dgn

Modelled salinity distribution under existing conditions at -12 m AHD

Figure No: **18**



STRATEGEN

Mangles Bay Marina Based Tourist Precinct

Changes in modelled salinity distributions with depth under existing conditions

Figure 19

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Salinity at local bores

ERM (2011a) identified three main bores used for irrigation purposes in the modelled area: Wells 1, 7 and 8, as shown in Figure 18. The modelling indicates that the water quality at these bores may be fresh at shallower depths (Figure 19), but marginal for irrigation at -12 mAHD, with salinity between 1000 and 2000 mg/L (Figure 18). This estimated water quality in Wells 7 and 8 is consistent with the water quality measured in Rotary Park Lake, adjacent to the bores. Ecoscape (2009) recorded a salinity of 2220 to 2230 mg/L in this lake, above the 2000 mg/L guideline.

Hydraulic conductivity testing

Hydraulic conductivity testing of the Safety Bay Sands Aquifer was conducted by pump testing of the bores PB1 and MB09S. The aim of this was to assist in selecting a suitable hydraulic conductivity value for use in the model and investigate the interaction between the two aquifers. Test pumping was initially undertaken on the bore PB1, but the hydraulic conductivity provided was considered unrealistically low for a sandy aquifer (MWH 2011b).

Test pumping was then undertaken on the shallow monitoring bore (MB09S) to determine another value for hydraulic parameters for the Safety Bay Sands. Results from this second test suggested high hydraulic conductivity (K) values in the range of 40 to 75 m/d (MWH 2011b). Literature search values for hydraulic conductivity of the Safety Bay Sands are between 5 and 50 m/d: these values are at the high end of, or above, this range (ERM 2011). The model has been calibrated to a K value of 16 m/day.

6.2.5 Numerical groundwater modelling

The key driver in determining the extent of acceptable impacts is the likelihood of impacts if they are to occur to Lake Richmond as a result of the inland marina. To investigate the impacts of construction and operation of the marina, a model was developed.

The numerical model was developed for the Proposal by ERM. The model includes the groundwater/surface water interactions of Lake Richmond and has been calibrated to local groundwater and surface water data. The model was peer reviewed by Phil Wharton, a modeller with experience in the hydrology of the Rockingham area. A copy of the numerical groundwater model, including the peer reviewer's report, is provided in Appendix 4.

The model itself was based on the monitoring undertaken for this survey, with additional information from a number of sources including:

- DoW and Water Corporation regional Perth Metropolitan groundwater model Perth Regional Aquifer Modelling System (PRAMS) (Davidson and Yu 2006) to assess groundwater availability, rainfall recharge and aquifer yields
- PRAMS model development: hydrogeology and groundwater modelling (Davidson and Yu 2006)
- Hydrogeology and groundwater resources of the Perth region, Western Australia, Western Australia Geological Survey, Bulletin 142 (Davidson 1995)
- groundwater level and quality monitoring of the superficial aquifer and Rockingham Sand within the Warnbro groundwater subarea undertaken by the DoW from 1975 – 2010
- Rockingham – Stakehill Groundwater Management Plan for the allocation of groundwater for current and future users and to protect groundwater-dependent ecosystems (DoW 2008)
- water abstraction/groundwater licence information (available upon request from the DoW)
- groundwater monitoring and investigations undertaken by the Water Corporation in association with the SDOOL pipeline made available by the Corporation.

The numerical groundwater model developed addresses the impact of the Proposal in both the construction and operational phases. The methodology for development of the model included:

1. Developing a conceptual hydrogeological model of the area including the understanding of the geological and hydrogeological relationships of the various units in particular: the relationship of the Safety Bay Sands and the underlying Tamala Limestone units; interaction of Lake Richmond with the groundwater system; impact of tidal influence on the groundwater systems; the dynamics of the saltwater interface; groundwater recharge; and, potential impacts on the regional groundwater system.
2. Construction and calibration of a numerical groundwater model to the existing monitoring data collected as part of this proposal and from long-term regional data. The results and observations of the test pumping would also be utilised in the calibration of the groundwater model.
3. Undertaking simulations for the above construction scenarios to assess likely aerial extent of impacts, including cumulative impacts due to dewatering associated with the proposed duplication of the SDOOL.
4. The construction and calibration of a solute transport model to allow simulations of the potential changes in groundwater salinity that may to develop as a result of the marina increasing the connection between the groundwater and the ocean.

As described in Section 3.1.2, the Water Corporation is planning to undertake duplication of the SDOOL pipeline in the next five years. The Water Corporation has commenced discussions with regulatory agencies on this work, but has not yet formally referred the proposal to the EPA. As recommended by the EPA, modelling for the Mangles Bay Proposal has been undertaken in conjunction with the Water Corporation to ensure that the modelling is consistent with the modelling undertaken for the SDOOL, and that cumulative impacts of the two proposals can be considered. The same modellers have been used for both Proposals and the model utilised for the Mangles Bay Marina will be utilised for the SDOOL modelling.

6.3 Evaluation of options or alternatives to avoid or minimise impact

If construction occurs without dewatering, the main source of impact from the Proposal to the surrounding environment is expected to occur as a result of the hydrological changes due to the operation of the inland marina. This impact occurs because the marina allows greater interaction between groundwater and the sea. Because of this, the ocean water levels have a larger impact upon groundwater levels, such that groundwater levels around the marina may drop.

6.3.1 Construction method alternatives

The primary potential impact due to construction is the dewatering that may be associated with construction. Three construction method alternatives were considered for the construction of the inland marina, these were:

1. A dry construction method involving significant dewatering to ensure that the base of the marina or canal being constructed remains dry during construction. Under this scenario, dewatering would occur over a period of approximately five years. Additional information on the dry construction scenarios can be found in Appendix 5.
2. Construction of a reduced marina with only one canal using dry construction techniques. Under this scenario, dewatering would also occur over five years, but with a break of approximately twelve months in the middle.
3. A wet construction method involving the use of excavators and dredges to construct the marina with the use of no to very little dewatering, as described in Section 3.4.1.

The impact of these construction methods were investigated using a numerical groundwater model.

The construction of the marina results in a decrease in groundwater levels in area immediately surrounding the marina, as there is greater connection between the sea and groundwater in this area (Figure 21). The model indicated the following changes in water level at Lake Richmond during the construction of the marina and canals:

- maximum decrease of 0.42 m for dry construction
- maximum decrease of 0.19 m for dry construction of a marina with only one canal
- maximum decrease of 0.032 m for wet construction (ERM 2011, provided in Appendix 5).

Figure 22 shows a modelled time sequence of water levels in Lake Richmond during the wet construction scenario. Given the wet construction method showed a significantly lower impact on water levels in the lake (0.03 m as opposed to 0.42 m), it was considered to provide a better environmental outcome. Hence a wet construction method has been selected for this proposal.

In order to understand the cumulative impacts of the Water Corporation SDOOL construction and the Marina construction and operation, two scenarios were modelled for the SDOOL construction. The first scenario was developed based on assumed dewatering requirements and this scenario is included in the ERM Groundwater Model Report at Appendix 5. The second scenario represents a refinement of construction methodology.

A further scenario for the SDOOL construction relates to the revised alignment which would be required if the MBMBTP was implemented. With reference to Figure 7, the revised alignment departs the current alignment west of Lake Richmond to pursue an alignment along the southern boundary of the Proposal. This scenario has not been modelled as this section of the SDOOL will have little to no interaction with groundwater. This is described in SDOOL Scenario 3 below.

SDOOL Scenario 1 - Trenching associated with SDOOL duplication and relocation installation will require temporary dewatering to a depth of 1.84 to -1.56 m AHD. The locations and dewatering elevation were provided in the engineering drawings provided to ERM by TABEC. The proposed installation plan uses two separate working crews, each advancing the trenching continuously from east to west in 100 m segments, with each dewatering segment comprising a length of approximately 200 m (50 m in front and behind the 100 m trench), advancing at an approximate speed of 12.5 m/day. This scenario was used to model the potential cumulative impacts of SDOOL construction and is included in the ERM Groundwater Model Report at Appendix 5

SDOOL Scenario 2 - Trenching associated with the SDOOL installation will require temporary dewatering to a depth of 1.86 to -1.95 meters (m) Australian Height Datum (AHD), which is up to about 2 m below mean water level. The locations and dewatering elevations were given in the engineering drawings provided to ERM by the Water Corporation. The most recent proposed SDOOL installation plan involves advancing the trenching continuously from east to west, with the pipe to be installed in 100 m sections (advancing at an approximate speed of 25 m/day) and each dewatering segment comprising of a length of approximately 200 m (100 m trench plus 50 m behind and in front of the trench). This scenario has been modelled by the Water Corporation to support their application for approval for the SDOOL duplication. The modelling report is not available for inclusion in this report.

SDOOL Scenario 3 – Revised alignment. A concept design for the proposed realignment of the SDOOL pipeline was undertaken by GHD, which took into account and assessed the existing invert levels at each end of the section traversing the Mangles Bay project site. A requirement of the realigned concept design includes a connection to the existing invert levels outside of the project boundary.

The current SDOOL onsite includes a scour and air valve near the Safety Bay Road / Memorial Drive intersection to allow the pipe line to be elevated to an invert of 1.94m AHD. The current pipe then operates under gravity flow to the western boundary of the project where the existing invert is approximately 1.0mAHD as shown on the GHD sketches. The GHD concept design allows for the realigned route to provide a connection between these boundary points (eastern and western extent) and also considers minimum cover for adequate protection above the pipe which is provided.

It is understood the maximum groundwater exists at approximately 0.8m AHD and therefore the depth of construction of the proposed concept design, would require minimal to nil dewatering during construction.

It is expected that an invert within approximately 0.3m of ground water may experience wet ground and over excavation to allow for adequate bedding to be laid under the realigned pipe may be required during construction.

Based on the concept GHD plans, a significant dewatering program is not expected to cater for the construction of the SDOOL realignment.

Because a wet construction method was chosen for marina construction, and very little dewatering will occur, it was not necessary to model a 'best' and 'worst' case in terms of the impacts of dewatering for the Proposal. As such, only one scenario for groundwater changes has been provided, based on the proposed marina design.

6.3.2 Minimising operational impacts

The size of the marina affects operational impacts. A larger marina offers a greater area for interaction between groundwater and the sea, and thus larger impacts may be expected. The size of the marina did not appear to significantly change the long-term impact on the lake. A marina without any canals resulted in a drop in water levels in the lake of 1.8 cm during operation, while a marina with canals resulted in a drop of 3.8 cm (refer report provided in Appendix 5). A marina with canals was considered preferable to increase boat usage. Design steps undertaken to minimise the operational impact of the Proposal on groundwater include reducing the length of the south eastern canal of the marina to minimise impact to groundwater near TEC FCT30a (Figure 18). The reduction in the depth of the canals from an initially proposed -4 mAHD to varying from -4 mAHD at deepest depth with shallowest depth being -2.7mAHD may also reduce the impact of the marina on groundwater. Assessment of likely direct and indirect impacts

The use of wet construction methods will significantly reduce the impact of the proposal during construction, as outlined in Section 6.3.1. The long-term impacts of marina operation on water quality were determined by running the model, with the marina, for a period of 1000 years. If wet construction is used, the impact of construction of the marina on groundwater levels or quality is less than the long-term impacts (ERM 2011 provided in Appendix 5).

6.3.3 Impacts of marina construction using wet excavation on groundwater quality

Saltwater intrusion occurs when the interface between the saltwater and fresh groundwater moves inland. The construction of the marina will allow saltwater to move further inland through the marina. The salinisation in areas where groundwater was previously fresh may result in previously fresh bores becoming saline and changes in vegetation types to more salt-tolerant species. The potential for saltwater intrusion was modelled as part of the groundwater modelling (provided in Appendix 5).

A level of -12 m AHD is approximately half the depth of the Safety Bay Sands and is within the lower waters of Lake Richmond. This level is also considered to represent a reasonable depth for groundwater bores in the area.

Salinity impacts of construction are shown at -12 mAHD. A level of -12 m AHD is approximately half the depth of the Safety Bay Sands and is within the lower waters of Lake Richmond. This level is also considered to represent a reasonable depth for groundwater bores in the area. As groundwater salinity increases with depth, and there will not be extensive dewatering to move saltwater at shallow depths, the impacts at this level are considered to represent a 'worst case' for change in salinity at shallower depths. Groundwater to the south and east of the marina is not expected to be significantly affected. Modelling the excavation of the marina using wet construction methods did not significantly alter the salinity distribution in the area at -12 mAHD; only areas within 200 m of the coast would experience salinities greater than 2000 mg/L (Figure 23). The change in salinity during construction is very limited outside the Proposal area, with the saltwater wedge extending south by approximately 40 m at Safety Bay Road and east by approximately 20 m at Boundary Road (Figure 23). None the scenarios modelled resulted in a change in salinity of Lake Richmond.

6.3.4 Impacts of construction using wet excavation on groundwater bores

The changes in low water levels associated with construction are generally less than 0.4 m. This is a small impact, and within the level of seasonal variation of 0.9 m cited in Section 6.2.4. This level of change is small and is thus considered unlikely to cause domestic or other bores to become dry.

The council irrigation wells 1, 7 and 8 are expected to show an increase in salinity from greater than 1000 mg/L (which is marginal for irrigation) to greater than 2000 mg/L, the maximum level considered acceptable for irrigation.

The area impacted by increased groundwater salinity is generally not residential in nature and as such, household bores in the Rockingham – Shoalwater area are generally not expected to be impacted by changes in salinity (Figure 23). However, there is the potential that a few households between Well 7 and 8 and Rotary Park may experience increases in bore salinity (Figure 23). Water quality in this area appears to be already marginal for irrigation, and lot sizes are generally small, so it is unlikely that many of these households use bores for irrigation.

Prior to construction, the Proponent will develop a Groundwater Quality Management Plan to address impacts of potential changes in salinity on groundwater users, including measures to inform householders, investigating potential changes in location for council irrigation bores and measures to mitigate impacts upon affected households. This will be supported by a program of groundwater salinity monitoring.

6.3.5 Impacts of operation on groundwater levels

The long-term operational impact of the marina on groundwater levels is similar to the impact during construction (Figure 21, Figure 25). The groundwater levels around the marina fingers equilibrate, with a larger area around the marina experiencing groundwater levels less than 0.1 mAHD than is currently the case. Under a low water scenario, the 0.2 mAHD contour moves closer to the marina than occurred during construction, showing that a smaller area experiences groundwater levels less than this (Figure 24, Figure 25). Under a high (winter) water level scenario, the reduction in water levels in the vegetated area surrounding the Proposal during operation is less than 0.2 m (Figure 24). Under a low (summer) scenario, the impact is closer to 0.1 m (Figure 25). A long-term reduction in groundwater levels of 0.038 m is expected at Lake Richmond (ERM 2011).

The changes in low water levels associated with this proposal are generally less than 0.4 m. This is a small impact, and within the level of seasonal variation of 0.9 m cited in Section 6.2.4. This level of change is small and is thus considered unlikely to cause domestic or other bores to become dry.

6.3.6 Impacts of operation on groundwater salinity

The increased connection between seawater and groundwater in the area surrounding the marina may result in an increase in saltwater intrusion in the marina at a depth of -12 mAHD (Figure 26). The area experiencing salinities greater than 4000 mg/L extends further south and east, particularly between the marina and Cape Peron. The saltwater interface is modelled as sitting approximately along the southern and eastern edge of the marina. There is also some additional intrusion to the northeast of the marina. Salinities of groundwater under Lake Richmond are not expected to change (Figure 26).

A small portion of the DEC-mapped TEC FCT 30a will be affected by the increase in salinity. However, this area is proposed to be cleared as part of the Proposal (Figure 26) and as described in Section 8.2.1, for the purposes of this PER the ENV (2010) mapped extent of the TEC is utilised until further mapping is undertaken.

The irrigation wells 1, 7 and 8 are expected to show an increase in salinity to greater than 2000 mg/L, the maximum level considered acceptable for irrigation.

The area impacted by increased groundwater salinity in the long-term is generally not residential in nature and as such, household bores in the Rockingham – Shoalwater area are generally not expected to be impacted by changes in salinity (Figure 23). However, there is the potential that some households between the Proposal Area and Rotary Park may experience increases in bore salinity (Figure 23).

Householders and landowners in the affected areas will be notified of the issue and offered alternative water supplies for irrigation as outlined in Section 6.3.4.

Source: Cadastral data supplied by Landgate (2010)
Groundwater Contours supplied by ERM (2011)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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environmental consultants

Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F056.dgn

Modelled groundwater contours during construction - high water levels

Figure No:
20

Source: Cadastral data supplied by Landgate (2010)
Groundwater Contours supplied by ERM (2011)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

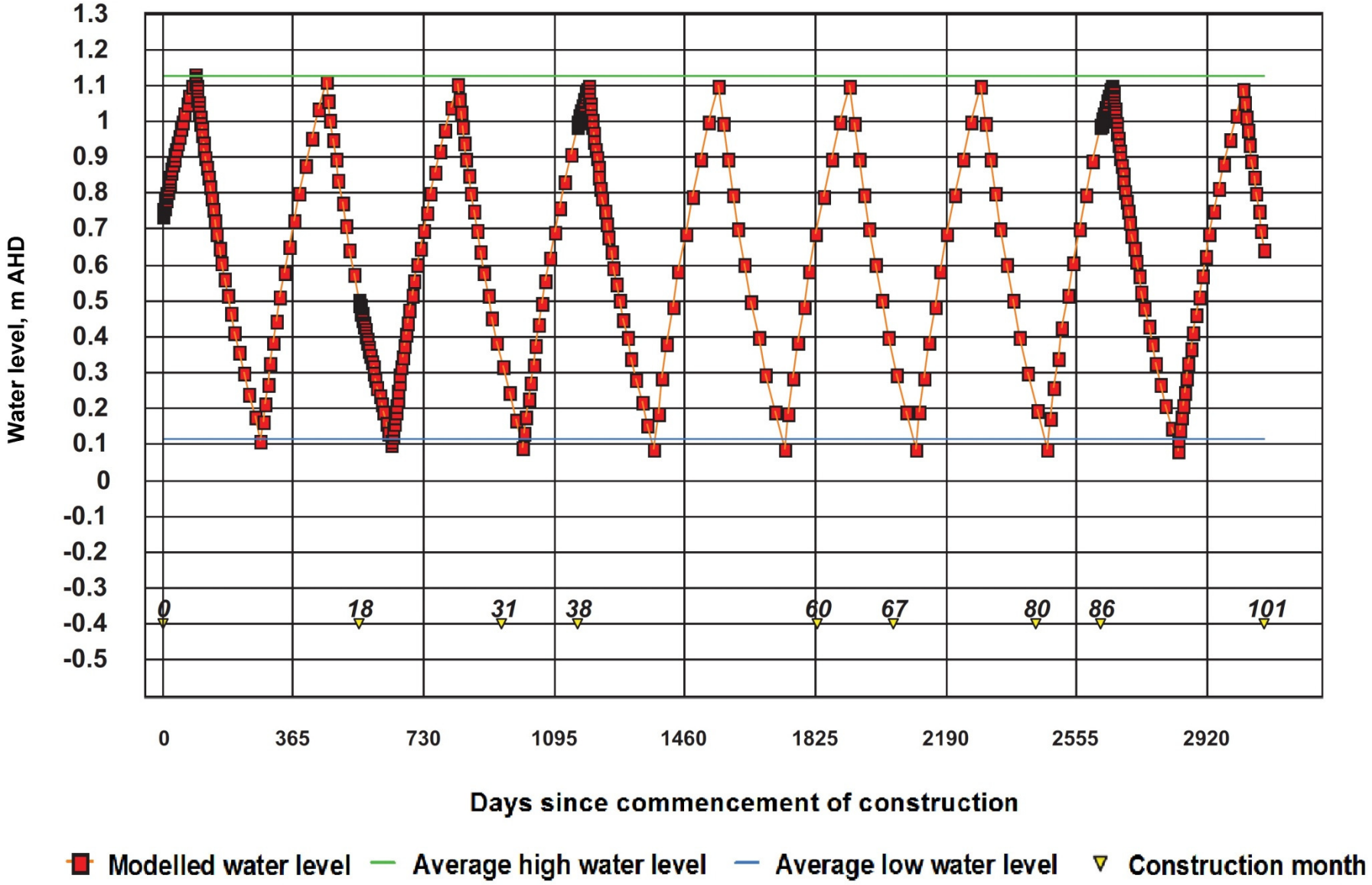
STRATEGEN environmental consultants

Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F037.dgn

Modelled groundwater contours during construction - low water levels

Figure No: **21**



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Mangles Bay Marina Based Tourist Precinct

Modelled Lake Richmond Water Level during construction

Figure 22

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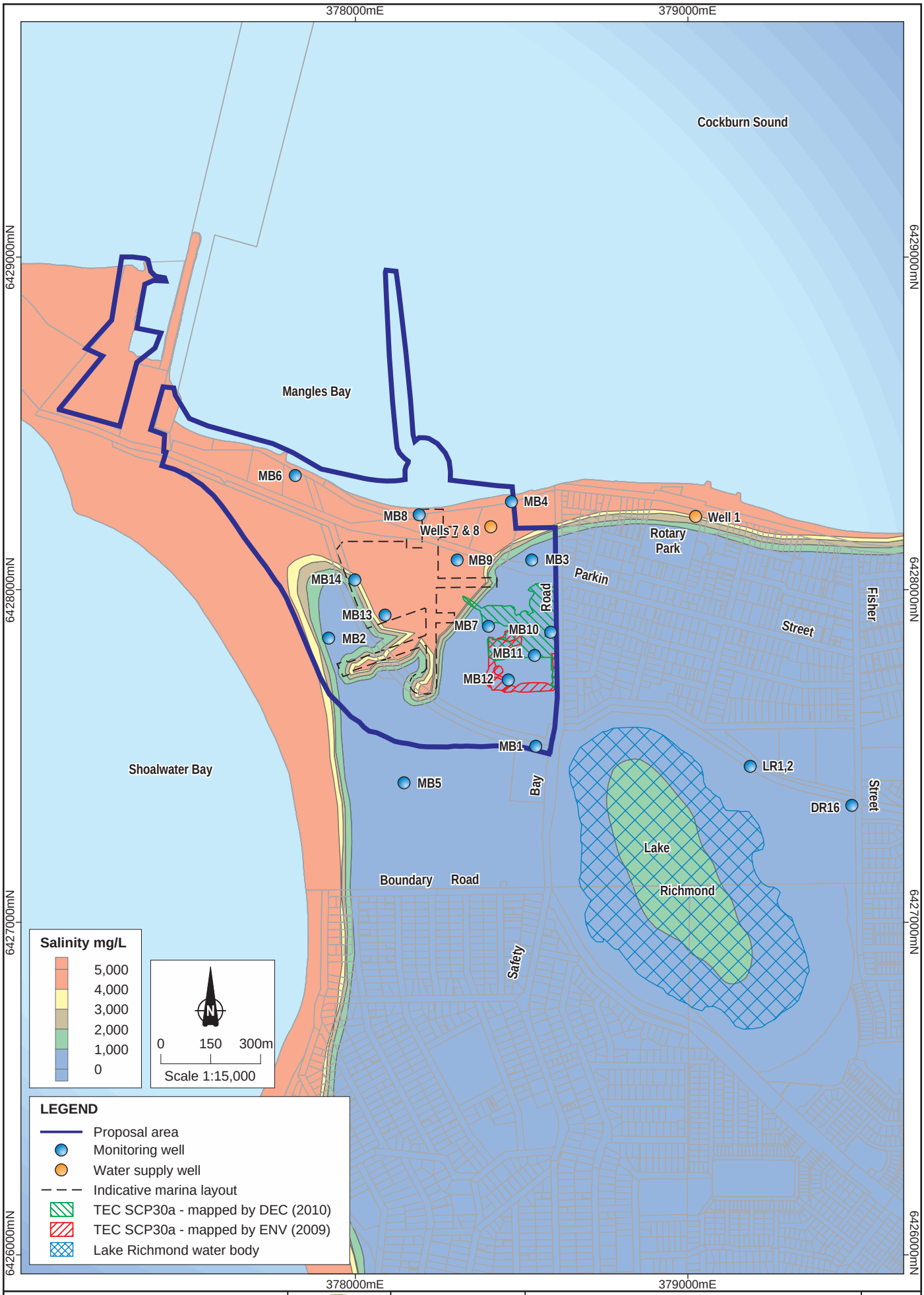

Source: Cadastral data supplied by Landgate (2010)
Modelled salinity supplied by ERM (2011)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F038.dgn

Modelled salinity distribution during construction at -12 m AHD

Figure No: **23**

Source: Cadastral data supplied by Landgate (2010)
Groundwater Contours supplied by ERM (2011)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F058.dgn

Modelled groundwater contours post construction - high water levels

Figure No: **24**

Source: Cadastral data supplied by Landgate (2010)
Groundwater Contours supplied by ERM (2011)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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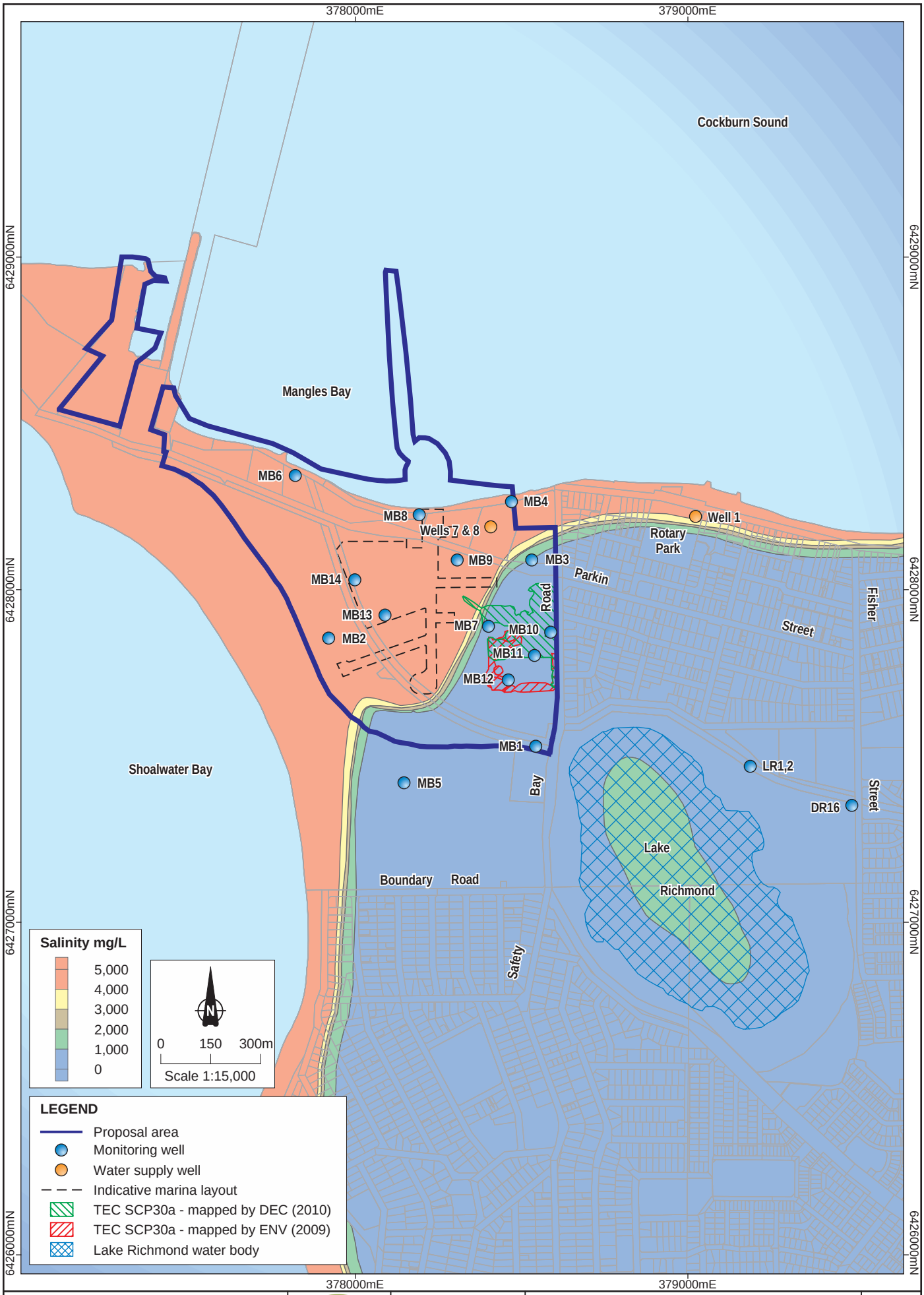
Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F041.dgn

Modelled groundwater contours post construction - low water levels

Figure No: **25**



Source: Cadastral data supplied by Landgate (2010)
Modelled salinity supplied by ERM (2011)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F039.dgn

Modelled salinity distribution during operation at -12 m AHD

Figure No: **26**

6.3.7 Impacts on water quality factors other than salinity

The clearing of vegetation for urban or rural land uses can lead to an increase in nutrient and metal concentrations in groundwater due to fertiliser use and anthropogenic inputs such as road runoff. Urban nutrient inputs are generally higher in areas with large blocks, due to increased areas of garden that are fertilised (Water and Rivers Commission 2002). The Proposal will be designed with the intent of maintaining or reducing groundwater nutrient concentrations in line with *Better Urban Water Management* (BUWM) (WAPC and DPI 2008). In line with *BUWM:*

- a District Water Management Strategy (DWMS) will accompany the Metropolitan Region Scheme amendment and outline concepts for water quality management on the site
- LWMS will accompany the LSP to outline the measures being undertaken to manage water quality (WAPC and DPI 2008).

Both documents will be approved by the DoW and City of Rockingham as part of the approval process. Measures undertaken may include treatment of stormwater prior to infiltration, minimising fertiliser use in POS and providing householder education on fertiliser use.

The potential impacts of changes in the quality of groundwater that discharges to Mangles Bay is discussed in Section 10.

6.3.8 Public Open Space irrigation within the Proposal Area

The development proposes the construction of only limited new areas of POS along the Mangles Bay foreshore (Figure 6). This area will be predominantly sandy beach and hard surfaces that will not require irrigation. Limited irrigation may be required for establishment and maintenance of landscaped areas during the drier months. This water may be sourced from offsite groundwater. The irrigation requirements and how these will be managed will be investigated as part of the LWMS.

6.4 Assessment of likely direct and indirect impacts

The following aspects may potentially impact on groundwater values within the Proposal area:

- changes to groundwater levels due to the presence of the marina allowing more interaction between local groundwater and the sea, resulting in:
  - lowering of water levels in nearby private garden bores
  - exposure of ASS if they exist within the land development area
- saltwater intrusion caused by the inland movement of the saltwater-groundwater (fresh) interface due to the inland marina, that may result in:
  - increasing salinity in local bores
  - salt entering the root zone of potentially salt sensitive native species.

As the marina will be constructed predominantly without dewatering, the construction of the marina will not impact upon groundwater levels. Limited, temporary dewatering may be required for construction of services, such as sewerage and gas. Potential for and nature of any cumulative impacts

Should the marina construction coincide with the relocation and duplication of the SDOOL pipeline by Water Corporation, dewatering and construction activities for both proposals may occur simultaneously.

Three SDOOL scenarios were assessed with construction technique/alignment representing the biggest impact being modelled (Appendix 5).

Using the construction methods advised by the Water Corporation and GHD (Section 6.3.1), the construction of the SDOOL is assessed as having the following impacts to Lake Richmond:

Scenario 1 - Without the marina present resulted in a decrease in water levels at Lake Richmond of 0.24 m (Appendix 5). With the marina being constructed at the same time, the decrease was 0.25 m.

Scenario 2 - Low seasonal water levels in Lake Richmond during the SDOOL duplication construction dewatering without recharge will be reduced by 0.11 m and return to natural conditions within a year after construction; Low seasonal water levels in Lake Richmond during the SDOOL duplication construction with dewatering recharge to the construction trench will be reduced by 0.009 m and return to natural conditions within 6 months after construction

Scenario 3 – the construction of the SDOOL at the revised alignment has little to no interaction with the groundwater table and therefore dewatering is not required and the SDOOL construction does not contribute to any impacts on Lake Richmond.

The cumulative impact of the two proposals on Lake Richmond is predominantly due to the construction of the SDOOL. As modelled, the construction of the SDOOL is a relatively short-term proposal, with dewatering expected to occur for 160 days (ERM 2011, provided in Appendix 5). Determining the acceptability of the impacts of the SDOOL duplication, and how these may be managed or mitigated, are not within the scope of this PER, but are a matter to be discussed between the Water Corporation and the relevant regulatory authorities.

6.5 Management measures and performance standards

Management measures will be implemented to minimise the impacts on groundwater. These management measures are described below:

1. Marina constructed will involve a wet construction method involving the use of excavators and dredges to construct the marina with the use of no to very little dewatering.
2. Dewatering for the relocation of the SDOOL and service construction is expected to be below the threshold where a dewatering license is required. Should it be decided that this volume will be exceeded, a license application and Dewatering Management Plan will be submitted to the DoW.
3. Prior to construction, the Proponent will develop a Groundwater Quality Management Plan to address impacts of potential changes in salinity on groundwater users, including measures to inform householders, investigating potential changes in location for council irrigation bores and measures to mitigate impacts upon affected households. This will be supported by a program of groundwater salinity monitoring.
4. Bores surrounding the marina will be monitored quarterly for water levels and salinity during construction, and for three years following construction.
5. A District Water Management Strategy will be prepared to accompany the MRS.
6. A LWMS will be prepared to accompany the LSP and outline management measures for groundwater quality and quantity, and potable and non-potable water supplies.

It is considered that with the use of these management measures and performance standards, the development can effectively manage any impacts on water quality.

6.6 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

After mitigation measures as described above, the proposal is expected to be able to:

1. Result in a minimal reduction in groundwater levels at Lake Richmond of 0.032 m during construction and 0.038 m during operation.
2. Ensure no impact to groundwater quality at Lake Richmond during construction or operation.
3. Manage the limited impacts to bore users in the Rotary Park area through the implementation of mitigation measures in line with the proposed Groundwater Quality Management Plan.

These impacts are considered to be acceptable as the key environmental values for groundwater surrounding the Proposal will not be significantly affected.

Through the implementation of the management measures and performance standards outlined above, it is considered that the Proposal will meet the EPA guidelines for the management of water.

7. Surface water impact assessment

7.1 Relevant environmental objectives, policies, guidelines, standards and procedures

7.1.1 EPA objectives

The EPA applies the following objective in assessing proposals that may affect surface water:

To maintain the integrity, ecological functions and environmental values of wetlands

To maintain the quantity and quality of water (groundwater and surface water) so that existing and potential environmental values, including ecosystem maintenance, are protected.

To maintain biological diversity where that represents the different plants, animals and micro-organism, the genes they contain and the ecosystems they form, at the levels of genetic diversity, species diversity and ecosystem diversity.

7.1.2 Legislation, policy and guidance

National

In 1996, the Australian and New Zealand Environment and Conservation Council (ANZECC) together with the Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) developed the National Principles for the Provision of Water for Ecosystems (ANZECC/ARMCANZ 1996). These national principles aim to improve the approach to water resource allocation and management and to incorporate the water requirements of the environment in the water allocation process. The overriding goal of the principles is to provide water for the environment to sustain and, where necessary, restore the ecological processes and biodiversity of water-dependent ecosystems.

A set of water quality guidelines for the protection of marine and freshwater ecosystems has also been released under the auspices of the National Water Quality Management Strategy (ANZECC/ARMCANZ 2000). The guidelines provide a comprehensive list of recommended low-risk trigger values for physical and chemical stressors in water bodies, and are applied to five geographical regions across Australia and New Zealand.

A series of guidelines on national water quality management have also been released by the NRMMC and, in some cases, in collaboration with the NHMRC and the Australian Health Ministers Conference. These guidelines address a range of issues including policies and processes for water quality management, water quality benchmarks, groundwater management, diffuse and point sources, guidelines for sewerage systems, effluent management and water recycling.

State water quality management strategy

The Government of Western Australia developed the State Water Quality Management Strategy in 2001 (Waters and Rivers Commission 2001) to supplement the National Water Quality Management Strategy with the objective 'to achieve sustainable use of the Nation's water resources by protecting and enhancing their quality while maintaining economic and social development'.

State water strategy

The Government of Western Australia developed the State Water Strategy in 2003 with the objective of achieving a sustainable water future for all Western Australians by:

- improving water use efficiency in all sectors
- achieving significant advances in water reuse
- fostering innovation and research
- planning and development of new source of water in a timely manner
- protecting the value of our water resources.

Wetlands Conservation Policy for Western Australia

The *Wetlands Conservation Policy for Western Australia* was developed by the Western Australian Government in 1997. Its main aims include:

- to prevent the further loss or degradation of wetlands, and promote wetland conservation, restoration and creation
- to maintain, in viable wild populations, the species and genetic diversity of wetland-dependent flora and fauna
- to maintain the abundance of waterbird populations, particularly migratory species
- to increase community awareness and appreciation of wetlands, and the importance of good management of wetlands and their catchments.

Environmental Protection of Wetlands Preliminary Position Statement

The *Environmental Protection of Wetlands Preliminary Position Statement* (Position Statement No. 4) (EPA 2004e) was developed by the EPA in 2004 and requires that:

- environmental values and functions of wetlands will not be adversely affected
- biological diversity of wetland habitats will be protected, sustained, and, where possible, restored
- environmental quality of the wetland ecosystems will be protected through sound management in accordance with the concept of 'wise use', and ecologically sustainable development principles
- no net loss of wetland values and functions are to occur.

Environmental Protection (Swan Coastal Plain Lakes) Policy 1992

Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 (EPP) prohibits degradation of any registered EPP lake without assessment by the EPA (EPA 1992). Lake Richmond is a registered lake under the EPP. The PER process is one EPA assessment tool for assessing impacts to an EPP lake.

Interim Recovery Plan No. 122: Thrombolite community of coastal freshwater lakes (Lake Richmond), interim recovery plan – 2003 – 2008

Interim Recovery Plans (IRPs) are developed within the framework outlined in Department of Conservation and Land Management Policy Statements Nos. 44 and 50 (CALM 2003b).

IRPs outline the recovery actions that are required to urgently address those threatening processes most affecting the ongoing survival of threatened taxa or ecological communities, and begin the recovery process.

The Interim Recovery Plan (to operate until it is replaced) provides guidance on the Objectives, Criteria for Success and Criteria for Failure for the Thrombolite community within Lake Richmond.

Guideline for the Determination of Wetland Buffer Requirements

The WAPC has developed a *Guideline for the Determination of Wetland Buffer Requirements* to assist land owners, developers, planners and architects in identifying appropriate buffering between wetlands and existing or proposed land uses that will enhance or maintain the significant attributes and values of the wetland (WAPC 2005b).

The EPA promotes that the requirements of wetland conservation can extend beyond reserve or wetland boundaries and that maintaining native vegetation around wetlands has a beneficial effect on water quality and aesthetics and is essential for wetland fauna.

As a general guide, a wetland function area is defined by the outer boundary of the wetland vegetation or the geomorphologic boundary, whichever is the larger (WEC 2002). A buffer of 50 m between intensive land uses and Conservation Category Wetlands and Resource Enhancement Wetlands is recommended (WAPC 2005b).

Stormwater Management Manual

The Stormwater Management Manual (DoW 2004-2007) was developed by the Government of Western Australia to provide a consistent approach to stormwater management, while considering a variety of stormwater management options to be considered by land developments across Western Australia. The manual provides case studies and planning approaches for the consideration of stormwater management at the early planning stages of a land development, with an emphasis on source controls, regulation and education.

The Stormwater Management Manual provides the minimum best management practice to be applied for the management of stormwater to land developments. The manual focuses on the need to integrate a range of stormwater management measures, including urban design principles to be considered within the framework of 'Water Sensitive Urban Design' that maximise local retention, reuse of stormwater and management of 'non-point source' pollutants.

7.2 Findings of surveys and investigations

7.2.1 Surface water hydrology of the Proposal area

The topography of the Proposal area varies between 0 and 8 mAHD (Figure 27). The site is higher in the south and west, due to the occurrence of a series of small rises that run in an approximate northeast to southwest direction. The Lake Richmond Outlet Drain runs through the site, along Memorial Drive (Figure 28).

The soils of the Proposal area and surrounds are Safety Bay Sands, which are known for their high permeability (Gozzard 1983). Because of this, rain falling in the area will infiltrate during storm events. Runoff is unlikely to occur, except perhaps during extreme events such as the 1 in 100 year rainfall event. Because of this and the general slope of the Proposal area towards the coast rather than Lake Richmond, and the presence of the Lake Richmond outlet drain on the site (Figure 28) runoff from the Proposal area would not currently enter the lake.

7.2.2 Lake Richmond

Lake Richmond is a perennial, freshwater lake occupying an area of approximately 49 ha and a depth of approximately 14 m (MWH 2011a), making it one of the deepest lakes in the Metropolitan area. The lake is thought to have been part of the Cockburn Sound and was isolated from the sea when part of the marine portion of Cockburn Sound was in-filled during the last 4000 years (CALM 2003b).

The interaction between Lake Richmond and groundwater changes over the year. During late winter and spring, the surface water levels in the lake rise faster than groundwater levels, and the lake discharges water to the north and west. During the summer and early autumn, the water level in the lake drops faster

than groundwater, and the lake receives water from groundwater on all sides. Between these times, groundwater flows through the lake, entering on the south and east and discharging to the north and west. Further information regarding this can be found in Section 6.2.4.

The lake also receives stormwater runoff from urban areas via three drains in the southern part of the lake (Figure 28) (MWH 2011a). It is estimated that approximately 1 GL/yr (1000 ML/yr) of stormwater enters the lake (MWH 2011b). There are no natural streams or creeks entering or leaving the lake. The outlet drain was constructed in 1968 (CALM 2003b) with inlet drains being constructed as the catchment became urbanised between this time and 2005.

The Lake Richmond Outlet Drain discharges water from the lake into Cockburn Sound when the water level exceeds the weir height of 0.58 mAHD. The weir also prevents seawater entering the lake during storm events, when sea levels rise.

Water levels in Lake Richmond have been monitored since 1946 and regular monitoring by DoW has occurred since 1978 (Figure 29). Water levels in the lake vary seasonally from between approximately 0.2 and 1.2 mAHD, with water levels generally peaking in spring and being lowest in summer/autumn, prior to the commencement of winter rainfall (MWH 2011a). Based on these levels, approximately 24.4 ha of the lake bed is considered to be seasonally inundated (i.e. inundated at the average high water level but not the average low water level (Table 9). Low water levels may vary by more than 0.3 m between years (Figure 29). High water levels are similarly variable between years (Figure 29).

Table 9 Lake Richmond average water levels and area inundated

Water level	Low	Mean	High	Annual variation
Average water level	0.2 mAHD	0.74 mAHD	1.2 mAHD	1 m
Area inundated (ha)	31.0	48.9	55.4	24.4

This change in water levels leads to the seasonal exposure of a significant area around the perimeter of the lake. Examples of this extrapolated from historical aerial photos show the historical extent of the lake waterbody, including high and low water levels as shown in Figure 30. In the higher water levels recorded, the thrombolites and some vegetation would be covered by water (Figure 30). At the low water levels, a portion of the area containing thrombolites would be covered in water.

Water quality in the lake is fresh, with values of between 400 mg/L and 1400 mg/L TDS being recorded (MWH 2011a). Prior to the construction of the drains, brackish salinity levels of 2000 mg/L to 3500 mg/L were recorded (Passmore 1970; CALM 2003b). The pH is slightly alkaline, and has varied between 8.3 and 9.3 (CALM 2003b).

Algal blooms have been previously recorded in the lake, including in 2002 and 2003 (Rose *et al.* 2004). One bloom sampled in September 2002 showed high levels of potentially toxic blue-green algae (*Microcystis* spp) (Naragebup 2003). Algal blooms are driven by elevated levels of the nutrients phosphorus and nitrogen (Hemond & Fechner-Levy 2000). No information was available on algal blooms in the lake since 2004.

The City of Rockingham is currently undertaking a Water Quality Study and developing an Integrated Catchment Management Plan for Lake Richmond.

Source:
Topographic data supplied by Landgate (2011)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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CAD Resources File No: g1937_MB_PER_F031.dgn

Proposal area topography

Figure No: **27**

Source:
Aerial Photography supplied by Landgate (2010)
Coordinate System: MGA94 Zone 50
Date: 10/1/2012
NB: Potential errors may occur in some areas

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CAD Resources File No:
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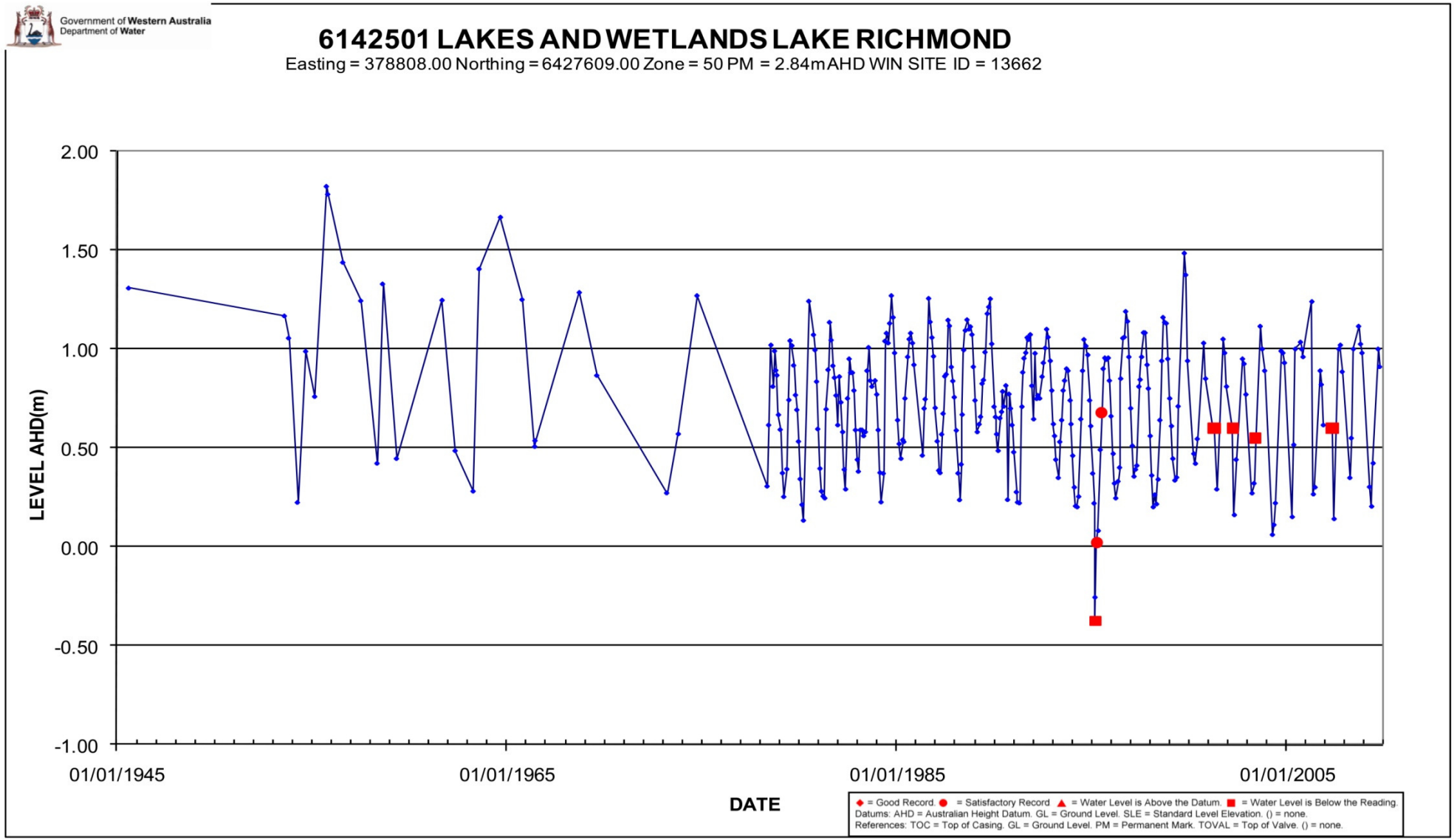
Surface water features and stormwater drainage

Figure No:
28



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Mangles Bay Marina Based Tourist Precinct

Lake Richmond historical surface water levels graph

Figure 29

strategen
Oct-2011

Source:
Aerial photography supplied by Landgate (2010)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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Lake Richmond historical surface water levels and extent of waterbody

Figure No:
30

Hydrology and Water Quality Monitoring Program

Lake Richmond has been monitored by MWH since January 2010, and monitoring is planned to continue until October 2011. This report includes monitoring results up to, and including, March 2011. The surface water investigations undertaken to date (MWH 2011b, provided in Appendix 5) include:

- depth transects of the lake
- lake water level monitoring using a datalogger
- monthly water quality monitoring at two sites; each sample is analysed for standard water quality (pH, EC, TDS, Na, K, Ca, Mg, Fe, Cl, SO_4, NO_3, HCO_3 and CO_3), TSS, DO, TN, TP, nitrite, RFP (subsequent anions), eight standard metals (As, Cd, Cu, Cr, Hg, Pb, Ni, Zn), hydrocarbons (TRH C_6 – C_{36}), turbidity (NTU) and colour
- monthly stratification monitoring at three sites in the lake with EC, pH, DO and temperature recorded at 1 metre depth intervals.

Monitoring locations are shown in Figure 32. Additional detail regarding the monitoring program and results can be found in Appendix 5.

Bathymetry and depth transects

Depth transects of Lake Richmond were undertaken by MWH in January 2010 (MWH 2011a). An additional detailed survey of the lake fringe bathymetry was undertaken by Strategen in August 2011 (Figure 30). Cross sections of Lake Richmond are provided in Figure 38, Figure 39, Figure 40 and Figure 41.

The lake has a comparatively flat, shallow edge between approximately 0 and 1.5 mAHD (Figure 30). Beyond this, a steep descent (generally greater than 1 in 6) occurs to a depth of -10 to -14 mAHD (MWH 2011a). The base in the middle of the lake appears to be relatively flat. Based on an average water level variation between 0.2 and 1.2 mAHD, the area of inundation in the lake would be expected to vary from between 31 ha and 55 ha over an average year.

Water levels

Water levels in the lake varied between approximately -0.1 and 0.85 mAHD over the monitoring period (MWH 2011a) (Figure 33). Water levels peaked in September 2010 following winter rains, and were at their lowest in March 2011 (Figure 33). Water levels were above the 0.58 mAHD level that allows water to flow out of the lake via the Outlet Drain between July and November 2011 (Figure 33). A July to November flow period was also recorded in 2002 (Naragebup 2003). The long-term average water level in the lake is 0.74 m (MWH 2011d) (Figure 29).

Water quality

Water quality was monitored monthly at two locations within the lake, and on one occasion at the stormwater outlet over the period January 2010 to March 2011 (Figure 32). The lake was generally alkaline, with pH varying between 7.6 and 9, which can be expected given the high concentrations of calcium carbonate (lime) in the local soils (MWH 2011a). The water was slightly brackish, with salinity between 520 and 660 mg/L (MWH 2011d).

Table 10 ANZECC/ARMCANZ (2000) guidelines for water quality in slightly disturbed ecosystems in south west Australia

Item	Freshwater lake guideline (mg/L)	Wetland guideline (mg/L)	Lake Richmond (average and maximum) (mg/L)
Total Phosphorus (TP)	0.01	0.06	0.02 0.03
Total Nitrogen (TN)	0.35	1.5	0.92 1.9

Nitrogen and phosphorus are important environmental chemicals, in that they provide nutrients for biological growth. However, elevated nitrogen and phosphorus concentrations can result in algal blooms, such as the *Microcystis* blooms that have occurred in the lake (Ecoscape 2008). Water quality in the lake exceeded the ANZECC/ARMCANZ (2000) guidelines for TN and TP in freshwater lakes in slightly disturbed ecosystems in south west Australia (Table 10). This is consistent with the results of Naragebup (2003), which noted that nitrogen and phosphorus levels in the lake exceeded the ANZECC guidelines with respect to nitrogen and phosphorus. This is not surprising given the urban nature of the surrounding areas and volumes of urban stormwater entering the lake. Nitrogen and phosphorus in the lake are likely to come from stormwater and groundwater from urbanised areas, due to the use of fertilisers on gardens and POS.

Stratification monitoring

Stratification monitoring was undertaken at three locations within the lake to determine whether the chemical and physical properties of the lake varied with depth (Figure 32) (MWH 2011d). This is an important parameter for deep lakes, such as Lake Richmond, where physical and chemical properties may vary significantly with depth. These changes may represent a lake interacting with saline water or represent changes in physical processes with depth that may impact on the behaviour of the lake. Properties may vary over the year due to changes in air temperature; solar radiation; degree of mixing due to wind; and, groundwater salinity following rainfall. All three locations showed similar results. Results for Site 2 are discussed under this heading. Results for all sites are provided in Appendix 5.

Lake Richmond appears to be a comparatively well mixed lake, with pH, temperature and EC remaining relatively stable above -10 mAHD, except during the summer months (MWH 2011d). Temperature in the lake varied between approximately 14 and 28°C, with deeper waters being a few degrees cooler than shallower waters in summer (Figure 34). There is a slight decrease of pH from approximately 9 to 7(Figure 35) and an increase in EC from 0.9 mS/cm (approximately 550 mg/L TDS) to 1.4 mS/cm (approximately 840 mg/L TDS) (Figure 36) with depth. While salinity at the bottom of the lake is slightly brackish, it is well below the salinity of seawater at approximately 35 000 mg/L.

Between January and April, a layer of more saline, alkaline and less oxygenated water occurs in the lower four metres of the lake. This appears to disappear in autumn, possibly due to increased wind mixing or freshwater inputs.

Functional Ecology

Thrombolites

The Thrombolite TEC is an association of microorganisms that aggregate in rock-like formations, formed by the deposition of calcium carbonate during growth and metabolic activity within the community micro-environment (Figure 31) (Moore 1991). The area of thrombolite habitat is not well defined. No formal mapping of the thrombolites has occurred (English V [DEC] 2011, pers. comm. 26 September).

Thrombolite structures at Lake Richmond occur from perhaps 0 mAHD to within the vegetated fringe of the lake (CALM 2003b). Old stranded thrombolites (no longer living) have been reportedly identified immediately to the east of Lake Richmond (CALM 2003b). It is therefore difficult to establish the veracity of the area covered by the active community or the ecological water requirements of the thrombolites. It is inferred that at least seasonal inundation and seasonal drying is required for thrombolites to persevere.

An unconfirmed observation made by a member of the public indicates that the Thrombolites have also established near the weir in the Lake Richmond Outlet Drain, since this was constructed in 1968. Whilst this is unsubstantiated (due to water levels being too high during the writing of this PER) (this potentially indicates that the community is capable of colonising new areas over time.

The survival and growth of the community is considered to be dependent upon light and a continuing supply of fresh water which is rich in calcium and bicarbonate/carbonate (ESSS 2007). Groundwater in the area contains these chemical components as a result of the dissolution of the shell fragments commonly found in the Safety Bay Sands (Davidson 1995). The thrombolites at Lake Richmond appear to

be adapted to fresh or brackish water, and would be unlikely to survive major increases in salinity (ESSS 2007).

Sedgelands in Holocene dune swales

The Sedgelands TEC occurs in linear damplands and occasionally sumplands between Holocene dunes. The TEC is not limited to Lake Richmond, occurring at eight locations in the Rockingham Becher Plain area and at two other locations in the South West, with a total estimated area of 130 ha (CALM 2002). Approximately 11 ha of this TEC occurs in a band around the edge of Lake Richmond (CALM 2002). This band extends to the edge of Safety Bay Road.

Hydrological regime is considered to be the primary non-biological factor that influences the characteristics of this TEC (CALM 2002). Depth, timing and duration of flooding and length of the dry period affect vegetation composition and distribution (CALM 2002). Sedgelands in damplands and sumplands of the Holocene dune swales have relatively specific water regime requirements to maintain current biology, but are tolerant of seasonal and longer-term variations that reflect natural climatic patterns. Maintenance of water level and quality is considered critical for this TEC (CALM 2002).

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Thrombolites at Lake Richmond

FIGURE 31

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Fauna

Aquatic vertebrates in Lake Richmond were surveyed by Rose (1998) and Rose *et al.* (2004). The 2004 survey found that the native *Pseudogobius olorum* (Swan River goby) was the most common species (Rose *et al.* 2004). The feral *Gambusia holbrooki* (mosquito fish) was also recorded in large numbers, and one native *Mugil cephalus* (sea mullet) was also caught (Rose *et al.* 2004). Feral *Carassius auratus* (goldfish) were also considered likely to be present in the lake.

Rose *et al.* (2004) also noted the presence of numerous introduced *Cherax destructor* (yabbies) in the lake, which "were observed coming out of holes that they had presumably constructed, within the thrombolites".

Five species of amphibians have also been observed in the area (ENV 2011a).

The minimal impacts modelled to occur to water levels in Lake Richmond, are not sufficient to impact these species.

Additional information regarding fauna in the Lake Richmond area can be found in Section 9.2.2.

Conservation Status and Buffers

Lake Richmond is listed as an EPP lake and as a Conservation Category wetland in the Geomorphic Wetlands of the Swan Coastal Plain dataset. Conservation Category wetlands are considered to support a high level of ecological attributes and functions. Lake Richmond is not listed under the Directory of Important Wetlands in Australia (Commonwealth) or List of Wetlands of International Importance of the Ramsar Convention (Commonwealth).

7.2.3 Rotary Park Lake

A small, artificial lake called Rotary Park Lake is located approximately 300 m east of the eastern boundary of the Proposal (Figure 1). The lake is a permanent water body maintained by City of Rockingham and has aesthetic value but little environmental value. The lake also has a drainage function (Ecoscape 2009). Ecoscape (2009) recorded a brackish salinity of 2220 to 2230 mg/L in this lake.

Rotary Park Lake is not listed as an EPP lake. It is not included in the Geomorphic Wetlands of the Swan Coastal Plain dataset.

Because of the limited size, limited environmental value of the lake and the limited potential for the Proposal to impact the lake, it was not monitored as part of this Proposal.

Source: Aerial Photography supplied by Landgate (2010)
Water monitoring data supplied by MWH (2010)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F024.dgn

Surface water monitoring locations and transects

Figure No: **32**

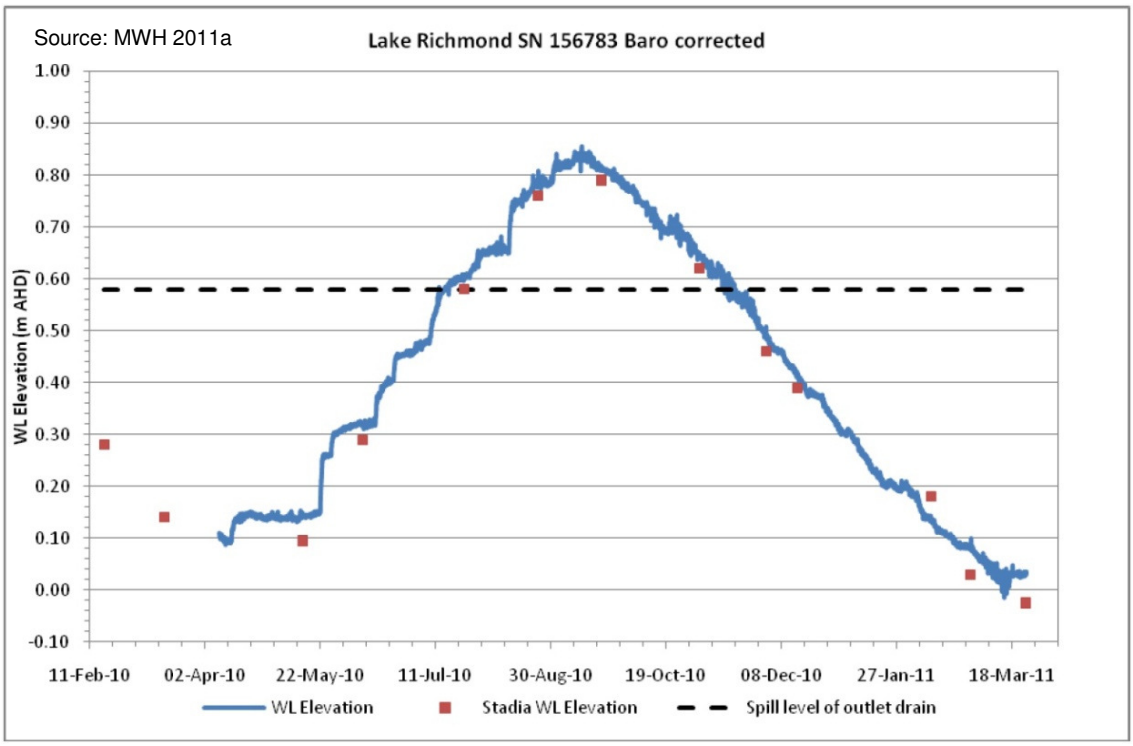


Figure 33 Lake Richmond surface water levels during monitoring

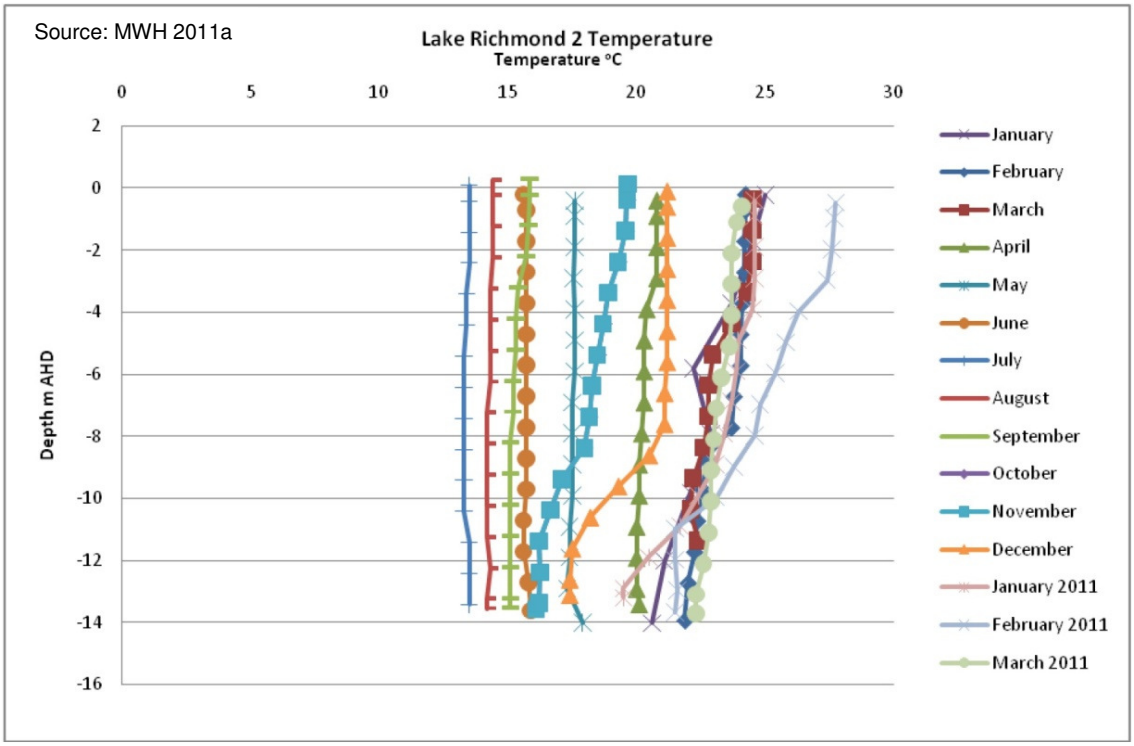


Figure 34 Lake Richmond temperature profiles during monitoring (Site 2)

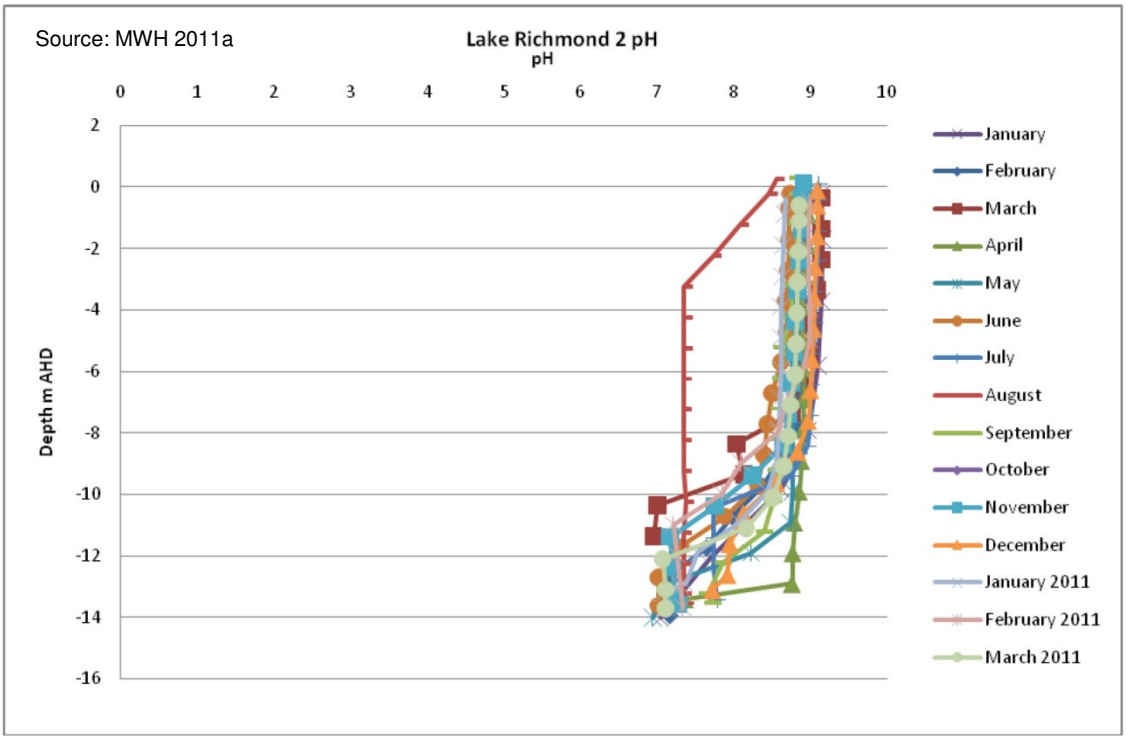


Figure 35 Lake Richmond pH profiles during monitoring (Site 2)

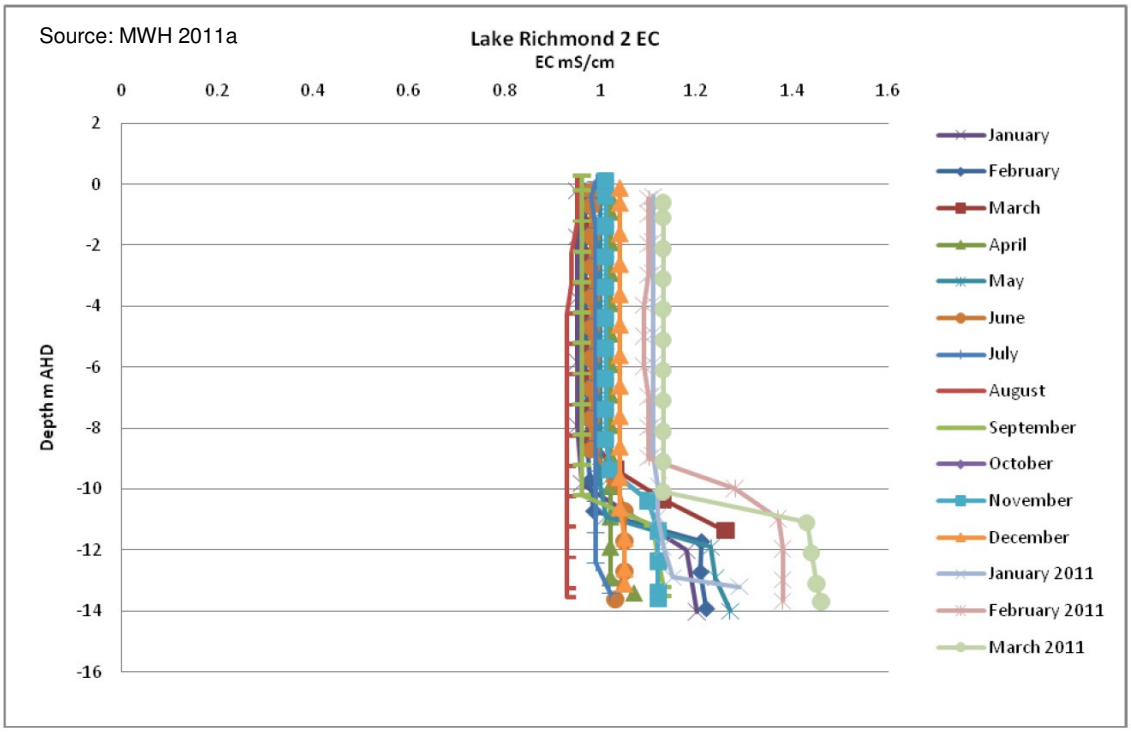
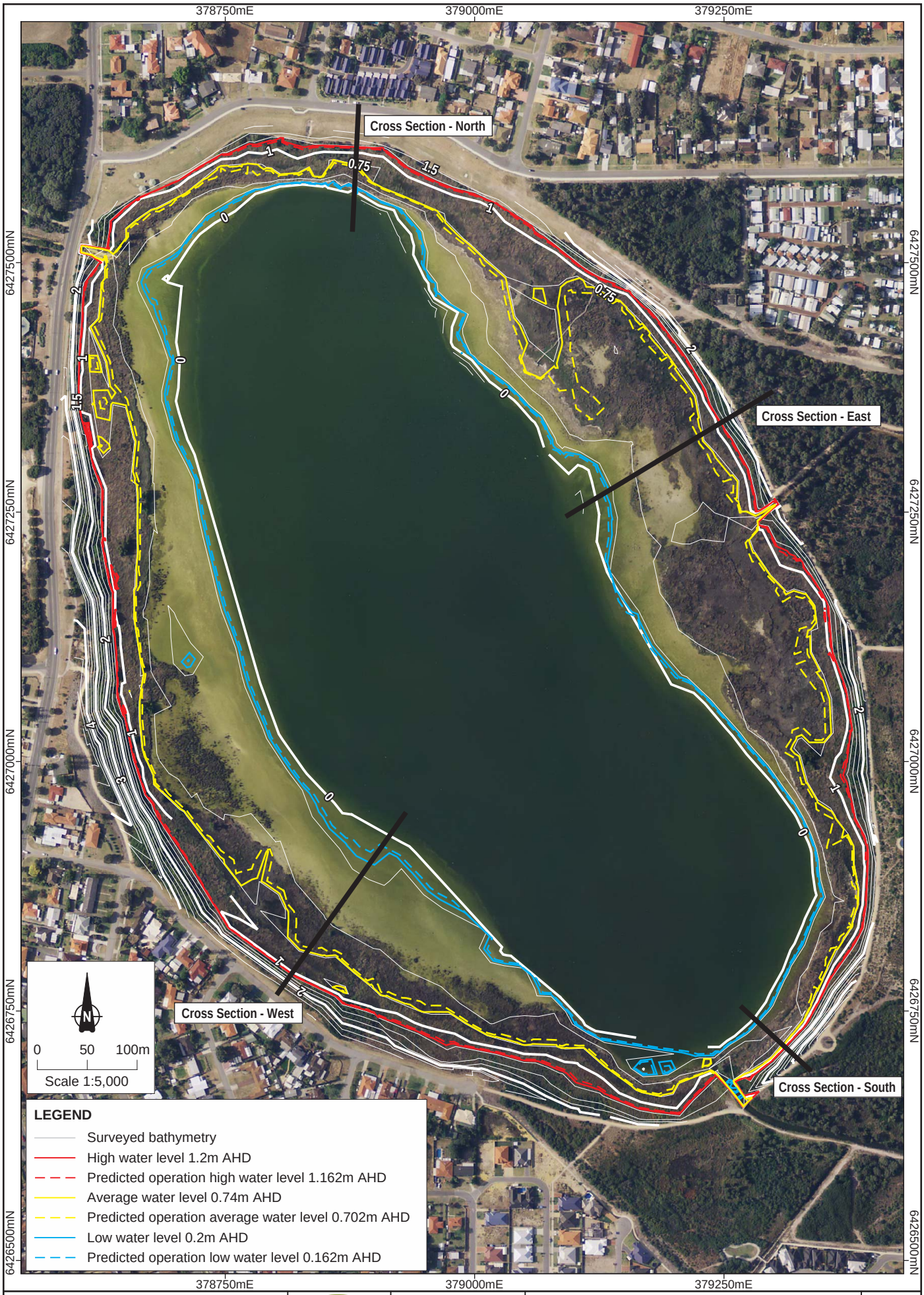


Figure 36 Lake Richmond electrical conductivity profiles during monitoring (Site 2)



Source:
Aerial photography supplied by Landgate (2010)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011
NB: Potential errors may occur in some areas

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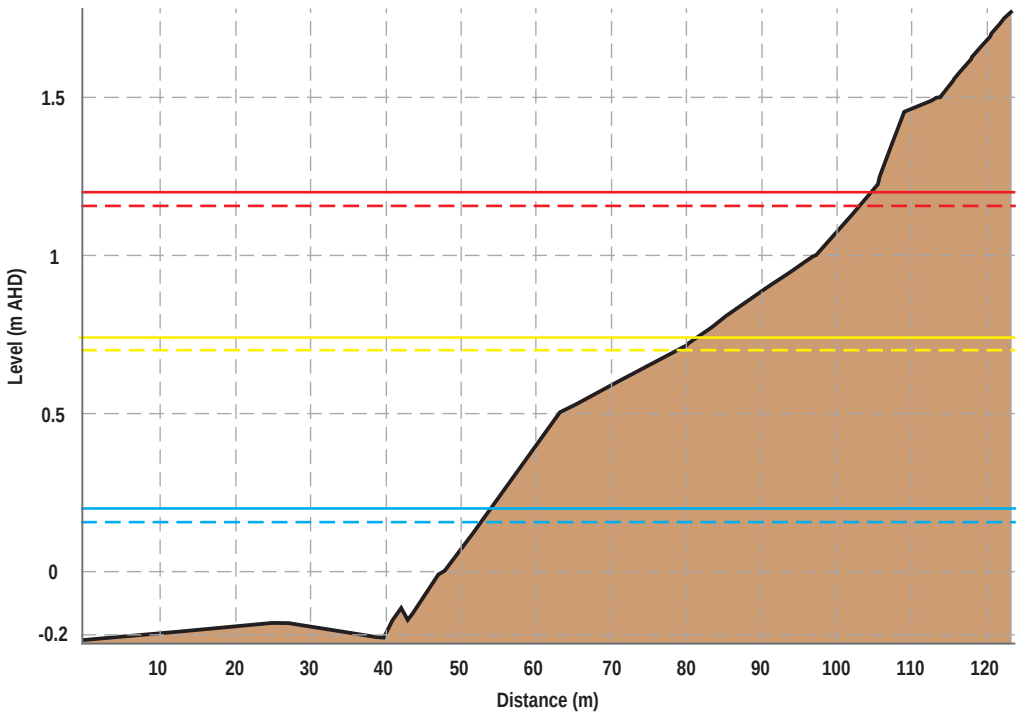
Predicted operational impact on Lake Richmond water levels

Figure No:
37



0 40m
Horizontal Scale 1:1,000

0 1m
Vertical Scale 1:40,000

LEGEND

- Surveyed bathymetry
- High water level 1.2m AHD
- Predicted operation high water level 1.162m AHD
- Average water level 0.74m AHD
- Predicted operation average water level 0.702m AHD
- Low water level 0.2m AHD
- Predicted operation low water level 0.162m AHD

Source:
Bathymetry supplied by ST Spatial
Date: 12/10/2011
NB: Potential errors may occur in some areas

STRATEGEN
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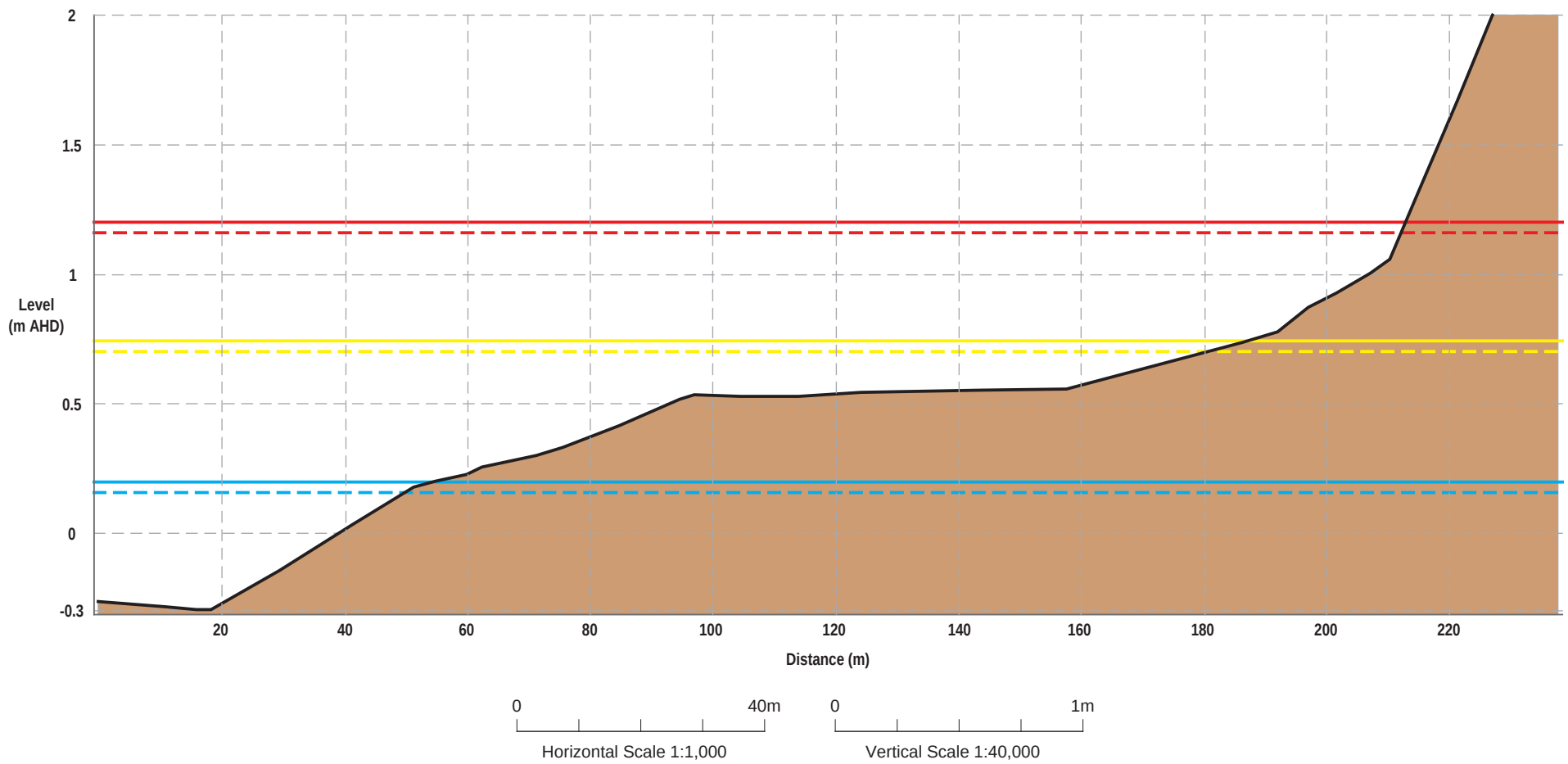
CAD Resources

CAD Resources File No:
g1937_MB_PER_F048.dgn

Lake Richmond cross section north

Figure No:
38



LEGEND

- Surveyed bathymetry
- High water level 1.2m AHD
- Predicted operation high water level 1.162m AHD
- Average water level 0.74m AHD
- Predicted operation average water level 0.702m AHD
- Low water level 0.2m AHD
- Predicted operation low water level 0.162m AHD

Source:
Bathymetry supplied by ST Spatial
Date: 12/10/2011
NB: Potential errors may occur in some areas

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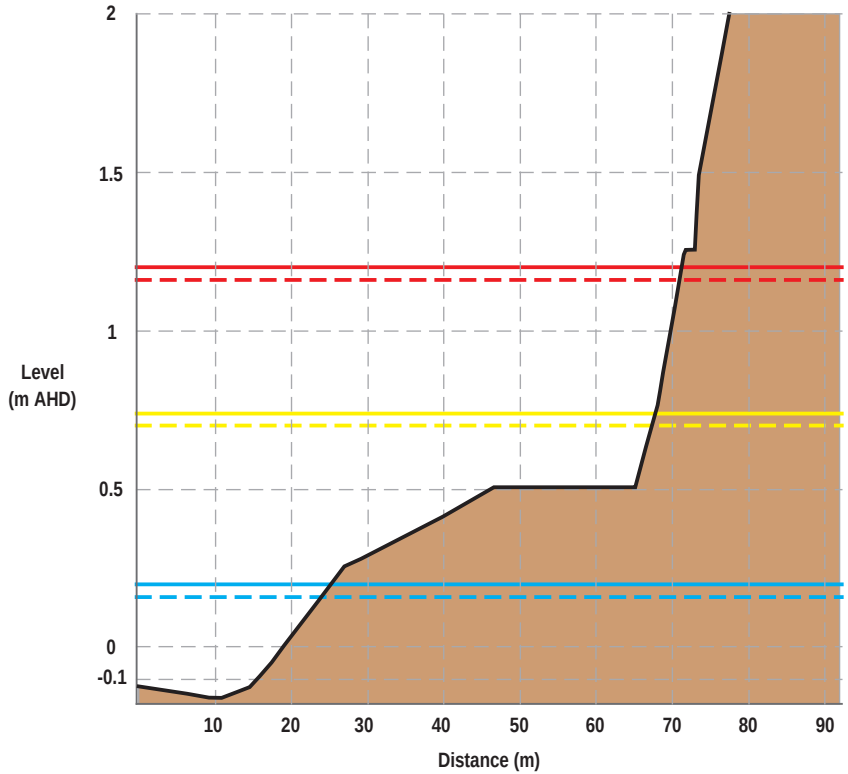
CAD Resources

CAD Resources File No:
g1937_MB_PER_F049.dgn

Lake Richmond cross section east

Figure No:
39



0 40m

Horizontal Scale 1:1,000

0 1m

Vertical Scale 1:40,000

LEGEND

- Surveyed bathymetry
- High water level 1.2m AHD
- Predicted operation high water level 1.162m AHD
- Average water level 0.74m AHD
- Predicted operation average water level 0.702m AHD
- Low water level 0.2m AHD
- Predicted operation low water level 0.162m AHD

Source:
Bathymetry supplied by ST Spatial
Date: 12/10/2011
NB: Potential errors may occur in some areas

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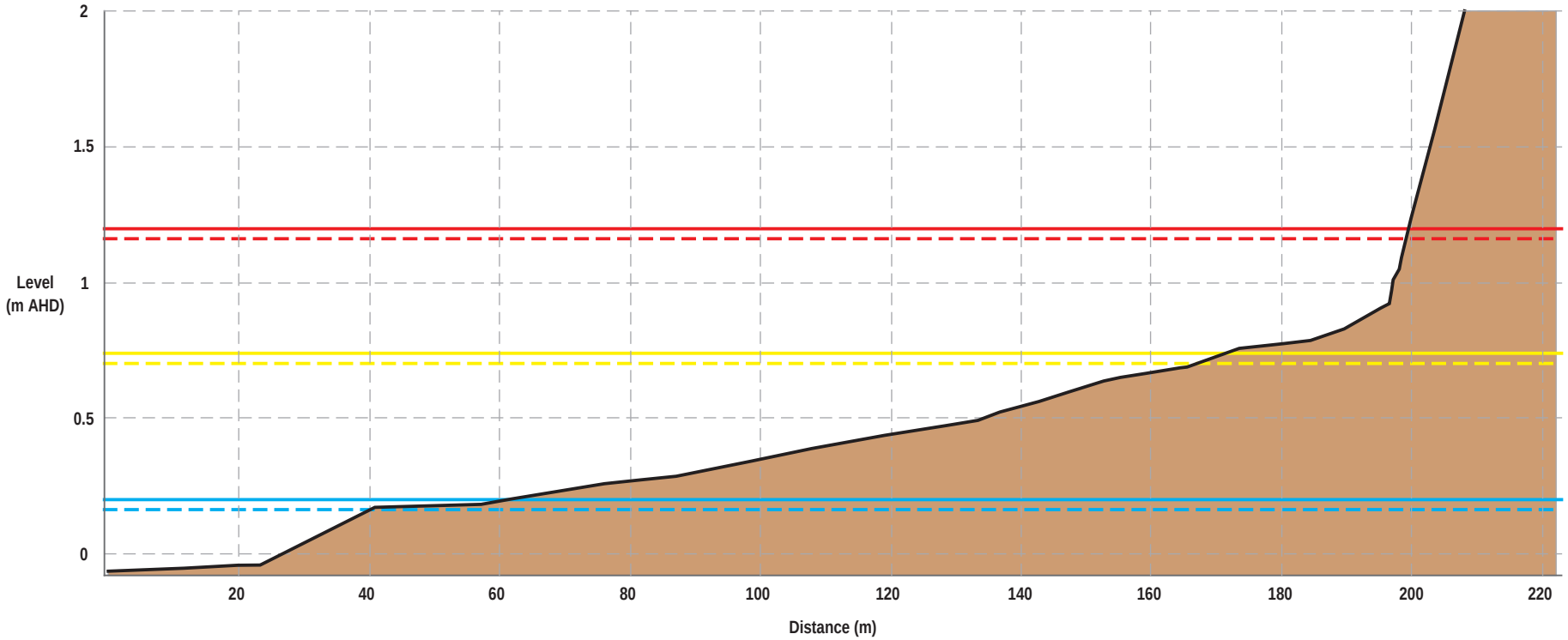
CAD Resources File No:
g1937_MB_PER_F050.dgn

Lake Richmond cross section south

Figure No:
40



0 40m
Horizontal Scale 1:1,000

0 1m
Vertical Scale 1:40,000

LEGEND

- Surveyed bathymetry
- High water level 1.2m AHD
- Predicted operation high water level 1.162m AHD
- Average water level 0.74m AHD
- Predicted operation average water level 0.702m AHD
- Low water level 0.2m AHD
- Predicted operation low water level 0.162m AHD

Source:
Bathymetry supplied by ST Spatial
Date: 12/10/2011
NB: Potential errors may occur in some areas

STRATEGEN
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CAD Resources File No:
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Lake Richmond cross section west

Figure No:
41

7.3 Evaluation of options or alternatives to avoid or minimise impact

The most effective way of minimising the long-term impact of the Proposal on surface water is to minimise the impact of construction by utilising a wet construction method, which avoids the need for dewatering during construction, as described in Section 6.3.1.

Stormwater from the Proposal area will not enter Lake Richmond, but will be treated and infiltrated onsite or discharged to the ocean. The Proposal will be connected to reticulated sewerage in line with Department of Health requirements.

7.4 Assessment of likely direct and indirect impacts

The main environmental value of surface water in the Mangles Bay area is supporting the ecology and aesthetics of Lake Richmond. The following aspects of the Proposal may potentially impact on the values of Lake Richmond:

- the construction and operation of the marina waterbody will lower regional groundwater levels drawdown which may lead to:
  - lowering of water levels in Lake Richmond
  - exposure of ASS if they exist around Lake Richmond
- saltwater intrusion caused by the inland movement of the saltwater-groundwater (fresh) interface due to the inland marina
- impacts to water quality, other than salinity
- increased population as a result of development may increase indirect impacts on Lake Richmond through uncontrolled access, rubbish and domestic pets
- impacts to Lake Richmond functional ecology
- impacts to Rotary Park Lake. .

Issues associated with ASS are discussed in Section 20. Potential impacts of stormwater runoff from the development into the marine environment are discussed in Section 10.

The edge of the lake includes two TECs that are protected under the EPBC Act. These are “Sedgelands in Holocene dune swales of the southern Swan Coastal Plain” and “Thrombolite (microbial) community of coastal freshwater lakes of the Swan Coastal Plain (Lake Richmond)”. Changes in surface water levels and quality in Lake Richmond may impact upon these communities.

7.4.1 Impact to Lake Richmond groundwater and surface water levels

The development will result in a slight decrease in groundwater levels at Lake Richmond of 0.032 m (3.2 cm) during construction and 0.038 m (3.8 cm) during operation (Section 6.3.5). Assuming that a change in groundwater levels leads to an equivalent change in lake water levels (a worst-case scenario), this would result in a decrease in lake levels of 0.032 m (3.2 cm) during construction and 0.038 m (3.8 cm) during operation. As the Proposal potential construction impacts are smaller and shorter-term than the operational impacts, the following section focuses on the operational impacts.

The annual variation in lake water level is approximately 1 m, and thus this change is less than 4% of the annual variation in lake water levels. The 0.038 m (3.8 cm) change is significantly less than the inter-annual variation in high and low water levels of 0.3 m discussed in Section 7.2.2. Thus the impacts on lake water levels are comparatively small (Table 11). The change in areas inundated in low, mean and high scenarios is similarly small, with 1.3 ha of additional area exposed due to the drop in water level at mean water level and 0.3 ha no longer experiencing inundation at a high water level (Table 11). These changes account for less than 6% of the area seasonally inundated (Table 11).

Table 11 Operational impact on Lake Richmond water levels and area inundated

Water level	Low	Mean	High
Current average water level	0.2 mAHD	0.74 mAHD	1.2 mAHD
Average water level with operational impacts (mAHD)	0.162 mAHD	0.702 mAHD	1.162 mAHD
Area currently inundated (ha)	31.0	48.9	55.4
Predicted area of inundation with operational impacts (ha)	30.5	47.6	55.2
Decrease in area inundated (ha)	0.5	1.3	0.27
Decrease as a percentage of the area seasonally inundated	1.6%	2.66%	0.48%

A series of cross sections were developed to show the impact of these changes on the lengths of shoreline exposed on the north, east, south and west sides of the lake (Figure 38 to Figure 41). The locations of the cross sections are shown on Figure 37. In each location and water level change, the maximum difference in terms of length of shoreline exposed is less than 5 m in summer (dry) (Figure 38 to Figure 41), with the difference in shoreline exposed being less than 2 m on average.

7.4.2 Impact to saltwater interface

Groundwater modelling of the Proposal shows no change in groundwater salinity at Lake Richmond as a result of the Proposal (Section 6.3.6). Within the Safety Bay Sand Aquifer, the saltwater interface will not approach within 500 m of the lake (Section 6.3.6). Hence the saltwater interface will not enter the lake, and thus the salinity of the lake is not considered to be impacted by the Proposal.

7.4.3 Impacts to water quality other than salinity

Surface water present in the lake is a mixture of groundwater and stormwater. The local groundwater is high in the calcium and carbonate/bicarbonate considered necessary for thrombolite growth, because of the high levels of calcium carbonate in the Safety Bay Sands. The movement of groundwater through the soils results in the dissolution of small amounts of calcium carbonate. This dissolution of this carbonate/bicarbonate material causes the lake to be slightly alkaline (pH 7.6 to 9). The proposal retains the current groundwater flow patterns and hence this dissolution of calcium carbonate The Proposal is therefore not expected to alter the pH of the lake.

Stormwater from urban areas may contain herbicides, pesticides and fertilisers. To manage the potential impacts of these pollutants, the DoW requires that stormwater is treated prior to infiltration or discharge through the use of mechanisms such as swales and gross pollutant traps (DoW 2004 – 2007). These measures will be used in the Proposal area to minimise the amount of these pollutants leaving the site.

Stormwater from the Proposal area will not enter Lake Richmond. In small rainfall events (less than the 1 in 1 year event) stormwater from roads will be infiltrated within the Proposal area through the use of Best Management Practices (BMPs) such as soakwells, swales and/or underground infiltration cells in a manner consistent with Water Sensitive Urban Design and the Stormwater management manual (DoW 2004 - 2007). These BMPs act as treatment mechanisms as well as infiltration measures. Rainfall events less than the 1 in 1 year event constitute 99% of the volume of rainfall (DoW 2004 - 2007). The infiltrated stormwater will recharge the groundwater table. A small portion of the infiltrated stormwater may enter the lake via groundwater flow, under circumstances of summer rainfall and a portion of the infiltration is positioned to south of the Proposal area, but the predominant flow direction for groundwater will remain towards Mangles Bay (Section 6).

Rainfall on future residential lots will be managed through the use of soakwells and/or rainwater tanks in smaller rainfall events with the potential for overflow to the road drainage system in larger events.

Treated stormwater will be infiltrated in smaller events. Options for stormwater management in larger events are subject to investigation. In larger events, stormwater may be discharged into Mangles Bay through the marina, as currently occurs at Port Bouvard and Mandurah Ocean Marina. Alternatively, water may be discharged into the realigned Lake Richmond Outlet Drain into Mangles Bay. Stormwater drainage will be treated prior to discharge. Drainage from the Proposal area will not enter Lade Richmond

or existing native vegetation. A combination of these options may also be used. The design will be outlined in the LWMS that will accompany the LSP, as required by *Better Urban Water Management* (WAPC and DPI 2008). Detailed design will be provided in the Urban Water Management Plans that will accompany subdivision plans.

Wastewater will be collected through a reticulated (piped) sewerage system, connected to the Water Corporation sewerage system.

Stormwater from an urban development can contain higher levels of nutrients and contaminants such as hydrocarbons and heavy metals than surface water or groundwater from bushland areas (DoW 2004-2007). Vegetated detention areas and gross pollutant traps will be used to treat stormwater prior to reduce nutrient and contaminant concentrations, prior to infiltration or discharge. The Proponent is also proposing to undertake rehabilitation around the lake, which will assist in improving water quality.

Because of the use of water treatment structures and infiltration to treat stormwater and limited impacts of increased population, stormwater from the Proposal is not expected to impact upon non-salinity water quality at Lake Richmond, including nutrient levels. The Proposal is therefore not expected to cause increased frequency of algal blooms or other water quality problems at the lake.

7.4.4 Moving of the Lake Richmond Outlet Drain

The current alignment of the Lake Richmond Outlet Drain is located within the Proposal area (Figure 28). The open drain will therefore need to be moved as part of the Proposal (Figure 28). The drain will be realigned as a piped drain along Hymus Street.

It is considered that the moving of the Lake Richmond Outlet Drain associated with the Proposal will not significantly impact on water levels in the lake. Any changes to the Outlet Drain will be undertaken in a manner that minimises the impact to any thrombolites present around the weir.

The need to move the Outlet drain provides a degree of complexity due to the presence and proposed duplication of the Water Corporation's SDOOL. The intersection of the outlet drain and the SDOOL will require further engineering design with both operating at a similar topographical level. This detail will be managed during the town planning phase of the project; however, it provides a potential mitigation option for Lake Richmond whereby the height of the weir could be raised, thus providing an increase in the maximum height of water in the lake.

7.4.5 Impacts on Lake Richmond due to increased population

The Lake Richmond portion of the RLRP is currently impacted by human activities, including pedestrian and dog access to Lake Richmond (DEC 2010a). These activities can impact upon water quality in the lake through rubbish disposal and unauthorised access to the lake.

The Proposal will result in an increased human population in the area, which is likely to result in increased pedestrian and pet movements in the RLRP. However, the change in population is not considered significant when compared to the broader increase in population in the area. The estimated increase in population due to the Proposal is 1500 to 2000 persons. This is relatively small compared to the estimated increase in the population of the City of Rockingham from 106 000 in 2011 to 165 000 in 2031 (CoR 2011).

The residents of the Proposal area are more likely to access the Lake Richmond area than those who live further away. However, the residents of the Proposal area are less likely to have dogs than other residents, as the lot sizes will be significantly smaller (mostly townhouses and apartments) than the existing lots in the area, which are predominantly free standing houses on larger lots. While the population will increase, the associated impact of people and their pets visiting the lake is likely to be small, due to the large area available for recreation at Cape Peron.

It is therefore considered that the increase in population associated with the Proposal will not significantly impact on water quality in the lake.

7.4.6 Impacts to Lake Richmond functional ecology

The impacts to water levels in Lake Richmond associated with the Proposal are considered unlikely to impact upon ecological water requirements for the TEC FCT 19 Sedgelands in Holocene Dune Swales on the Swan Coastal Plain (Section 8.4). The impact is comparatively small in terms of reduction in water levels (0.038 m) and is therefore considered highly unlikely to alter species composition by drawing water below the rooting level of local plants. This drop is also within the 0.3 m inter-annual variation in low water levels observed in the lake.

The *Interim Recovery Plan No. 122: Thrombolite community of coastal freshwater lakes (Lake Richmond), interim recovery plan – 2003 – 2008* (CALM 2003b) lists the following criteria for success and failure.

Criteria for success:

- maintenance of water quality and levels in Lake Richmond
- maintenance of the vigour and extent of the microbial community including maintenance of the composition of the microbial species
- an increase in the area of this community or its catchment area under conservation management.

Criteria for failure:

- significant and sustained detrimental changes to water quality or levels in Lake Richmond
- significant decline in area as measured by physical damage or loss of thrombolite structures
- decline in health as measured by a major shift in composition of the microbial community.

The TEC thrombolite community is assessed as not being impacted by the predicted changes to water level, which, whilst sustained, is not significant in terms of the current variability of the lake. Low water levels are experienced at Lake Richmond during the summer months (March to April) (CALM 2003b) where little to no recharge of the lake occurs from direct rainfall or stormwater runoff into Lake Richmond. As shown in Figure 38 to Figure 41 the largest impact from the change in water levels (0.038 m) in terms of shoreline exposure will be experienced during the drier months (March to April). Whilst the full extent of the thrombolite community is unknown, visible thrombolites are already exposed during these months and therefore a minor increase in additional exposure of shoreline is unlikely to impact the community.

As the groundwater flow direction is not expected to change as a result of the Proposal, groundwater will still flow through soils high in calcium and carbonate/bicarbonate which is considered necessary for thrombolite growth. The dissolution of this carbonate/bicarbonate material is what causes the lake to be slightly alkaline (pH 7.6 to 9). The Proposal is therefore not expected to alter the pH of the lake. The salinity of the lake is also not expected to change. The water quality experienced by the Sedgelands and Thrombolite TECs is therefore not expected to be impacted.

It is therefore considered that the Proposal will not impact upon the factors considered important for continued survival of thrombolites.

Impacts to wetland fauna species, including migratory birds, are discussed in Section 9.5 (Fauna) and Section 15.4 (Matters of NES).

7.4.7 Impacts to Rotary Park Lake

The Proposal is considered unlikely to result in changes in groundwater levels at Rotary Park Lake (Figure 17 and Figure 25). The park is currently on the edge of the groundwater saline intrusion zone, however the groundwater salinity (and hence lake water salinity) in the park may increase (Section 6.3). This may alter the species present in the park. This is not considered to be a significant impact as the lake is artificial and does not have significant environmental values.

7.5 Potential for and nature of any cumulative impacts

Cumulative impacts of the Proposal being constructed and operating at the same time as Water Corporation's SDOOL duplication project are discussed in Section 6.3.1. Modelling indicates that any cumulative impact would be largely due to the SDOOL duplication and that mitigation of these impacts would therefore be the responsibility of that project.

It is noted that there are no other known projects that may negatively impact upon water levels and quality in the area.

7.6 Management measures and performance standards

7.6.1 Proposed mitigation measures

Management measures will be undertaken to minimise the impact of the Proposal on Surface Water. These management measures will include:

- minimising the amount of dewatering associated with the Proposal
- undertaking rehabilitation within the Proposal area and within the proposed service corridor
- utilising best management practices to treat stormwater prior to infiltration or discharge in line with the Stormwater Management Manual (DoW 2004-2007).

A LWMS will be submitted with the LSP for the development outlining the details of the measures to be undertaken to manage stormwater water quality and quantity in the development.

A CEMP addressing the protection of the environmental values of Lake Richmond can be found in Appendix 5.

7.6.2 Possible mitigation through raising of weir

The height of the weir wall on the Lake Richmond Outlet Drain is currently 0.58 mAHD. The weir controls the outflow of water from the lake as surface water. Water currently overtops the weir for approximately four to eight months per year, depending on rainfall. Increasing the weir height and decreasing the width of the weir would decrease the amount of water leaving the lake as surface water each year.

While the primary source of water lost to the lake is considered to be groundwater, reducing surface water outflows may partially offset the decrease in water levels associated with the Proposal. Increasing the weir height would increase water levels during the winter period when water levels may be above the top of the weir. However, once the water level falls below 0.58 mAHD, the change would not have an effect. The effectiveness of the changes to the weir would need to be modelled through the use of combined surface water – groundwater modelling to confirm the effectiveness of such a mitigation option.

Any changes to the weir would need to be discussed and approved by the City of Rockingham, Water Corporation, DEC, DoW and DSEWPaC. As such, the potential raising of the weir should be considered as a possible mitigation option, depending on the views of these agencies.

7.6.3 Lake Richmond buffer management

The edge of the wetland vegetation at Lake Richmond can be considered to be the edge of the wetland boundary. The western side of the lake, corresponds with the edge of Safety Bay Road and is due to the presence of the road and cleared areas to the western side of the road. To the north of the lake, the wetland area is bounded by a grassed area and then Lake Street and residential development. The residential development and cleared areas are within 50 m of the edge of the wetland area. A 50 m buffer from the edge of the wetland vegetation can be considered to be the acceptable standard for a Conservation Category Wetland (WAPC 2005b).

The only non-conservation land use proposed within 50 m of the wetland area is the proposed service corridor. Where clearing is not necessary for access purposes, this area is planned to be rehabilitated following service construction, pending Water Corporation approvals for the SDOOL duplication. A section of the existing Water Corporation service easement at Lake Richmond is vegetated and was rehabilitated following works on the SDOOL in 2005/6.

As the 50 m buffer will generally be retained intact and rehabilitation will occur, the impact of the proposal upon the integrity of the buffer of Lake Richmond is considered to be minimal.

7.7 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

The Proposal is expected to result in the following outcomes in relation to surface water:

1. The Proposal is likely to result in a decrease of water levels in Lake Richmond of 0.032 m during construction and 0.038 m during operation. This decrease is not considered to significantly impact the ecology of the lake.
2. The change in the location of the saltwater interface within the groundwater will not impact upon Lake Richmond during construction or operation of the Proposal.
3. The moving of the Lake Richmond Outlet Drain will not impact upon water levels in the lake.
4. Stormwater from the Proposal will not directly enter the lake and hence there will be no change in surface water quantities or quality entering the lake, or the current hydraulic performance of the lake, as a result of the Proposal.
5. The increased population in the Lake Richmond area as a result of the Proposal is not expected to significantly impact upon the lake.
6. The Proposal is not expected to significantly impact upon the TECs present at Lake Richmond.
7. As the 50 m buffer will generally be retained intact and rehabilitation will occur, the impact of the proposal upon the integrity of the buffer of Lake Richmond is considered to be minimal.
8. The Proposal will not impact upon lake water quality, and hence will not result in an increase in the frequency of algal blooms in the lake.
9. The Proposal is not expected to have an impact on the function and ecology of Lake Richmond.

These impacts are considered to be acceptable as the key environmental values of Lake Richmond will not be significantly affected by the Proposal.

8. Terrestrial flora and vegetation impact assessment

8.1 Relevant environmental objectives, policies, guidelines, standards and procedures

8.1.1 EPA objectives

The EPA applies the following objective in its assessment of proposals that may affect vegetation and flora:

To maintain the abundance, species diversity, geographic distribution and productivity of flora and fauna at species and ecosystems levels through the avoidance or management of adverse impacts and improvements in knowledge.

EPA Position Statement No. 2

EPA Position Statement No. 2 (EPA 2000a) provides an overview of the EPA position on the clearing of native vegetation in Western Australia. Principles and related objectives and actions have been adopted from national strategies in the development of this Position Statement. In assessing a proposal, the EPA will take into account the following principles when considering impacts on vegetation:

- comparison of proposal scenarios, or options, to evaluate protection of biodiversity at the species and ecosystems levels, and demonstration that all reasonable steps have been taken to avoid disturbing native vegetation
- no known species of plant or animal is caused to become extinct as a consequence of the proposal and the risks to threatened species are considered to be acceptable
- no association or community of Indigenous plants or animals ceases to exist as a result of the proposal
- there is a comprehensive, adequate and secure representation of scarce or endangered habitats within and/or in areas biologically comparable to the Proposal area protected in secure reserves
- if the proposal is large (in the order of 10–100 ha or more, depending on where in the State) the Proposal area itself should include a comprehensive and adequate network of conservation areas and linking corridors whose integrity and biodiversity are secure and protected
- the onsite and offsite impacts of the proposal are identified and the proponent demonstrates that these impacts can be managed.

EPA Position Statement No. 3

EPA Position Statement No. 3 (EPA 2002) discusses the principles the EPA would apply when assessing proposals that may have an effect on biodiversity values in Western Australia. The outcomes sought by this Position Statement are intended to:

- promote and encourage all proponents and their consultants to focus their attention on the significance of biodiversity and, therefore the need to develop and implement best practice in terrestrial biological surveys
- enable greater certainty for proponents in the environmental impact assessment process by defining the principles the EPA will use when assessing proposals that may have an effect on biodiversity values.

EPA Guidance Statement No. 33

EPA Guidance Statement No. 33 (EPA 2008) provides guidance on assessing vegetation where it is considered significant for a range of reasons including:

- scarcity
- unusual species
- novel combination of species
- a role as a refuge
- a role as a key habitat for threatened species, or large populations representing a significant proportion of the local or regional total population of a species
- being representative of the range of a unit
- a restricted distribution.

TECs, as listed by DEC and under the EPBC Act, are of high significance.

In addition, DEC maintains a list of Priority Ecological Communities (PECs) which identifies those communities that need further investigation before possible nomination for TEC status. PECs are considered to be of a Regional to State level of significance (ENV 2010).

EPA Guidance Statement No. 51

EPA Guidance Statement No. 51 (EPA 2004b) provides guidance on standards and protocols for terrestrial flora and vegetation surveys, particularly those undertaken for the environmental impact assessment of proposals.

EPA Guidance Statement No. 10

EPA Guidance Statement No. 10 (EPA 2006a) provides guidance on the level of assessment for proposals affecting natural areas within the System 6 region and Swan Coastal Plain portion of the System 1 Region.

8.1.2 Legislation, policy and guidance

State protection

In a legislative context, the preservation and conservation of flora and ecological communities is covered primarily by the following Western Australian legislation:

- *Wildlife Conservation Act 1950 (WA) (WC Act)*
- *Environmental Protection Act 1986 (WA)*
- *Conservation and Land Management Act 1984 (WA).*

The WC Act protects all native flora in Western Australia. Flora considered to be rare are gazetted as Declared Rare Flora (DRF) under section 23F of the WC Act. Under the WC Act it is illegal to remove or damage DRF without approval. DRF are specifically scheduled for protection under the WC Act and are species that have been adequately searched for, and are deemed to be either rare, in danger of extinction, or otherwise in need of special protection.

Priority species are those listed by DEC as potentially threatened but for which there is insufficient evidence to properly evaluate their conservation significance. They range from Priority one to Priority four species, and are as follows:

- Priority One: Poorly Known Taxa. Taxa, which are known from one or a few (generally <5) populations, which are under threat
- Priority Two: Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat
- Priority Three: Poorly Known Taxa. Taxa which are known from several populations, at least some of which are not believed to be under immediate threat
- Priority Four: Rare Taxa. Taxa which are considered to have been adequately surveyed and which whilst being rare, are not currently threatened by any identifiable factors.

Note that of the above classifications, only DRF has statutory standing. The Priority flora classifications are employed by the DEC to manage and classify their database of species considered potentially to be at risk, but these categories have no legislative status for protection in addition to the native vegetation clearing legislation.

Bush Forever Policies, Principles and Processes

Bush Forever relates to the areas identified through the Bush Plan process undertaken by the Government of Western Australia to ensure that bushland, an important aspect of the urban environment, is given proper recognition and consideration in the development of Western Australia's cites, particularly Perth. The policy objectives of Bush Forever are to:

- meet the needs and aspirations of the community of Western Australia for the appropriate protection and management of bushland of regional significance in the Swan Coastal Plain portion of the Perth Metropolitan Region
- establish a conservation system that is (as far as achievable) comprehensive, adequate and representative of the ecological communities in the region
- achieve the protection of Bush Forever Sites through a collective and shared responsibility on the part of government, landowners and the community
- secure partnerships between landowners, government and the community in conservation management through government and community advice, assistance with incentives
- establish a range of measures that will enable the recommendations of Bush Forever for the protection of regionally significant bushland to be implemented by 2010
- bring a greater certainty to the processes of land use planning and environmental approvals by the early identification and protection of areas of regionally significant bushland.

Bush Forever is concerned with the protection of regionally significant bushland and associated wetlands. The Proposal area intersects with Bush Forever Site 355 and is adjacent to Bush Forever Site 358. Regionally significant bushland is defined with areas that represent:

- a range of ecological communities
- areas with high diversity
- areas containing rare or threatened communities or species
- areas that maintain ecological systems or natural processes
- areas that provide scientific or evolutionary importance
- areas containing conservation category wetlands, including fringing vegetation and associated upland vegetation.

State Planning Policy 2.8 Bushland Policy for the Perth Metropolitan Region

State Planning Policy 2.8 (SPP 2.8) applies the *Town Planning Act 2005* in relation to Bush Forever within the Perth Metropolitan area (WAPC 2005a). SPP 2.8 provides the policy measures for the planning, assessment and decision making criteria and processes relating to development of bushland areas in the Perth Metropolitan region. SPP 2.8 states that proposals or decision making should:

- recognise regional significant bushland protection and its management as a primary purpose and a fundamental planning consideration
- ensure that all reasonable steps have been taken to avoid, minimise or offset any likely adverse impacts
- adopt or incorporate the impact assessment process stipulated in SPP 2.8 where there is likely to be an unavoidable adverse impact on regionally significant bushland within a Bush Forever area
- recognise that Bush Forever area boundaries and the regionally significant bushland therein, have been defined using the best available information but may be subject to further analysis
- encourage, support and require, consistent with the policy, bushland management plans and the management of regionally significant bushland for conservation purposes
- support coordinated bushland management advice and assistance through the DEC, in conjunction with other relevant government and non-government agencies.

Australian Government protection

In a legislative context, the preservation and conservation of flora and ecological communities is covered by the following Commonwealth legislation:

- *Environment Protection and Biodiversity Conservation Act 1999* (Australian Government) (EPBC Act). Species and vegetation communities are protected as Matters of NES if they are listed under Schedule 1 of the EPBC Act.

8.2 Findings of surveys and investigations

The Proposal area has been subject to a number of flora and vegetation surveys undertaken to map the vegetation communities and flora species present and identify any vegetation communities and flora species of conservation significance. Key flora and vegetation surveys of the Proposal area include:

- Keating & Trudgen 1986: A Flora and Vegetation Survey of the Point Peron – Lake Richmond Area
- Bennett 2005: Flora and Vegetation, Point Peron, Western Australia
- ENV 2010: Flora and Vegetation Survey of the Mangles Bay Area, Cape Peron, Rockingham
- AECOM 2011: Assessment of TEC 30a, Corner of Memorial Avenue and Safety Bay Road, Rockingham.

The extent of flora and vegetation surveys of Cape Peron, including the Proposal area, is shown in Figure 42.

Keating and Trudgen 1986, Flora and Vegetation Survey

The historical flora and vegetation survey of the Cape Peron – Lake Richmond area was conducted on behalf of the WA State Planning Commission. The aims of the survey were:

- to identify and list as many flora species present in the study area as possible
- to document any populations of rare or geographically restricted species encountered
- to produce a 1:5000 scale vegetation map of the study area with accompanying descriptions of each of the vegetation type and their distributions.

This report is provided in Appendix 5 for further reference.

Bennett 2005, Flora and Vegetation Survey

Bennett Environmental Consulting Pty Ltd (Bennett) 2005 undertook a detailed Level 2 flora and vegetation survey of the Proposal area and surrounds. The level of survey required was determined in accordance with EPA Guidance Statement No. 51 (EPA 2004b) based on the potential impacts of the Proposal and the likely flora and vegetation to be present within the Proposal area. The objective of the survey was to record and map the vegetation units and vegetation condition within and outside the Proposal area and record the location of DRF and Priority Flora. The survey was undertaken in June 2005 after the annual species had commenced germination but many species were still too small for positive identification, and therefore a spring survey was recommended for completion of a more comprehensive species list.

This report is provided in Appendix 5 for further reference.

ENV 2010, Flora and Vegetation Survey

The ENV (2010) Flora and Vegetation Survey consisted of a desktop assessment and spring field survey. The objective of the survey was to undertake a targeted spring flora and vegetation survey for TECs and DRF and Priority Flora.

This report is provided in Appendix 5 for further reference.

AECOM 2011: Assessment of TEC 30a

Previous assessment by various consultants and the Department of Environment and Conservation (DEC) have resulted in conflicting results as to the extent of TEC 30a, leading to the need for this verification study. In early November 2011 AECOM Australia Pty Ltd (AECOM 2011) undertake the verification.

This report is provided in Appendix 5.

8.2.1 Vegetation within the Proposal area

Vegetation Units

Cape Peron is within the Drummond Botanical Subdistrict of the Darling Botanical District of the South western Botanical Province as defined by Beard (1981). Beard (1981) mapped Cape Peron as scrub heath, mixed shrubs and heathland, mainly Proteaceous and Myrtaceous.

All vegetation of Cape Peron is representative of the Quindalup Complex, as described by Heddle *et al.* (1980), of which approximately 48% of its pre-European extent in the Metropolitan area remains. Approximately 5.2% of the pre-European extent is within reserves that meet the International Union for Conservation of Nature (IUCN) criteria. The complex is described as a coastal dune complex consisting mainly of two alliances – the strand and foredune alliance and the mobile and stable dune alliance. Local variations include the low closed forest of *Melaleuca lanceolata-Callitris preissii* and the closed scrub of *A. rostellifera*.

Bennett (2005) recorded and described 25 different vegetation units as occurring in the Proposal area (Table 12 and Figure 43). Detailed descriptions of these vegetation units are provided in Appendix 5. Keating & Trudgen (1986) recorded 16 vegetation units, one of which was not recorded by Bennett (2005); *Olearia axillaris* shrubland. Keating & Trudgen (1986) did not record any of the taller units recorded by Bennett (2005), vegetation units 19, 21 – 24, nor a completely degraded unit, vegetation unit 25. ENV (2010) did not record any vegetation units.

Table 12 Vegetation unit descriptions mapped at Cape Peron (Bennett 2005)

Vegetation unit	Description	Total area mapped
Shoreline		
1	Open Low Heath of *Frankenia pauciflora* and scattered *Sarcocornia blackiana*.	1.2
2	Very Open Herbland of **Cakile maritima* occasionally associated with *Carpobrotus virescens* and *Tetragonia decumbens*.	0.3
3	Open Low Heath of *Tetragonia decumbens* and *Frankenia pauciflora* over grass weeds.	0.7
4	Grassland of *Spinifex hirsutus* over a Low Shrubland of *Tetragonia decumbens.*	0.4
Fore dune		
5	Very Open to Open Grassland of *Spinifex longifolius* and Open Low Heath of **Pelargonium capitatum*.	3.8
6	Open Low Heath of *Olearia axillaris* and **Pelargonium capitatum* over an Open Grassland.	10.5
7	Open Low Heath of *Scaevola crassifolia* and *Olearia axillaris* over Grassland of introduced species.	3.3
8	Open Shrubland of *Olearia axillaris* and *Acacia rostellifera* over a Low Shrubland of *Rhagodia baccata* and a Sedgeland of *Lepidosperma gladiatum.*	1.1
9	Open Heath of *Acacia rostellifera* over Sedgeland of *Lepidosperma gladiatum* over Grassland.	
10	Tall Open Shrubland of *Acacia rostellifera* over an Open Heath of mixed species dominated by *Spyridium globulosum* and *Alyxia buxifolia.*	0.2
11	Closed Tall Scrub of *Acacia rostellifera* over a Low Shrubland dominated by *Olearia axillaris* and Rhagodia baccata over a Herbland/Grassland of weeds.	5.2
Stable dune		
12	Low Shrubland of **Pelargonium capitatum* and Herbland of *Acanthocarpus preissii* over a Grassland/Herbland of introduced species.	17.1
13	Closed Tall Scrub to Open Heath of *Acacia rostellifera* over an Open Low Heath of mixed species or a Closed Grassland of introduced species.	39.3
13/16		4.9
14	Closed Heath of *Acacia rostellifera* and *Alyxia buxifolia* over an Open Herbland/Grassland of introduced species.	0.8
15	Closed Tall Scrub of *Acacia rostellifera* over Open Shrubland of *Rhagodia baccata* and a Very Open Grassland of introduced species.	8.2
16	Closed Tall Scrub of *Acacia rostellifera* and *Olearia axillaris* over an Open Sedgeland of *Lomandra maritima.*	41.6
17	Closed Low Heath of *Melaleuca huegelii* var. *huegelii* and *Templetonia retusa* over a Grassland/Herbland of weeds.	0.2
18	Closed Heath of *Pittosporum ligustrifolium* with *Acacia rostellifera* and *Scaevola nitida* over an Open Sedgeland of *Lepidosperma gladiatum*.	0.7
19	Shrubland of *Melaleuca huegelii* var. *huegelii* and *Melaleuca lanceolata* over Herbland of *Senecio pinnatifolius* and Grassland of introduced species.	0.7
20	Closed Tall Scrub of *Melaleuca huegelii* var. *huegelii* over Low Shrubland of *Rhagodia baccata* and *Scaevola nitida*.	0.4
21	Low Open Forest of *Eucalyptus gomphocephala* over Shrubland of *Acacia rostellifera* over Herbland/Grassland of introduced species.	1.7
22	Closed Forest of *Melaleuca lanceolata* and *Callitris preissii* over mulch.	0.08
23	Closed Forest of *Agonis flexuosa* var. *flexuosa* over Sedgeland of *Lepidosperma gladiatum*.	0.5
24	Open Forest of *Eucalyptus gomphocephala* over Low Open Forest of *Agonis flexuosa* var. *flexuosa*, *Callitris preissii* and *Melaleuca lanceolata* over a Herbland of introduced species.	1.5
Degraded area		
25	Closed Grassland of **Hyparrhenia hirta* over Herbland of **Oxalis pes-caprae.*	0.6

Abbreviations: subsp. = subspecies, var. = variety, * = introduced species/weed, ? = thought to be the correct species name. sp. = species – used where the genus but not the species is known

Source: Aerial photography supplied by Landgate (2010)
FCT mapping supplied by ENV (2010)
Vegetation mapping supplied by BEC (2005)
Bush Forever Sites supplied by Department of Planning
Coordinate System: MGA94 Zone 50 ; Date: 10/1/2012
NB: Potential errors may occur in some areas

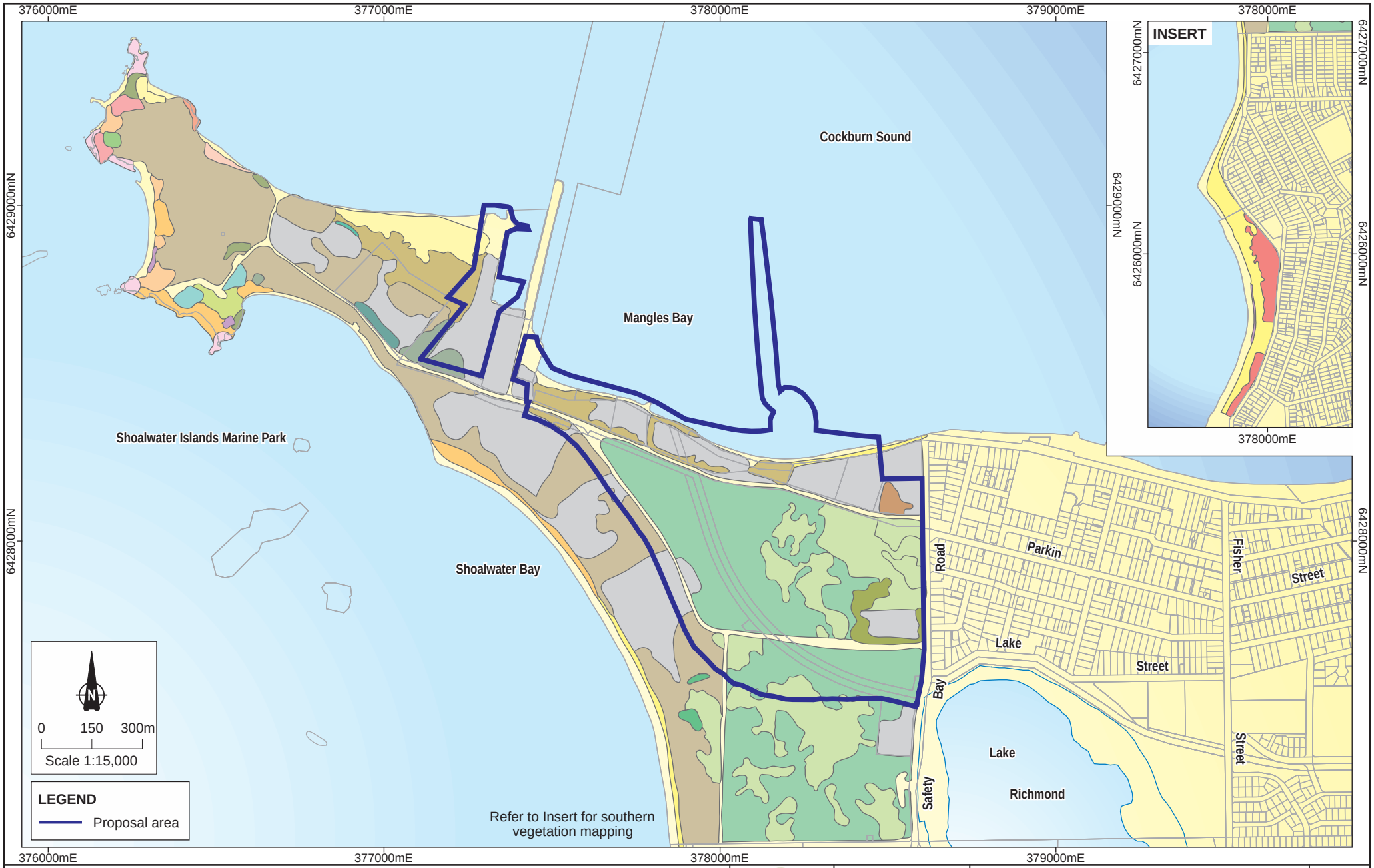
STRATEGEN
environmental consultants

Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F029.dgn

Extent of flora and vegetation surveys across Cape Peron

Figure No:
42



Source:
Cadastral data supplied by Landgate
Vegetation Mapping supplied by Bennett Environmental Consulting (2005)
Coordinate System: MGA94 Zone 50
Date: 12/10/2011

NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F020.dgn

Vegetation units mapped at Cape Peron (Bennett 2005)

Figure No:
43

Shoreline

VU1 Open Low Heath of *Frankenia pauciflora* and scattered *Sarcocornia blackiana* in reddish yellow sand in depression in limestone outcrops

VU2 Very Open Herbland of *Cakle maritima occasionally associated with *Carpobrotus virescens* and **Tetragonia decumbens* in cream sand

VU3 Open Low Heath of **Tetrgonia decumbens* and *Frankenia pauciflora* over grass weeds in brown sand with limestone outcropping

VU4 Grassland of *Spinifex jirsutus* over a Low Shrubland of **Tetragonia decumbens* in cream sand

Foredune

VU5 Very Open to Open Gassland of *Spinifex longifolius* and Open Low Heath of **Pelargonium capitatum* in creamy yellow sand

VU6 Open Low Heath of *Olearia axillaris* and **Pelargonium capitatum* over an Open Grassland of introduced species in cream sand

VU7 Open Low Heath of *Scaevola crassifolia* and *Olearia axillaris* over Grassland of introduced species in yellow sand

VU8 Open Shrubland of *Olearia axillaris* and *Acacia rostellifera* over Low Shrubland of *Rhagodia baccata* and a Sedgeland of *Lepidosperma gladiatum* in yellow sand

VU9 Open Heath of *Acacia rostellifera* over Sedgeland of *Lepidosperma gladiatum* over Grassland of weeds in brown sand

VU10 Tall Open Shrubland of *Acacia rostellifera* over an Open Heath of mixed species dominated by *Spyridium globulosum* and *Alyxia buxoflia* in yellow sand above a limestone knoll

VU11 Closed Tall Shrub of *Acacia rostellifera* over a Low Shrubland dominated by *Olearia axillaris* and *Rhagodia baccata* over a Herbland/Grassland of weeds in dark brown sand over yellow sand

Stable Dune

VU12 Low Shrubland of **Pelargonium capitatum* and Herbland of *Acanthocarpus preissii* over a Grassland/Herbland of introduced species

VU13 Closed Tall Scrub to Open Heath of *Acacia rostellifera* over an Open Low Heath of mixed species or a Closed Grassland of introduced species

VU14 Closed Heath of *Acacia rostellifera* and *Alyxia buxifolia* over an Open Herbland/Grassland of introduced species in yellow brown sand

VU15 Closed tall Scrub of *Acacia rostellifera* over Open Shrubland of *Rhagodia baccata* and a Very open Grassland of introduced species in cream sand

VU16 Closed Tall Scrub of *Acacia rostellifera* and *Olearia axillaris* over an Open Sedgeland of *Lomandra maritima* in yellow sand

VU17 Closed Low Heath of *Melaleuca huegelii* var. *huegelii* and *Templetonia retusa* over a Grassland/Herbland of weeds in brown sand

VU18 Closed Heath of *Pittosporum ligustrifolium* with *Acacia rostellifera* and *Scaaevola nitida* over an Open Sedgeland of *Lepidosperma gladiatum* in brown sand

VU19 Shrubland of *Melaleuca huegelii* var. *huegelii* and *Melaleuca lanceolata* over Herbland of *Senecio pinnatifolius* and Grassland of introduced species in yellow sand

VU20 Closed Tall Scrub of *Melaleuca huegelii* var. *huegelii* over Low Shrubland of *Rhagodia baccata* and *Scaevola nitida* in pale yellow sand

VU21 Low Open Forest of *Eucalyptus gomphocephala* over Shrubland of *Acacia rostellifera* over Herbland/Grassland of introduced species in yellow brown sand

VU22 Close

VU1-d Forest of *Melaleuca lanceolata* and *Callitris preissii* over mulch in yellow sand

VU23 Closed Forest of *Agonis flexuosa* var. *flexuosa* over Sedgeland of *Lepidosperma gladiatum* in grey sand

VU24 Open Forest of *Eucalyptus gomphocephala* over Low Open Forest of *Agonis flexuosa* var. *flexuosa*, *Callitris preissii* and *Melaleuca lanceolata* over a Herbaldn of introduced species in grey sand

Degraded

VU25 Closed Grassland of **Hyparrhena hirta* over Herbland of **Oxalis pes-caprae* in grey sand

DEV Developed Area

Source: Vegetation Supplied by Bennett Environmental Consulting Date: 12/10/2011	STRATEGEN environmental consultants	Drawn: CAD Resources CAD Resources File No: g1937_MB_PER_F020_Leg.dgn	**Vegetation units mapped at Cape Peron (Bennett 2005) Legend**	Figure No: **43**

Floristic community types

Eight FCTs have been identified as occurring onsite (Bennett 2005 and ENV 2010) and were mapped by ENV (2010) (Figure 44). Bennett (2005) inferred the FCTs for each vegetation unit (Table 13) using Gibson *et al*. (1994). A PATN numerical analysis[3] was also undertaken by EA Griffin and Associates (EA 2005) to confirm the inferences for the vegetation units that occurred within the proposed development area (Table 13). The PATN analysis was limited in its application due to the relatively small number of flora species recorded from the study quadrats on Cape Peron (due to the mostly 'degraded' condition of the vegetation).

The AECOM survey of TEC 30a has been used to further refine the areas of floristic community types present within the Proposal area.

Table 13 Floristic community types for vegetation units mapped

Floristic community type	Inferred vegetation units mapped by Bennett (2005)	PATN confirmation	Total Area Mapped at Cape Peron	Area within Proposal area
FCT 16 Highly saline seasonal wetlands	1, 3	-	1.85	0.00
FCT 29a Coastal shrublands on shallow sands	2, 8, 9, 10, 11, 12, 15	Vegetation Unit 12: probably 29b, but may be 29a Vegetation Unit 15: possibly 29b or 30b or 30c	27.03	10.72
FCT 29b *Acacia* shrublands on taller dunes	13, 14, 16, 17, 18, 20	Vegetation Unit 16: probably 29b	87.05	33.75
FCT S13 Northern *Olearia axillaris – Scaevola crassifolia* shrublands	6, 7	-	4.96	0.44
FCT S14 *Spinifex longifolius* grasslands and low shrublands	4, 5	-	4.31	0.17
FCT 30a *Callitris preissii* (or *Melaleuca lanceolata*) forest and woodlands	19?, 22, 24	Vegetation Unit 24: Probably FCT 30a (TEC)	2.41	4.27**
FCT 30b Quindalup *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands	21, 23	-	2.32	0.56
FCT S15 Weed group	25	-		

* area refers to mapped occurrence within the Proposal area, not area to be cleared

[3] PATN is a software package that extracts and displays patterns in complex data. PATN generates estimates of association (resemblance, affinity, distance) between any set of objects described by a suite of variables or attributes. PATN then classifies the objects into groups (Blatant Fabrications 2004).

Conservation significance

Threatened Ecological Community – FCT30a

FCT 30a *Callitris preissii (*or *Melaleuca lanceolata*) forest and woodlands is listed as a TEC by the DEC within the 'Vulnerable'[4] conservation category. It is not listed by the Australian Government (ENV 2010). There are three occurrences of FCT 30a in the survey area extent as mapped by ENV but only one in the Proposal area (Figure 45). The TEC located within the Proposal area is near the corner of Memorial Drive and Safety Bay Road. The TEC was recorded by Bennett (2005) and ENV (2010), in an area occupying approximately 1.57ha.

Subsequent to the ENV 2010 survey, the DEC undertook an assessment of the area mapped by ENV as FCT 30a. The DEC mapped area of FCT 30a covers a greater area than the occurrence mapped by either Bennett 2005 or ENV 2010 (Figure 45), both of which map the TEC community and surrounding vegetation communities not mapped as the TEC, very similarly

Based on the variability between the DEC mapping and previous mapping of the TEC, AECOM were commissioned by Cedar Woods to undertake a verification survey of TEC 30a. The presence of the TEC, FCT 30a was confirmed at the site during the field assessment conducted by AECOM on 4 November 2011. The AECOM mapped extent of TEC 30a and the condition of the vegetation within this extent is shown in Figure 46. Data collected from two permanent monitoring quadrats at the site also supports this result Appendix 5. Based on DEC advice, spatial mapping of the extent of the TEC focused on the presence of *Callitris preissii* and the results of this mapping are presented in Figure 45. The extent of mapping of the TEC vegetation type is more widespread than previously mapped by Bennett (2005) and ENV (2010). The results align most closely with mapping conducted by DEC (2010) at the site. Some locations that were previously mapped as TEC 30a vegetation type may have since been cleared or disturbed, including a location to the west of the parkland that supports only *Acacia rostellifera* and weeds, including Japanese Pepper (**Schinus molle*) (Appendix 5). However, an area of *Callitris preissii* close to Memorial Drive near the corner of Safety Bay Road has recently been slashed, rendering the condition here to be poorer (Figure 46).

The mapping of vegetation condition within the mapped extent of the TEC vegetation type would be a useful tool for determining the sustainability and conservation potential of specific areas within the site. DEC's advice is that the true TEC is confirmed where *Callitris preissii* occurs in moderately good condition vegetation (Jill Pryde, *pers.comm.* 2011). Moderately good or better condition vegetation could be interpreted to be equivalent to "Good" condition or better, in accordance with the Keighery (1994) scale. In this regard, only about 65% of the site (2.8 hectares of a total of 4.3 hectares of the mapped TEC) would be considered to meet the criteria and be confirmed as the true TEC 30a. The areas of the TEC in better condition ("Good" or better, Figure 2), are considered to have the highest conservation potential. Keating and Trudgen (1986) mapped the vegetation of the area in question as cleared and supporting a vegetation community coded ArAb (*Acacia rostellifera* and *Alyria buxifolia*, Open – Closed Heath) (Figure 47). This vegetation community, mapped by Keating and Trudgen (1986) contained none of the dominant species identified in 2005 by Bennett, nor none of the dominant species associated with TEC FCT 30a.

The Bennett 2005 and ENV 2010 reports were developed following adherence to the methodological practices prescribed by EPA Guidance Statement No. 51, including the establishment of quadrats in identified vegetation community types. Advice from the DEC indicates that the Bennett 2005 results may have been impacted by a recent fire, however, no observations of fire impacts to the vegetation are present in the Bennett 2005 report. ENV (2010) utilised the vegetation community mapping and quadrat areas established by Bennett (2005). This has resulted in no quadrat data being available from Bennett (2005) or ENV (2010) specific to the area of discrepancy between the mapping of these reports and the DEC mapped occurrence of TEC FCT 30a. The Bennett report is explicit in describing the methodology employed both in the selection of vegetation community types for quadrat establishment and effort outside of the established quadrats "The area outside of the quadrat was also surveyed to record additional (opportunistic) species for the vegetation unit".

[4] 'Vulnerable' conservation category for TECs: An ecological community that is declining or has declined in distribution and/or condition and whose ultimate security has not been secured OR still widespread but will become increasingly endangered in the near future if threatening processes continue or begin to operate.

With reference to Figure 48, the vegetation of the area mapped by the DEC as FCT 30a has changed over the past 60 years as a result of anthropogenic activities. The earliest aerial photograph available (1953), appears to support low, dunal heath type vegetation. The appearance of taller vegetation typology is coincident with the establishment of the recreational oval. Consistent with the Keating and Trudgen (1986) report, the northern part of the subject area has been historically cleared and supported accommodation.

The previous flora and vegetation surveys, historical aerial photographs and Bennett (2005) observations of rehabilitation effort in the area (or portion of) mapped by DEC as FCT 30a, indicates that the extent of the vegetation community observed by DEC may be recent and a result of either natural recruitment or rehabilitation works (or both).

The history of the establishment of the mapped occurrence of TEC FCT 30a suggests that the community type is responsive to rehabilitation / colonisation.

The other two occurrences of FCT 30a at Cape Peron as mapped by ENV (2010) are located outside the Proposal area. The first is located on the boundary of Rockingham Beach Primary School, approximately 1.3 km to the southeast of the Proposal area and was mapped as being in 'good' condition; however there is no native understorey present and since the Bennett 2005 survey which identified the site, all the *Callitris preissii* have died (ENV 2010). This vegetation community is not a viable representation of FCT 30a and does not represent the TEC as it has likely been subject to recent degrading factors. The second occurrence is located at the base of the western-most car park, approximately 1 km from the Proposal area. This site is surrounded by dunal vegetation and is a viable representation of the TEC (Figure 44).

No other vegetation units occurring on Cape Peron or in the Proposal area are listed or probable TECs.

Priority Ecological Community

Two of the FCTs are listed as PECs by the DEC (ENV 2010). Reservation and conservation status of these FCTs was described by Gibson *et al*. (1994):

- FCT 29b (Priority 3): poorly reserved and susceptible (a community of concern due to evidence that it can be modified or destroyed by human activities, or would be vulnerable to new threatening processes)
- FCT 30b (Priority 3): well reserved and susceptible.

FCT 29b (Priority 3) is described across the majority of Cape Peron and is well represented inside and outside the Proposal area (Table 13). FCT 30b (Priority 3) occurrences are in 'good' condition (ENV 2010) with 24% of the area of FCT 30b mapped at Cape Peron, located within the Proposal area.

Vegetation condition

The vegetation condition[5] of Cape Peron mapped by ENV (2010) varies between 'very good' and 'completely degraded' (excluding development areas). Figure 49 highlights that the majority of the vegetation mapped at Cape Peron is in 'good' condition, while Table 14 indicates the condition of the uncleared vegetation within the Proposal area.

[5] Vegetation condition rating (Department of Environmental Protection 2000):

Pristine = Pristine or nearly so, no obvious signs of disturbance.

Excellent = Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.

Very good = Vegetation structure altered, obvious signs of disturbance.

Good = Vegetation structure significantly altered by very obvious signs of multiple disturbances; retains basic vegetation structure or ability to regenerate it.

Degraded = Basic vegetation structure severely impacted by disturbance; scope for regeneration but not to a state approaching good condition without intensive management.

Completely degraded = The structure of the vegetation is no longer intact and the area is completely or almost completely without native species.

Figure 46 shows the condition of TEC FCT 30a as mapped by AECOM (2011).

The high variability of the condition is reflected by the fragmentation of the area by different infrastructure, roads, tracks, weeds and rubbish. The volume of people that use the area everyday has contributed to the degradation of the vegetation both directly through trampling and spread of weeds and indirectly through the need for additional infrastructure such as roads and amenities (ENV 2010).

The Proposal area, which in the 1986 survey was regarded as 'degraded' (Keating & Trudgen 1986), is recovering. Basic vegetation units are developing and several species were recorded in the area that were not recorded elsewhere (e.g. *Calothamnus quadrifidus*) (Strategen 2006). It is anticipated that with time, the vegetation will continue to recover and develop into a dense shrubland.

Several areas associated with development were 'degraded' or 'completely degraded'. The 'completely degraded' sites were those where there are holiday homes and other infrastructure.

Table 14 Area and proportion of each vegetation condition type in the Proposal area

Vegetation condition	Area mapped at Cape Peron (ha)	Area mapped in Proposal area (ha)	Proportion of area mapped in Proposal area (%)
Very good	25.70	18.08	70.4%
Very good to Good	8.45	0.02	0.2%
Good	70.16	20.18	28.8%
Good to Degraded	4.77	1.55	32.6%
Degraded to Completely Degraded	10.18	2.51	24.6%
Completely Degraded	8.07	5.32	66.0%

Bush Forever

Much of the Proposal area is located within the Bush Forever Site 355 (Figure 42). Bush Forever Site 355 is 174.5 ha in area of which approximately 107.1 ha is vegetated (Figure 42).

Bush Forever (Government of Western Australia 2000) states a detailed survey was undertaken of the site by Keating and Trudgen in 1986, which resulted in 60% of the flora taxa being sampled with no significant species being found. The site meets six specific coastal reserve criteria, which include:

- Quindalup Dune types: youngest, older and beach ridge plain
- continuing natural processes: 174.5 ha (107.1 ha of bushland) of Quindalup Dunes extending to 3.1 km inland from the point
- shoreline: soft (sandy) and Hard (rock)
- linkage: contains Quindalup/Spearwood Dunes (Tamala Limestone) interface; roads and developments fragment site
- vegetation: typical Quindalup/Spearwood units
- habitats: significant reptile species.

The Cape Peron site features rocky headlands displaying excellent exposures of the aeolian phase of Tamala Limestone, connected to the mainland by a series of Holocene beach-sand and dune-sand ridges of the Safety Bay Sands (Government of Western Australia 2000). The Cape Peron site is recognised as forming a linkage with Bush Forever Site 358, *Lake Richmond* (29 ha total area; approximately 27 ha vegetated), which is to the east; Safety Bay Road separates the two areas. The Cape Peron site is also part of Greenways[6] 1, 93 and 97 (Tingay & Associates 1998).

[6] The term 'greenways' is a generic term that has been used to describe ecological linkages in the landscape that connect natural areas, preferably with continuous corridors of native vegetation, in ways that allow both fauna and flora to move between these areas to access resources and suitable habitat for survival and reproduction. A study of Perth's greenways by Tingay and Associates (1998) identified proposed greenway corridors linking the Park internally and to external areas.

Source:
Cadastral data supplied by Landgate
FCT Mapping supplied by ENV
Coordinate System: MGA94 Zone 50
Date: 12/10/2011

NB: Potential errors may occur in some areas

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Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F005.dgn

Floristic Community Type (FCT) mapping across Cape Peron (ENV 2010)

Figure No: 44

Source: Imagery supplied by Landgate (2010)
TEC mapping supplied by BEC (2005), ENV (2008), DEC (2010), Aecom (2011)
Coordinate System: MGA94 Zone 50
Date: 8/2/2012
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn: CAD Resources
CAD Resources File No: g1937_MB_PER_F044.dgn

Mapped extent of TEC SCP30a

Figure No: **45**

Source:
Cadastral data supplied by Landgate
TEC Mapping Supplied by Aecom (2011)
Vegetation Conditoin Mapping supplied by Aecom
Coordinate System: MGA94 Zone 50

Date: 8/2/2012
NB: Potential errors may occur in some areas

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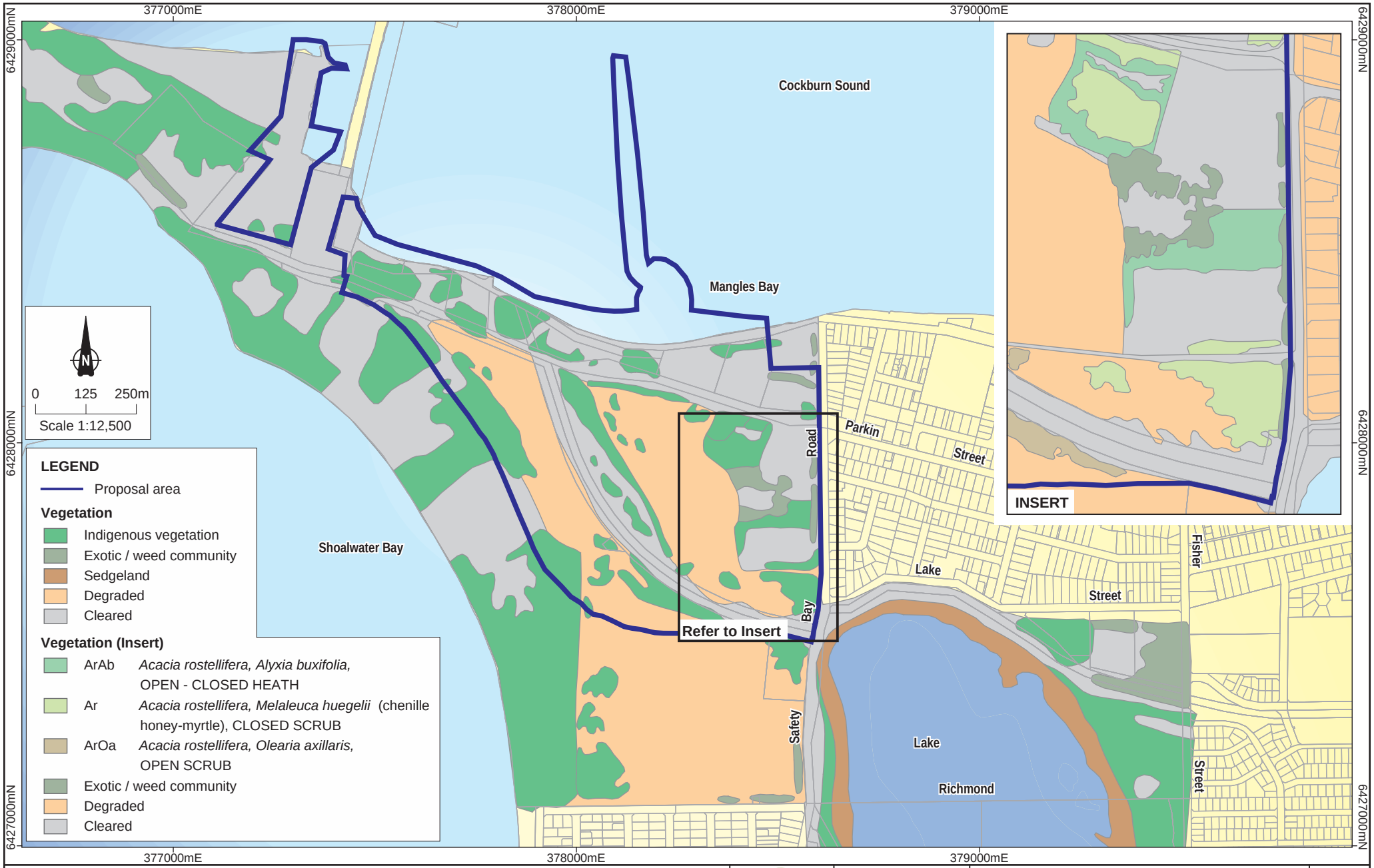
Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F061.dgn

TEC extent and condition (mapped by Aecom)

Figure No:
46



Source:
Cadastral data supplied by Landgate
Vegetation Mapping supplied by Keating and Trudgen 1986
Coordinate System: MGA94 Zone 50
Date: 8/2/2012

NB: Potential errors may occur in some areas

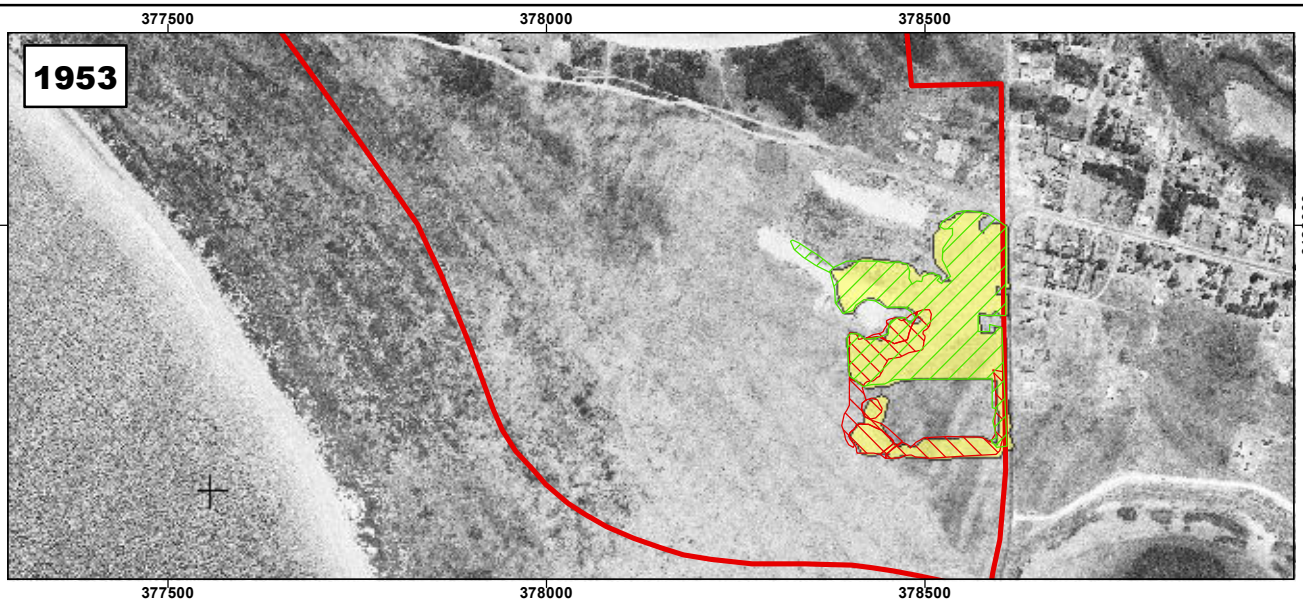
STRATEGEN environmental consultants

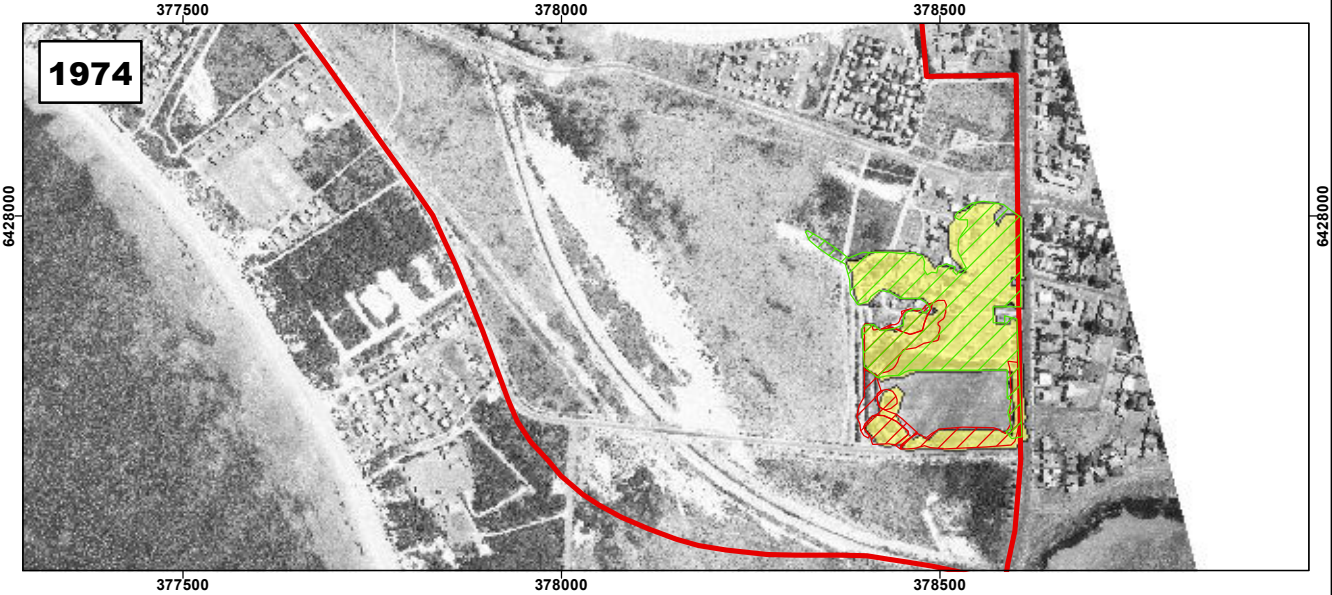
Drawn: CAD Resources

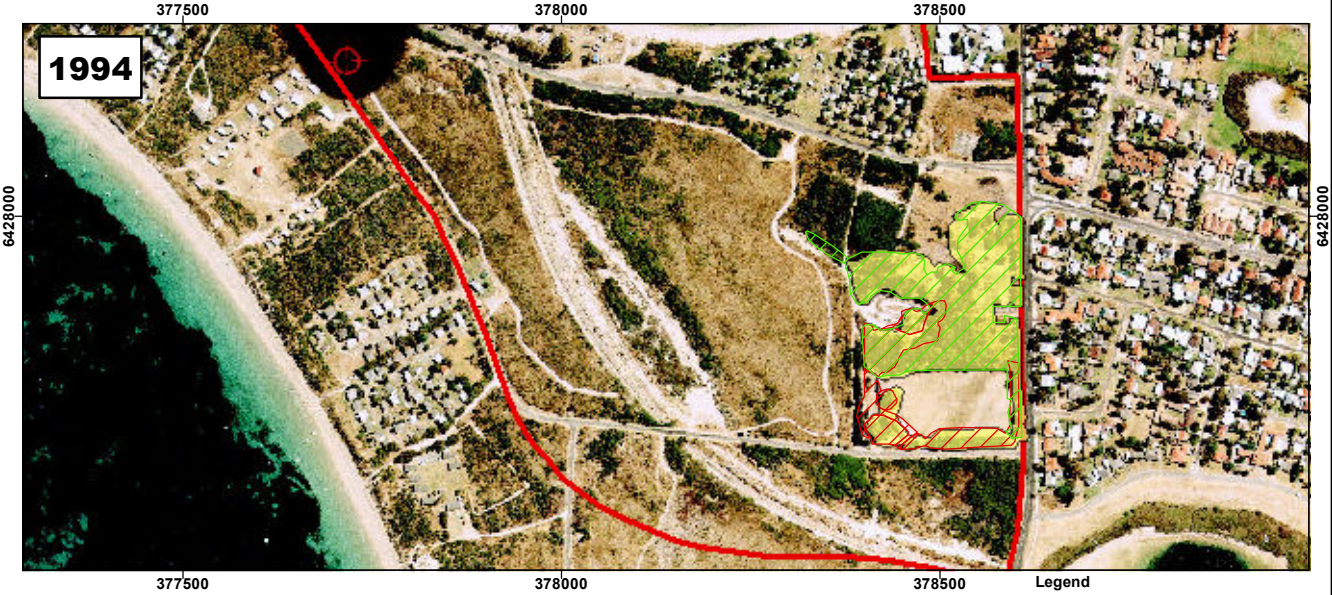
CAD Resources File No: g1937_MB_PER_F052.dgn

Keating and Trudgen vegetation mapping

Figure No: **47**







0 100 200 m

Scale 1:10,000

N

Legend

- TEC SCP30a - mapped by DEC (2010)
- TEC SCP30a - mapped by ENV (2009)
- TEC SCP30a - mapped by AECOM (2011)
- Proposal area

Source: Imagery supplied by Landgate (2010)
Coordinate System: MGA94 Zone 50
Date: 08/02/2012
NB: Potential errors may occur in some areas

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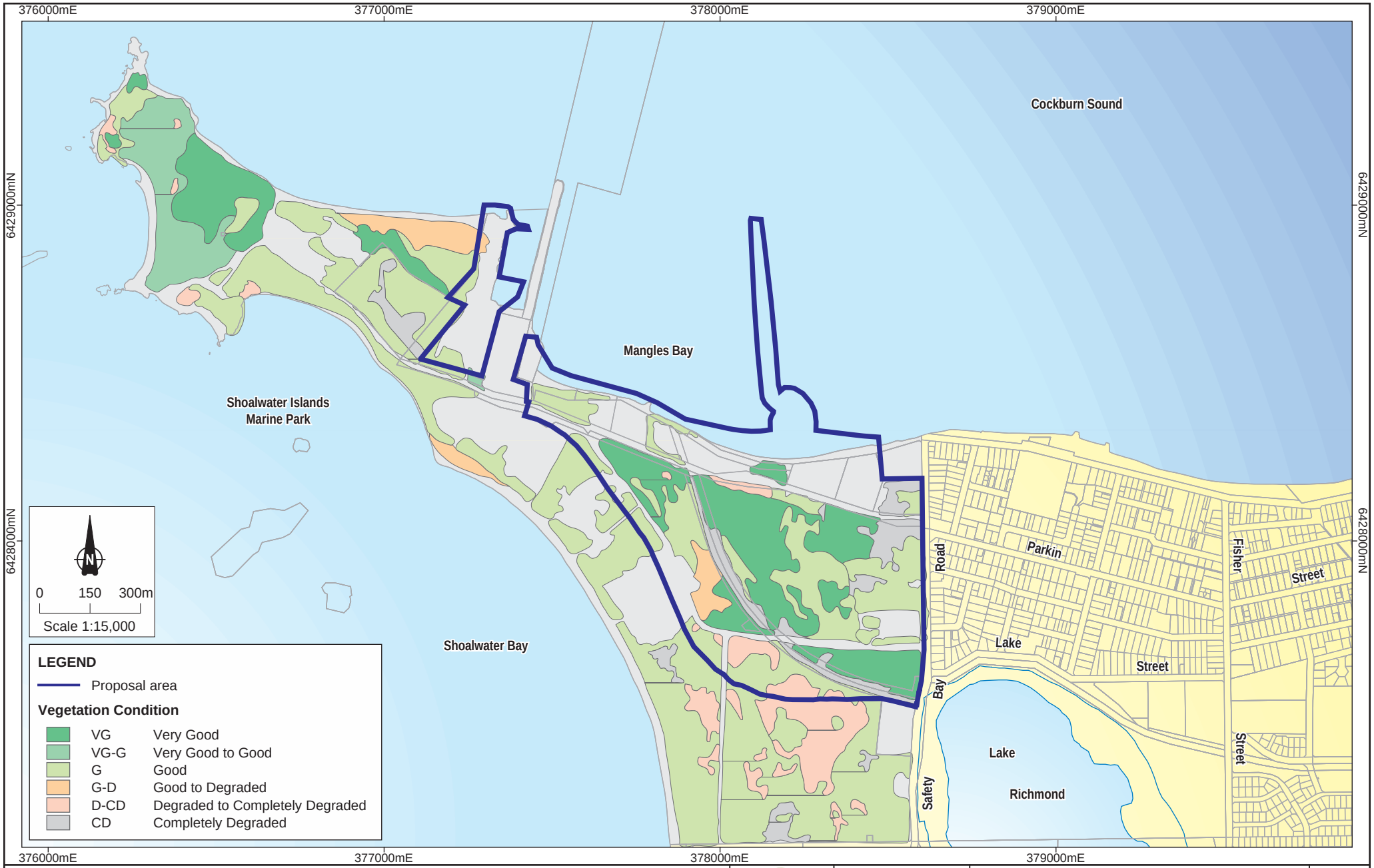
Compiled: atomeo

File: Figure 48 Historical Imagery.mxd

Historical imagery

Figure No: 48



Source:
Cadastral data supplied by Landgate
Vegetation Condition mapping supplied by ENV
Coordinate System: MGA94 Zone 50
Date: 8/2/2012

NB: Potential errors may occur in some areas

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Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F006.dgn

Vegetation Condition mapping of Cape Peron

Figure No:
49

8.2.2 Vegetation adjacent to the Proposal

Bush Forever Site 358 *Lake Richmond* is located adjacent to the Proposal area and within the RLRP (Figure 118).

The Bush Forever site is located on the Quindalup Vegetation Complex consisting of uplands, shrublands and wetland units. The lake is bordered by flats devoid of permanent vegetation surrounded by sedges at the base of surrounding coastal dunes. The sedgeland is several metres wide and is underlain by peaty soil. The area is dominated by *Baumea juncea*, *Scirpus validus* and clumps of bulrush *Typha orientalis* (ENV 2011a). The vegetation community surrounding Lake Richmond and within Bush Forever Site 358 is FCT 19 Sedgelands in Holocene dune swales of the southern Swan Coastal Plain which is identified as a TEC by the WA DEC and is listed under the EPBC Act.

Sedgelands in Holocene dune swales

The Sedgelands TEC occurs in linear damplands and occasionally sumplands between Holocene dunes. The TEC is not limited to Lake Richmond, but occurs at eight locations in the Rockingham Becher Plain area and at two other locations in the South West, with a total estimated area of 130 ha (CALM 2002). Approximately 11 ha of this TEC occurs in a band around the edge of Lake Richmond (CALM 2002). This band extends to the edge of Safety Bay Road.

Hydrological regime is considered to be the primary non-biological factor that influences the characteristics of this TEC (CALM 2002). Depth, timing and duration of flooding and length of the dry period all affect vegetation composition and distribution (CALM 2002). Sedgelands in damplands and sumplands of the Holocene dune swales have relatively specific water regime requirements to maintain current biology, but are tolerant of seasonal and longer-term variations that reflect natural climatic patterns. Maintenance of water level and quality is considered critical for this TEC (CALM 2002).

8.2.3 Flora within the Proposal area

A total of 54 vascular plant families, 112 genera and 132 taxa, of which 67 are endemic and 65 are weeds were recorded by Bennett (2005) and/or ENV (2010). The dominant families were Poaceae (grass family), Asteraceae (daisy family), Myrtaceae (myrtle family) and Papilionaceae (pea family). An outline of the species observed and recorded during each survey is provided in Appendix 5.

Declared Rare and Priority flora

Four DRF and 15 Priority Flora species were identified from the DEC database as potentially occurring in the Cape Peron area (ENV 2010); however no DRF or Priority Flora species were recorded during the Bennett (2005) or ENV (2010) survey (Figure 50).

One species, *Dodonaea hackettiana* (Priority 4), has been previously recorded from the vicinity of Cape Peron outside the Proposal area. Considering the species was not found in the location that it was previously known to occur, nor the rest of the Cape Peron survey area by the two intensive surveys undertaken (Bennett 2005 and ENV 2010), it can be assumed that it was misidentified or the individuals have subsequently died.

The potential for the Proposal area to contain DRF or Priority Flora is considered to be low. The area has been surveyed intensively (traversed on foot) during spring at peak flowering time and no DRF or Priority flora were identified.

Six flora species considered by Bush Forever (Government of Western Australia 2000) to be of significance for the Quindalup dune system in the Perth Metropolitan area were recorded during the Bennett (2005) and/or ENV (2010) survey (Table 15).

Table 15 Significant species identified by Bush Forever recorded at Cape Peron

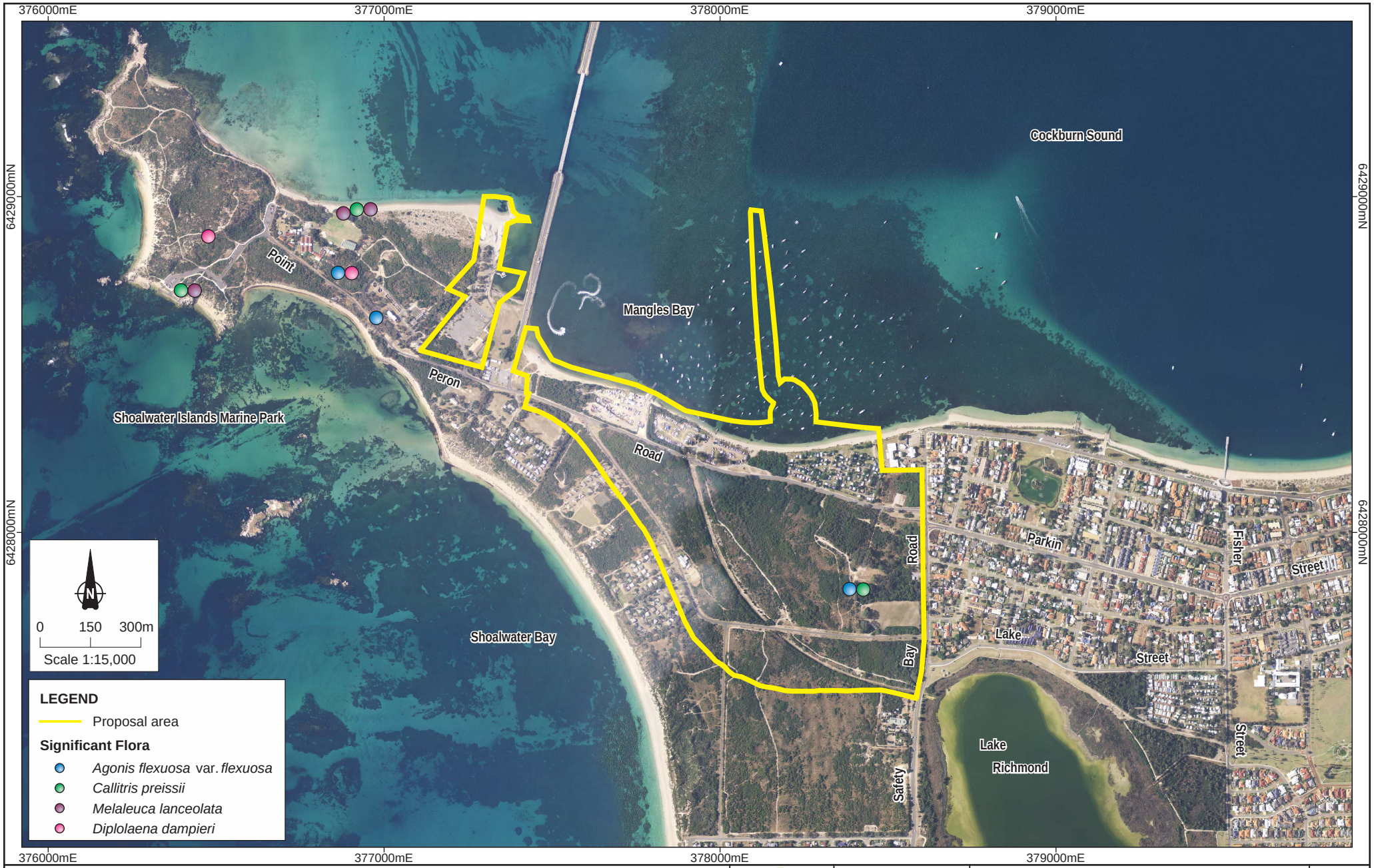
Species	Significance category	Floristic Community Type (FCT)
Agonis flexuosa var. *flexuosa*	At northern extension of known range Significant population	FCT 30b
Allocasuarina lehmanniana	Significant population	FCT 29a
Callitris preissii	Significant population Endemic to Swan Coastal Plain in Perth Metropolitan area	FCT 30a
Diplolaena dampieri	At northern extension of known range Significant population	FCT 29a
Hibbertia cuneiformis	At northern extension of known range Significant population	FCT 29a
Melaleuca lanceolata	Disjunct population (geographically or ecologically isolated from other populations of the same species) Significant population	FCT 30a

Flora potentially sensitive to groundwater changes

Of the species recorded during surveys, nine have been identified as being potentially susceptible to changes in groundwater levels and three as being susceptible to changes in groundwater quality (ENV 2010).

Table 16 Flora species potentially sensitive to groundwater level and quality changes

Susceptible to changes in groundwater levels	Susceptible to changes in groundwater quality
Spinifex hirsutus	*Callitris preissii*
Spinifex longifolius	*Desmocladus flexuosus*
Ficinia nodosa	*Leucopogon parviflorus*
Lepidosperma gladiatum	
Lepidosperma sp. Coastal Dune (R. J. Cranfield 9963)	
Agonis flexuosa	
Eucalyptus gomphocephala	
Melaleuca lanceolata	
Frankenia pauciflora	



Source:
Imagery supplied by Landgate
Significant Flora data supplied by ENV (2010)
Coordinate System: MGA94 Zone 50
Date: 8/2/2012

NB: Potential errors may occur in some areas

STRATEGEN
environmental consultants

Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F018.dgn

Flora species of conservation significance

Figure No:
50

Introduced flora

A total of 65 weed species (49% of the total number of taxa) were recorded by Bennett (2005) and/or ENV (2010) surveys. Weed species are listed in respective reports (provided in Appendix 5), all of which have been determined as weeds by CALM (1999). In addition, four cultivated species and a group of unidentifiable grasses were recorded.

The weeds present are generally typical for urban sites but some weed species recorded had been planted as part of rehabilitation, mainly within lease areas. Cultivated species planted for ornamental purposes were not recorded by the survey.

Nine of the weed species were rated by CALM (1999) as 'High'[7] including:

- *Asparagus asparagoides* (bridal creeper)
- *Bromus diandrus (*great brome)
- *Ehrharta calycina* (perennial veldt grass)
- *Eragrostis curvula* (African love grass)
- *Eurphorbia terracina* (Geraldton carnation weed)
- *Hyparrhenia hirta (*tambookie grass)
- *Lagurus ovatus* (Hare's tail grass)
- *Pelargonium capitatum* (rose pelargonium)
- *Romulea rosea* (guildford grass).

One Declared Plant species, **Asparagus asparagoides*, listed by the *Agriculture and Related Resources Protection Act 1976* was found in the study area (ENV 2010). This species is listed as Priority 1 for the whole State.

Species widespread throughout the area include *Euphorbia terracina*, (Geraldton carnation weed, 'High'), *Pelargonium capitatum* (rose pelargonium, 'High'), *Lagurus ovatus* (Hare's tail grass, 'High') and *Lolium rigidum* (wimmera ryegrass, 'Moderate'). Another common weed species in the area was *Trachyandra divaricata* (onion weed), which is rated as 'Mild'[8]. This species is known to be aggressive in interdunal beach heathland (Hussey *et al*. 1997).

8.3 Evaluation of options or alternatives to avoid or minimise impact

The TEC, FCT30a *Callitris preissii* community has been identified near the corner of Memorial Drive and Safety Bay Road. The Proposal will clear 1.93 ha of TEC FCT 30a. The Proposal was designed to minimise direct and indirect impacts on the TEC FCT 30a. These include:

- the length of one of the eastern arms was shortened to reduce the potential for hydrological impacts on the vegetation community
- it is proposed to retain and consolidate TEC FCT 30a into a more sustainable shape of a remnant of approximately 3.95 ha, where the boundary to area ratio is improved when compared to the current configuration of the remnant. This will comprise the retention of 1.12 ha of Very Good condition vegetation, rehabilitation of 1.61 ha that currently does not support FCT 30a and 1.22 ha of FCT 30a that has been identified as being in Good – Degraded condition.

[7] Ratings based on three criteria; invasiveness, distribution and environmental impacts. 'High' rating indicates weed is prioritised for control and/or research.

[8] 'Mild' rating indicates monitoring of the weed and control where appropriate.

8.4 Assessment of likely direct and indirect impacts

The Proposal will result in the clearing of a total area of up to 40 ha. The majority of the Proposal area is within both the RLRP and Bush Forever Site 355. Bush Forever Site 358, incorporating Lake Richmond and its surrounding vegetation, is adjacent to the south eastern corner of the Proposal area. In addition to the physical removal of native vegetation, there is the potential for secondary impacts to vegetation health arising from changes in the groundwater hydrology to be considered in the assessment. Both of these effects may reduce the values of the RLRP without appropriate management.

The following aspects of the Proposal may affect flora and vegetation values:

- clearing of vegetation for the development will directly reduce the extent of vegetation communities with minimal disturbance expected to occur to TECs
- dewatering to lower groundwater levels to allow for the excavation of the marina may affect groundwater-dependent vegetation
- creation of new saltwater interface as a result of the land based marina may affect saltwater/freshwater interface dependent vegetation
- increased population as a result of development may increase indirect impacts on vegetation through uncontrolled access, rubbish and domestic pets
- vehicle movements and earthworks have the potential to introduce and spread weed species
- fragmentation of Bush Forever Site 355 as a result of clearing for the development
- dust generation due to earthworks and vehicle movements has the potential to smother vegetation
- potential edge effects to surrounding vegetation from clearing and construction activities.

8.4.1 Vegetation clearing

Clearing requirements for the Proposal will result in the clearing up to 40 ha excluding areas that are already 'completely degraded' and development areas already cleared, such as the caravan park and fishing club (Figure 51). The remnant vegetation of the Proposal area (excluding already developed areas) was generally assessed to be in 'good' or 'very good' vegetation condition comprising 61% of the Proposal area. There are small areas of 'degraded' and 'completely degraded' vegetation in the Proposal area due to public access, clearing for infrastructure, road and track edges (Bennett 2005). The edges of these tracks were typically in poorer condition than the vegetation further away. The vegetation along the drain that bisects the area blended with the surrounding vegetation and in some sections included weedy areas, but mostly was in 'good' vegetation condition.

Clearing of vegetation will directly reduce the extent of vegetation communities; however, all of the vegetation complexes impacted by clearing are well represented at Cape Peron outside the Proposal area and clearing required for the Proposal would not result in any vegetation complexes being cleared to less than 10% of the original extent (Table 13). Five FCTs in the Proposal area will be directly impacted by clearing including:

- FCT S14: *Spinifex longifolius* grasslands and low shrublands
- FCT 29a: Coastal shrublands on shallow sands
- FCT 29b: Acacia shrublands on taller dunes (P3 PEC)
- FCT 30a: *Callitris preissii* (or *Melaleuca lanceolata*) forest and woodlands (TEC)
- FCT 30b: Quindalup *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands (P3 PEC).

The TEC located within the Proposal area near the corner of Memorial Drive and Safety Bay Road is in 'very good' to 'degraded' condition (Figure 46). The area is surrounded by native vegetation and there are many informal tracks that dissect the area and rubbish has been dumped adjacent to the site. These degrading influences will need to be controlled if the vegetation community is to be conserved.

The TEC (FCT 30a) is approximately 4.3 ha in total size. The Proposal will clear 1.93 ha of TEC FCT 30a ranging from very good to degraded to good condition. It is proposed to retain and consolidate TEC FCT 30a into a more sustainable shape of a remnant of approximately 3.95 ha, where the boundary to area ratio is improved when compared to the current configuration of the remnant. This will comprise the retention of 1.12 ha of Very Good condition vegetation, rehabilitation of 1.61 ha that currently does not support FCT 30a and 1.22 ha of FCT 30a that has been identified as being in Good – Degraded condition. Management measures, such as demarcating Environmental Exclusion Areas, will be implemented to protect and manage the TEC from additional clearing and potential community activities such as motorcycling and illegal rubbish dumping (discussed in 'Indirect disturbance and spread of weeds' sub-section below). The P3 PECs will remain well represented outside the Proposal area and where possible, these communities within the Proposal Area will be retained as part of the development.

Based on flora and vegetation surveys conducted to date, no DRFs or Priority Flora will be directly impacted by clearing.

Clearing for the development may result in the potential fragmentation of Bush Forever site 355 and this impact is discussed in Section 17. The Proposal proposes to impact upon 40 ha of native vegetation within Bush Forever site 355 and 37 ha within the RLRP. The area represents less than 1% of the RLRP which covers an area of 4270 ha (RLRP Management Plan, DEC 2010a).

The development will provide offsets that involve support for the management, protection and rehabilitation of vegetation in the Cape Peron area of RLRP thereby enhancing the biodiversity including botanical values in those sections of Regional Park and improving the ecological linkage between Lake Richmond and Cape Peron. A further offset is proposed through securing a parcel of land that is currently not protected, with similar or greater conservation value. The rehabilitation and possible land acquisition offsets will be determined (in consultation with the DEC and OPEA) in accordance with the EPA Position Statement No. 9 on Environmental Offsets.

8.4.2 Groundwater levels and quality changes

The lowering of the water table and change in groundwater quality by creation of a new saltwater interface is likely due to the dewatering activities required for the excavation and construction of the marina may potentially impact upon vegetation health and condition.

Groundwater levels recorded manually during the study period varied between 0.05 and 0.95 mAHD (MWH 2011a). Under a high (winter) water level scenario, the reduction in water levels in the vegetated area surrounding the Proposal during operation is less than 0.2 m (Section 6.3.5). Under a low (summer) scenario, the impact is closer to 0.1 m (Section 6.3.5). This drawdown may indirectly impact flora species identified in Table 16 such as *Eucalyptus gomphocephala* (tuart) or *Agonis flexuosa*. However, the magnitude of this groundwater level change is not considered to be significant in the context of seasonal variation in groundwater levels of 0.3 to 0.7 m and is within the known range of all vegetation species and communities.

The hydrological requirements of TEC 19 are well documented. Extracted from Interim Recovery Plan No. 110 Sedgelands in Holocene Dune Swales 2002 – 2007 (CALM 2002), the hydrological requirements of this TEC are described as follows "*Both long-term regional data (up to 24 years of records) and short-term site specific data at Port Kennedy indicate that the seasonal watertable fluctuation in the swale wetlands is low, generally less than 0.5 m. Although maximum watertable levels range from 0.4 m to 1.9 m below ground, some of the wetlands (sumplands) contain very limited areas of surface water during the winter months."* As the development will result in a change in groundwater levels of 0.038 m at Lake Richmond, where the community is located, it is considered that the community will not be impacted by changes in groundwater levels.

Groundwater in the Safety Bay Sands in the study area generally has a total dissolved salts (TDS) of less than 1 000 mg/L, except in areas within 200 m of the coast (Section 6).

With reference to Figure 52, the impact on water quality, by way of saline intrusion is limited and is not expected to impact any of the mapped TECs, except a small portion of the DEC mapped TEC FCT 30 which is proposed to be cleared. There may be some change in water quality under areas of community

SCP 29a and SCP 29b to the south of the site (Figure 52). These communities also occur in areas where the salinity is currently greater than 1 000 mg/L at Cape Peron and Shoalwater Bay (Figure 52). It is therefore considered that this change in salinity will not impact upon this community.

8.4.3 Indirect disturbance and spread of weeds

The proposed marina development will most likely result in an increased residential population of the area and increase in tourism activity leading to an increased public usage of the Cape Peron area. Increased vehicle movements during construction and post-construction of the proposed marina development may result in uncontrolled and unmanaged access to vegetated areas which can lead to:

- introduction and/or spread of weeds
- illegal rubbish dumping
- direct disturbance of vegetation and flora (e.g. from trampling and erosion of existing sandy tracks).

Currently there is evidence of bushland degradation, some of which is due to uncontrolled access at Cape Peron owing to the network of sandy tracks through vegetated areas and the associated invasion of weeds along track edges and degradation of vegetation adjacent to the tracks. Improving visitor access facilities as part of the Proposal will improve the protection of native vegetation through the provision of hard paths, increased management presence in the area and the removal and rehabilitation of unnecessary paths. Therefore, increased visitor access to the area is not expected to result in the impacts listed above.

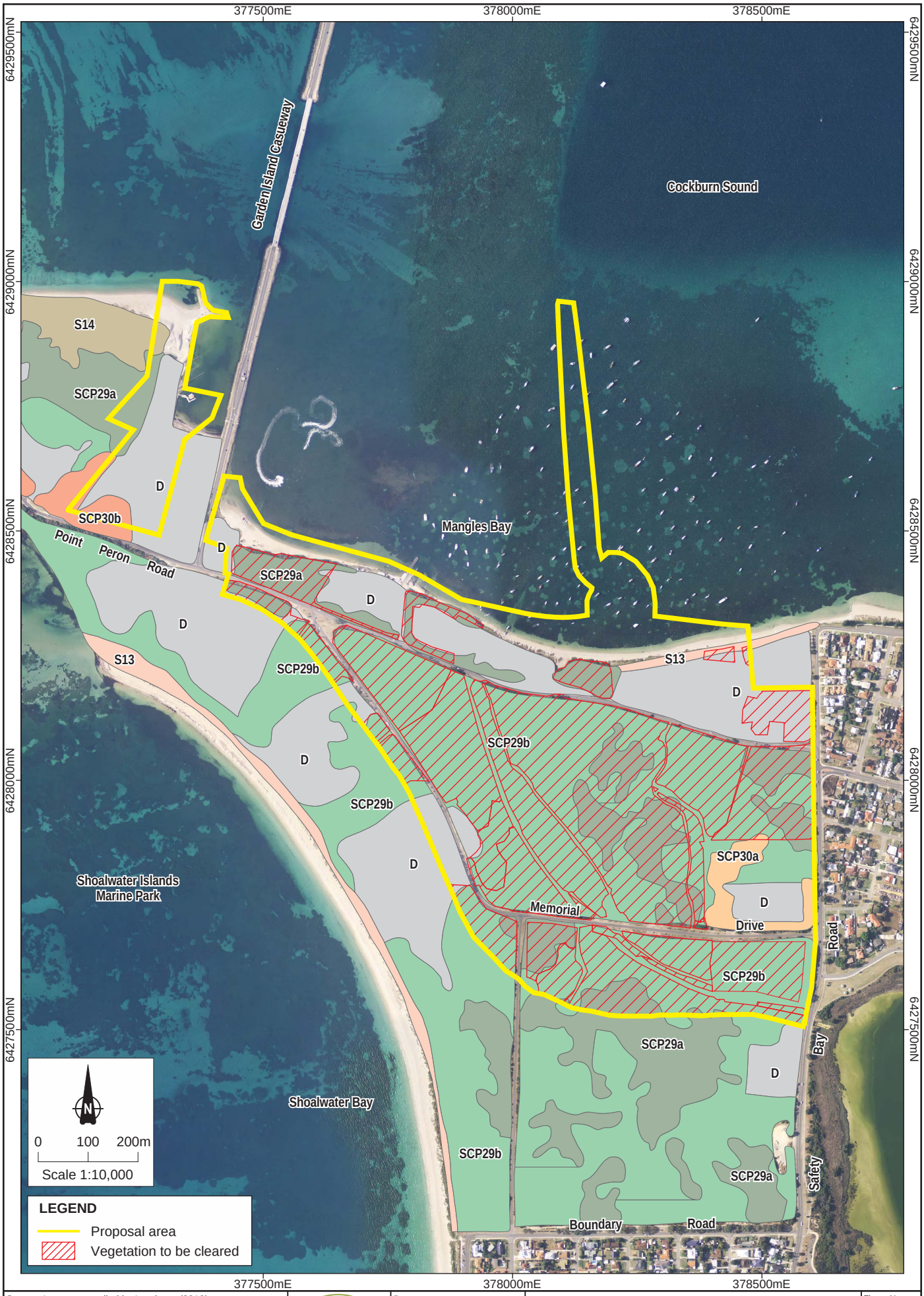
8.4.4 Dust Generation

Earthworks during construction will generate dust which may have direct physical effects on plants such as blockage and damage to stomata, shading, abrasion of leaf surface or cuticle and cumulative effects (e.g. drought stress on already stressed species). Dust also has the potential to adversely affect the health of construction workers and nearby residents.

Dust will be managed throughout the clearing and construction phase of development in accordance with DEC (2011a) publication " A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities" through the use of water trucks or other suitable dust suppression methods. Areas left exposed following development will be rehabilitated or sealed where appropriate, to reduce the risk of dust generation.

8.4.5 Potential edge effects

There is the potential for edge effects to occur to the vegetation surrounding the Proposal area, including the TEC FCT 30a surrounding the small grassed area on the corner of Memorial Drive and Safety Bay Road and the remnant vegetation adjacent in the RLRP (also Bush Forever Site 355). Degrading influences such as general construction activities during the construction phase of the Proposal, recreational walking, littering and domestic pets may potentially affect these areas. These potential edge effects would only be minor and would be subject to proposed management strategies which include rehabilitation and management effort within the TEC FCT 30a and RLRP.



Source: Imagery supplied by Landgate (2010)
FCT Mapping supplied by ENV (2010)
Coordinate System: MGA94 Zone 50
Date: 8/2/2012
NB: Potential errors may occur in some areas

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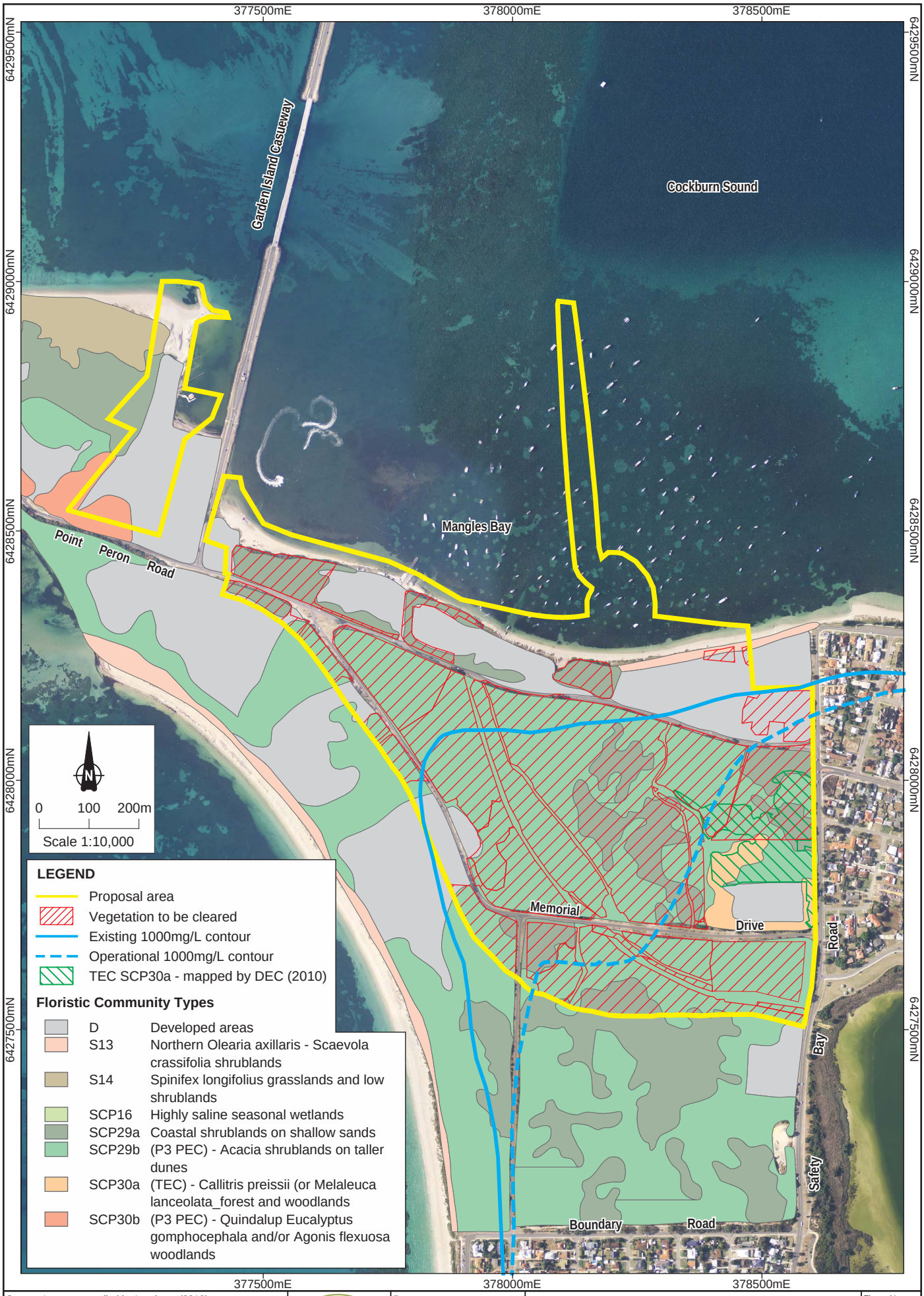
Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F028.dgn

Vegetation communities to be cleared as a result of the Proposal

Figure No: **51**



Source: Imagery supplied by Landgate (2010)
FCT Mapping supplied by ENV (2010)
Coordinate System: MGA94 Zone 50
Date: 2/8/2012
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CAD Resources File No: g1937_MB_PER_F060.dgn

Salinity level changes and surrounding vegetation

Figure No: **52**

8.5 Potential for and nature of any cumulative impacts

The Proposal has the potential to exacerbate the fragmentation of flora and vegetation of the Cape Peron portion of the RLRP and in turn Bush Forever Site 355. Implementation of the Proposal will not terminate connectivity between Bush Forever Site 358 (Lake Richmond) and the vegetation on Cape Peron; however, the importance of the connectivity provided by the vegetation adjacent to the south western shoreline (Shoalwater Bay) increases. Rehabilitation effort will be focused on improving the quality and linkage capabilities of these areas.

8.6 Management measures and performance standards

Clearing of vegetation will be minimised as far as practicable while still allowing construction and operation to be undertaken in a safe manner. Management strategies will include the use of a ground disturbance authorisation procedure, clear demarcation of areas approved for clearing, and environmental awareness training to ensure that employees are aware of the requirement to minimise ground disturbance.

The Proposal will clear 1.93 ha of TEC FCT 30a. It is proposed to retain and consolidate TEC FCT 30a into a more sustainable shape of a remnant of approximately 3.95 ha, where the boundary to area ratio is improved when compared to the current configuration of the remnant. This will comprise the retention of 1.12 ha of Very Good condition vegetation, rehabilitation of 1.61 ha that currently does not support FCT 30a and 1.22 ha of FCT 30a that has been identified as being in Good – Degraded condition.

In addition to reducing the footprint of the development during the design process, comprehensive mitigation measures are proposed for 56 ha of vegetation locally within the RLRP to offset the potential impacts of the proposed development, including impacts on vegetation and flora values. Proposed vegetation and flora mitigation measures also address the impact on the Bush Forever Site and include the protection and rehabilitation of the remnant vegetation of Cape Peron within the Bush Forever Site to enhance the conservation values and ecological linkage with Lake Richmond. The rehabilitation program would include:

- a strategic weed control program with the aim of a net decrease in weeds in the area
- planting and/or seeding disturbed areas with local provenance species where appropriate
- consolidating and formalising walking tracks in sensitive areas to reduce disturbance to vegetation
- fencing where required to protect vegetation
- stabilisation of disturbed dune areas
- establish a monitoring program to evaluate rehabilitation performance.

A community objective for the Proposal is to provide a sum of up to $5 000 000 to enhance the balance of Cape Peron outside the Proposal area. The funding will be for activities including rehabilitation activities and the acquisition of land with comparable or greater conservation value to secure the land for conservation. The funding will be part of an offsets package to offset the vegetation loss and area excised from the RLRP and Bush Forever Site 355. The offsets package will be developed in consultation with DEC, OEPA, DoP and the City of Rockingham.

Specific rehabilitation prescriptions for the final Proposal will be identified in consultation with DEC and detailed in a Rehabilitation Management Plan.

The final form and extent of the above offsets will be determined in accordance with EPA Position Statement No 9.

The potential for the introduction of weeds will be managed through vehicle hygiene procedures for earth-moving equipment during the pre-construction and construction phases. Ongoing weed management during the construction phase will be undertaken through regular weed spraying programs.

Dust will be managed through the use of water trucks or other suitable dust suppression methods.

8.7 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

Development will result in the clearing of up to 40 ha of remnant vegetation which has experienced varying degrees of disturbance, including extensive weed invasion. Notwithstanding these disturbances, some of the vegetation to be cleared is considered regionally significant on the basis of floristic communities, as defined by Gibson *et al*. (1994).

FCT 30a near the corner of Memorial Drive and Safety Bay Road is a 4.3 ha ha area that is an example of a TEC of variable condition. The Proposal will clear 1.93 ha of TEC FCT 30a. It is proposed to retain and consolidate TEC FCT 30a into a more sustainable shape of a remnant of approximately 3.95 ha, where the boundary to area ratio is improved when compared to the current configuration of the remnant. This will comprise the retention of 1.12 ha of Very Good condition vegetation, rehabilitation of 1.61 ha that currently does not support FCT 30a and 1.22 ha of FCT 30a that has been identified as being in Good – Degraded condition. By area the outcome will provide a limited loss of TEC, however, an improvement in condition and future management will be achieved.

The Proposal will not result in any vegetation complexes being cleared to less than 10% of the original extent. Approximately 48% of the pre-European extent Quindalup Vegetation Complex remains in the Metropolitan area. No DRF or Priority Flora will be affected by the Proposal as no specimens were located during the extensive flora and vegetation surveys of the Cape Peron.

Changes in groundwater quality and levels are not anticipated to impact vegetation in the area.

The Proponent will provide offsets in accordance with EPA Position Statement No 9. The Proponent is discussing opportunities with the DEC to achieve no net loss to the conservation estate, possibly through a contribution to a land acquisition with similar or greater conservation value. The proposed support for the management, protection and rehabilitation of vegetation in the Regional Park to enhance the biodiversity, including botanical values in the Regional Park and improving the ecological linkage between Lake Richmond and Cape Peron, will assist to offset any loss of conservation values within the Regional Park.

9. Terrestrial fauna impact assessment

9.1 Relevant environmental objectives, policies, guidelines, standards and procedures

9.1.1 EPA objectives

The EPA applies the following objectives in assessing proposals that may affect fauna:

To maintain the abundance, diversity geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement of knowledge

To maintain biological diversity that represents the different plants, animals and microorganisms, the genes they contain and the ecosystems they form, at the levels of genetic diversity, species diversity and ecosystem diversity.

9.1.2 EPA Position Statements, Guidance Statements and Guidelines

EPA Position Statement No. 3

EPA Position Statement No. 3 (EPA 2002) discusses the principles the EPA would apply when assessing proposals that may have an effect on biodiversity values in Western Australia. The outcomes sought by this Position Statement are intended to:

- promote and encourage all proponents and their consultants to focus their attention on the significance of biodiversity and, therefore, the need to develop and implement best practice in terrestrial biological surveys
- enable greater certainty for proponents in the environmental impact assessment process by defining the principles the EPA will use when assessing proposals that may have an effect on biodiversity values.

EPA Guidance Statement No. 56

EPA Guidance Statement No. 56 (EPA 2004c) provides guidance on standards and protocols for terrestrial fauna surveys, particularly those undertaken for the environmental impact assessment of proposals.

EPA Guidance Statement No. 20

EPA Guidance Statement No. 20 (EPA 2009a) provides guidance on standards and protocols for surveys for Short Range Endemics (SRE) fauna, particularly those undertaken for the environmental impact assessment of proposals.

9.1.3 Regulatory Framework

State Protection

The preservation and conservation of fauna is covered by the following Western Australian legislation:

- *Wildlife Conservation Act 1950 (WA)*
- *Conservation and Land Management Act 1984.*

In Western Australia, rare or endangered species are protected by the Wildlife Conservation (Specially Protected Fauna) Notice 2010(2), under the WC Act. Schedules 1 and 4 in this notice are relevant to this assessment, providing a listing of the species protected by this Notice.

Fauna are also listed by DEC as Priority species if they are potentially threatened but for which there is insufficient evidence to properly evaluate their conservation significance. They range from Priority 1 to Priority 5 species, and are as follows:

- Priority 1: Poorly Known Taxa. Taxa, which are known from one or a few (generally <5) populations, which are under threat
- Priority 2: Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat
- Priority 3: Poorly Known Taxa. Taxa which are known from several populations, at least some of which are not believed to be under immediate threat
- Priority 4: Rare Taxa. Taxa which are considered to have been adequately surveyed and which whilst being rare, are not currently threatened by any identifiable factors
- Priority 5: .Taxa that are conservation dependent. If conversation programs were ceased, the taxa would become threatened within five years.

Note that the Priority status does not have statutory standing. The Priority fauna classifications are employed by the DEC to manage and classify their database of species considered potentially to be at risk, but these categories have no legislative status for protection in addition to the native vegetation clearing legislation.

Australian Government Protection

The Federal EPBC Act protects species listed under Schedule 1 of the Act. In 1974, Australia became a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). As a result, an official list of endangered species was prepared and is regularly updated. This listing is administrated through the EPBC Act. The current list differs from the various State lists; however, some species are common to both.

Australia is party to the Japan-Australia (JAMBA), China-Australia (CAMBA) and Republic of Korea-Australia (ROKAMBA) Migratory Bird Agreements. Most of the birds listed in these agreements are associated with saline wetlands or coastal shorelines. A number of migratory birds not associated with freshwater wetlands are also listed on these international treaties. In addition, migratory birds are protected by the EPBC Act.

9.2 Findings of surveys and investigations

The Proposal area was subject to extensive terrestrial fauna, subterranean fauna, SRE invertebrate fauna and a targeted GSM survey (Bamford 2005; Subterranean Ecology 2010a, 2010b, 2010c, 2010d; ENV 2011a; ENV 2011b) (refer to Figure 53 for an outline of the Survey area). Objectives of these surveys were to identify the abundance and diversity of fauna likely to occur within the Proposal area and the significance of the potential impacts of the Proposal to those identified species, particularly those of conservation significance. Studies were completed in accordance with EPA Position Statement No.20 (EPA 2009a) and Guidance Statement No. 56 (EPA 2004c).

The following description of the fauna of the Proposal area is adapted from Bamford (2005), Subterranean Ecology (2010a, 2010b, 2010c, 2010d) and ENV (2011a and 2011b) unless otherwise stated. The methodology and full results of these surveys are included in Appendix 5.

9.2.1 Terrestrial fauna habitats

Four terrestrial fauna habitats were identified within the survey area:

- shoreline habitat
- coastal heath habitat
- woodland habitat
- wetland habitat (ENV 2011a).

Cleared and degraded areas were also present. Wetland habitat was not found within the area to be cleared for land development. All habitat types within the Survey area were present outside the land development area (Table 17 and Figure 54).

Table 17 Areas of fauna habitat within Proposal area

Habitat type	Total in survey area (ha)	Percentage of survey area (%)	Total in Proposal area (ha)	Total to be cleared for the Proposal (ha)	Percentage cleared of total surveyed habitat (%)
Shoreline	4.15	2.0	1.89	0,9	21
Coastal heath	113.37	54.5	37.52	35.2	31
Woodland	19.29	9.3	5.75	2.18	10.8
Wetland	16.93	8.1	0	0	0
Cleared/degraded	54.26	26.1	22.24	22.24	41
Total	208.01 (153.74 ha not cleared or degraded)	100%	67.41 (45.17 ha not cleared or degraded)	60.52 (38.28 ha not cleared or degraded)	23%

Source:
Aerial photography supplied by Landgate (2010)
Fauna mapping supplied by ENV (2010)
Coordinate System: MGA94 Zone 50
Date: 8/2/2012
NB: Potential errors may occur in some areas

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Extent of ENV fauna surveys across Cape Peron

Figure No:
53

Source:
Cadastral data supplied by Landgate
Fauna Habitats supplied by ENV (2011)
Coordinate System: MGA94 Zone 50
Date: 8/2/2012

NB: Potential errors may occur in some areas

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Fauna habitat types surveyed (ENV 2011a)

Figure No:
54

Shoreline habitat

The Shoreline habitat type fringes the coastline within the Proposal area and consists of tidal reef platforms, limestone outcropping and sandy bays. The vegetation within this habitat type consists of an open heath of *Frankenia pauciflora* (sea heath) and scattered *Sarcocornia blackiana* on sandy or limestone soils (ENV 2011a). This habitat type has a minor representation within the survey area being 4.15 ha or 2% of the survey area (Figure 54).

This habitat provides shelter and foraging opportunities for a number of different species including migratory waders and marine birds on the sandy bays and headlands, and small ground-dwelling reptiles and mammals in the rocky limestone outcropping at Cape Peron (ENV 2011a). Pied cormorants and silver gulls were observed roosting on the rocky limestone outcropping (ENV 2011a). Pied Oystercatchers and common sandpipers are also known to forage within the exposed rocky limestone outcropping and reef platforms (ENV 2011a). The shoreline habitat type can provide foraging opportunities to waders, as well as nesting opportunities for sooty and bridled terns (ENV 2011a). The Shoreline habitat type is considered as having a moderate habitat value for fauna species within the survey area and was generally in an 'Excellent' condition (ENV 2011a).

Coastal heath habitat

The Coastal Heath habitat type formed the coastal and near-coastal areas of the survey area and was the dominant habitat type within the survey area (113.4 ha or 54.5% of the survey area) (Figure 54). The vegetation within this habitat type consists of a closed to open heath of *Acacia rostellifera* (summer-scented wattle) and *Olearia axillaris* (coastal daisy bush) over a closed mixed grassland of *Lomandra maritima* and introduced species over white to light brown sands (ENV 2011a). This habitat provides shelter and foraging opportunities for a number of different species including ground-dwelling reptiles and mammals in the near-coastal and coastal areas (ENV 2011a).

This habitat showed signs of disturbance through cleared and developed areas along with a strong influx of weed species (ENV 2011a). The Coastal Heath habitat type was deemed as having a moderate habitat value to fauna species within the Survey area (ENV 2011a). Based on the Keighery condition scale, the Coastal Heath habitat was found to be in 'Very Good' to 'Good' condition, with areas of disturbance, clearing and weed infestation (ENV 2011a).

Woodland habitat

The Woodland habitat type is found in small isolated pockets of dense vegetation within the survey area and forms a small proportion of the Proposal area (19.3 ha or 9.3% of the Survey area) (Figure 54). The vegetation within this habitat type consists of an open forest of *Eucalyptus gomphocephala* (tuart) and *Agonis flexuosa* over a closed shrubland of *A. rostellifera* and mixed grassland of introduced species over light brown sands (ENV 2011a).

This habitat provides shelter and foraging opportunities for a number of different species including arboreal reptiles and mammals and a number of different avian species (ENV 2011a). Burrowing frogs may be found in this habitat type as the dense vegetation provides comparatively moist conditions suitable for frogs (ENV 2011a).

There were signs of disturbance through cleared and developed areas along with a strong influx of weed species, with the habitat being in 'Good' condition based in the Keighery scale (ENV 2011a). The tuarts did not contain any breeding hollows suitable for nesting black cockatoo species and only provide a minor amount of roosting potential (ENV 2011a). The Woodland habitat type was deemed as having a moderate habitat value to fauna species within the Survey area (ENV 2011a).

Wetland habitat

The Wetland habitat type is outside the Proposal area and is primarily located around Lake Richmond. A total of 16.9 ha or 8.1% of the Survey area was found to be wetland habitat. However, extensive wetland areas occur outside the survey area, around Lake Richmond (Figure 54). The lake is bordered by flats devoid of permanent vegetation, and then sedges at the base of surrounding coastal dunes. The sedge land is several metres wide and is dominated by *Baumea juncea* (bare twigrush), *Schoenoplectus validus* (lake club rush) and clumps of the introduced bulrush **Typha orientalis*[9] (ENV 2011a).

This Wetland habitat provides shelter and foraging opportunities for a number of different species including wetland waders and ducks on the fringes of the lake to small ground dwelling reptiles and mammals in the associated fringing vegetation. Lake Richmond also provides a permanent freshwater system in which frogs can carry out their life cycle. The Wetland habitat type can provide foraging opportunities for waders and *Merops ornatus* (Rainbow Bee-eater).

The Wetland habitat type was deemed as having a high habitat value for fauna species within the Survey area. The condition of the Wetland habitat surveyed was found to be Excellent according to the Keighery scale (ENV 2011a).

Regional context of fauna assemblage

In terms of species composition and richness, Cape Peron has been identified as being typical of small woodland remnants on the Swan Coastal Plain (ENV 2011a).

To verify the similarity of Cape Peron with other localities in the Swan Coastal Plain, the fauna assemblage was compared with baseline surveys and fauna compositions of the following neighbouring sites (Table 18):

- Jandakot Airport
- East Rockingham
- Norman Road
- Talbot Road.

Table 18 Regional comparisons of fauna assemblage

Location	Amphibians	Reptiles	Birds	Mammals	Overall
Cape Peron	5	19	65	6	95
Jandakot Airport	3 (2)	21 (13)	46 (29)	14 (5)	84 (49)
East Rockingham	0 (0)	17 (12)	44 (30)	12 (4)	73 (46)
Norman Road	4 (2)	12 (9)	N/A	5 (2)	21 (13)
Talbot Road	7 (3)	13 (10)	N/A	4 (1)	24 (14)
Swan Coastal Plain	13	64	311	33	421

+Values in parentheses are the number of species in each fauna group, or overall, shared with the ENV 2010 Cape Peron field survey.

The two nearest comparison sites, Jandakot Airport and East Rockingham, have a high degree of similarity to Cape Peron; particularly in the case of songbirds (87.5% shared similarity). The reptile assemblage at these sites is also similar to Cape Peron (>50% of similarity), likely a result of the relatively close proximity of the sites. In addition Cape Peron demonstrates a high level of reptile assemblage similarity (75%) with the Norman Road and Talbot Road comparison sites, likely due to the similarity in size of these remnant woodlands.

[9] Asterisks (*) denote species that are not native.

Although there are strong similarities between the comparison site assemblages and that of Cape Peron, there are a number of species which were not recorded at all of the sites, particularly mammals and reptiles. This is likely a function of the fragmentation of habitats and urbanisation of these areas which has occurred since European settlement. Reductions in available habitat area are likely to limit the ability for fauna species to maintain a viable population, resulting in localised extinctions within the small woodland fragments found on the Southwest Coastal Plain.

Significance of fauna habitat

The bushland of the Proposal area and surrounds is part of Bush Forever Site 355, as discussed in Section 8.2.1. Although considered to be of regional significance through the Bush Forever classification, in terms of fauna habitat the area is not considered to be of critical regional significance due to the high level of commonality of the habitats within both the survey area and wider surrounds (ENV 2011a). Each of the four habitat types mapped within the Cape Peron study area extend beyond the Proposal area and has already been subject to a high level of fragmentation and disturbance.

The survey area is isolated from other woodland remnants due to existing urbanisation, thus the only regional connectivity with the site is for highly mobile species such as birds. Disjunct habitats, such as the pocket present at Cape Peron, are utilised by birds as stepping stones between different areas. In addition to being disjunct at a regional level, the habitat present in the vicinity of the Proposal area is fragmented due to the previous land use and disturbance in Cape Peron (Table 19).

Table 19 Condition of fauna habitat present in the vicinity of the Proposal area

Habitat condition	Coastal Heath (ha)	Shoreline (ha)	Wetland (ha)	Woodland (ha)	Total (ha)
Excellent	-	-	16.23	-	16.23
Very Good	16.12	-	-	1.26	18.08
Very Good to Good	-	-	-	-	-
Good	14.68	0.01	-	3.84	20.09
Good to Degraded	1.39	0.10	-	-	1.49
Degraded to Completely Degraded	2.31	-	-	-	2.41
Completely Degraded	1.49	-	-	0.20	1.69

9.2.2 Terrestrial vertebrate fauna recorded within the Proposal area

Desktop studies of potential fauna abundances conducted during previous investigations were undertaken by Bamford (2005), which identified 187 non-marine species that may either potentially occur or have previously been recorded in the surveyed area. This total included 121 species of birds, 17 species of native mammals, 42 species of reptiles and seven amphibians. Surveys within the Proposal area, Lake Richmond and Bush Forever Site 353 by ENV (2011a) recorded 17% of the native mammals, 52% of the birds, 45% of the reptiles and 71% of the amphibians potentially occurring (Table 20). This low percentage of findings is considered likely to be due to the degraded and fragmented nature of the habitat (ENV 2011a). The migratory nature of bird species in the area is likely to also have reduced the number of species observed (Bamford 2005).

Table 20 Species recorded in the Survey area (after Bamford 2005; ENV 2011a)

Fauna Group	Species potentially present (Bamford 2005)	Species recorded (ENV 2005; Bamford 2005; Harewood 2009)	Species recorded (ENV 2011a)
Birds	121	44	66 (includes3 introduced species)
Mammals	17	12	6 (includes 3 introduced species)
Reptiles	42	17	19
Amphibians	7	-	5
Conservation significant	53	-	7 (34 potentially occurring)
Total	187	73	96 (includes 6 introduced species)

Mammals

A total of six mammal species from five families were recorded during the survey. The most frequently represented family was Muridae with two species, the remaining four families were represented by only one species.

Thirty one mammal species have previously been recorded within the surrounds of Cape Peron. A mammal survey was undertaken within the area by ENV (2011a) to support the Proposal. The survey included Lake Richmond (Bush Forever site 358). ENV (2011a) recorded three native mammal species within the Survey area, being:

- *Chalinolobus gouldii* (Gould's wattled bat)
- *Austrononus australis* (white-striped freetail-bat), also known as *Tadarida australis*
- *Rattus fuscipes* (western bush rat).

The white-striped freetail-bat and western bush rat are both found within the southwest of the state and are commonly recorded in biological surveys (ENV 2011a). Gould's wattled bat is common in Southern Australia.

No Priority or EPBC listed mammals were found in the survey area. A full copy of the ENV survey can be found in Appendix 5.

Introduced species

ENV (2011a) recorded three native introduced mammal species within the survey area, being:

- **Mus musculus* (house mouse)
- **Oryctolagus cuniculus* (rabbit)
- **Vulpes vulpes* (red fox).

Birds

A total of 66 bird species from 29 different families were recorded during the ENV survey (ENV 2011a) (Appendix 5). The most frequently represented family was Anatidae (ducks) with six species and *Meliphagidae* (honeyeaters) with five species (ENV 2011a). Six species of migratory birds were found in the Survey area, but no other conservation listed species (ENV 2011a).

Introduced species

Three introduced bird species were recorded:

- **Columba livia* (domestic pigeon)
- **Streptopelia senegalensis* (laughing turtle-dove)
- **Dacelo novaeguineae* (laughing kookaburra).

These species are widespread across much of the southwest of Western Australia (Johnstone and Storr 1998).

Herpetofauna

Reptiles

Nineteen reptile species from seven separate families were recorded during the survey (ENV 2011a). The most frequently represented family was Scincidae (skinks) with nine species followed by Pygopodidae (legless lizards) with three species (ENV 2011a). The most commonly recorded species were *Acritoscincus trilineatum* (southwestern cool skink), *Hemiergis quadrilineata* (two-toed earless skink) and *Tiliqua rugosa* (bobtail) (ENV 2011a).

A total of 51 reptile species have previously been recorded within the surrounds of Cape Peron, with the current survey recording only one new species; the *Chelodina oblonga* (oblong turtle), which is commonly found within wetlands on the Swan Coastal Plain (ENV 2011a).

One species of conservation significance was recorded in the survey area; *Lerista lineata* (the lined skink). Listed as Priority 3 by the DEC, the lined skink was recorded 31 times at all six sites within the survey area (ENV 2011a).

Amphibians

The survey recorded five amphibian species from two families (ENV 2011a). The most commonly recorded species was *Litoria moorei* (Motorbike Frog) and *Heleioporus eyrei* (Moaning Frog) (ENV 2011a).

No conservation listed amphibians are recorded as occurring in the Proposal area (ENV 2011a).

Freshwater fish and crustacea

Aquatic vertebrates in Lake Richmond were surveyed by Rose (1998) and Rose *et al.* (2004). The 2004 survey found that the native *Pseudogobius olorum* (Swan River goby) was the most common species (Rose *et al.* 2004). One native *Mugil cephalus* (sea mullet) was also caught (Rose *et al.* 2004).

No conservation listed fish or crustaceans have been recorded in the Proposal area.

Introduced species

The following species of introduced freshwater fish and crustacean have also been recorded (Rose *et al.* 2004):

- *Gambusia holbrooki* (mosquito fish)
- *Carassius auratus* (goldfish)
- *Cherax destructor* (yabbie).

9.2.3 Species of conservation significant terrestrial vertebrate fauna

Conservation significant vertebrate fauna species indicated in searches of the DEC NatureMap Database or EPBC Act Protected Matters Database as potentially occurring in the Proposal area are summarised in Table 21.

Table 21 Potentially occurring conservation significant vertebrate fauna species

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Mammals						
Isoodon obesulus fusciventer (quenda)	Priority 5	-	Occurs within forest, heath or coastal scrub. Distributed along the coast of south western Western Australia from Moore River to Israelite Bay.		*	Likely. Suitable habitat is present.
(Chuditch, western quoll)	Schedule 1	Vulnerable	Occurred on the Swan Coastal Plain until 1930s, current distribution restricted to southwest of Western Australia. Main portion of remaining populations occur within Jarrah forest, and drier woodland and Mallee shrublands associated with the Wheatbelt.			Unlikely. Due to lack of suitable habitat.
(Red-tailed phascogale)	Schedule 1	Endangered	Wandoo, Sheoak woodland associations. Exhibits a preference for long unburnt habitat with continuous canopy, as well as tree hollows.			Unlikely. Due to lack of suitable habitat.
Setonix brachyurus (quokka)	Schedule 1	Vulnerable	Current distribution includes two offshore islands (Rottnest and Bald Islands) and a number of sites in the southwest of Western Australia. Prefers dense streamside vegetation, heaths and shrubs of mainland and offshore islands, to *Agonis linearifolia*-dominated swamps in Jarrah forest and re-growth within Karri forest.			Unlikely. Due to lack of suitable habitat.
Hydromys chrysogaster (water rat, rakali)	Priority 4	-	Freshwater habitats, from subalpine streams and other inland waterways to lakes, swamps, and farm dams			Unlikely, but may occur at Lake Richmond, which is outside the Proposal area.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Birds						
Calyptorhynchus banksii naso (forest red-tailed black cockatoo)	Schedule 1	Vulnerable	Inhabits dense Jarrah, Karri and Marri forests receiving more than 600 mm average rainfall annually (DSEWPaC 2011c). Also known to occur in woodlands which include Blackbutt, Wandoo and Tuart species.		*	The fauna survey undertaken by ENV in 2009 (2011a) did not record this species during the survey. Potential habitat for this species is present within and outside the Proposal area as individual Tuart species. The ENV fauna survey (ENV 2011a) however, did not record potential foraging or breeding habitat with little roosting potential for cockatoo species within the Proposal area. The potential habitat within the Proposal area is located within the 'area to remain uncleared' with Tuart species present within the TEC "Callitris preissii (or Melaleuca lanceolata) forest and woodlands'. Tuart species are also present PEC SCP30b 'Quindalup Eucalyptus gomphocephala and/or Agonis flexuosa woodlands'. The Proposal does not propose to clear any tuart species.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Calyptorhynchus latirostris (Carnaby's cockatoo, short-billed black-cockatoo)	Schedule 1	Endangered	Inhabits native eucalypt woodlands that contain Salmon Gum and Wandoo and in shrubland or kwongan heathland dominated by Hakea, Dryandra, Banksia and Grevillea species (DSEWPaC 2011c). Nests in hollows of smooth-barked eucalypts especially Salmon Gum (*Eucalyptus salmonophloia*) and Wandoo (*Eucalyptus wandoo),* nests have also been found in other eucalypts including York Gum (*Eucalyptus loxophleba*), Flooded Gum (*Eucalyptus rudis*), Tuart (*Eucalyptus gomphocephala*) and the rough-barked Marri (*Corymbia calophylla*). During the non-breeding season, the species roosts in tall native or introduced eucalypts, and occasionally in Marri and pines. Species known to be used for roosting include Flat-topped Yate (*E. occidentalis*), Salmon Gum, Wandoo, Karri (*E. diversicolor*), Blackbutt (*E. patens*), Tuart (*E. gomphocephala*), Blue Gum (*E. globulus*, introduced), *Pinus radiata* and *P. pinaster* (DSEWPaC 2011c).		*	Investigations undertaken by ENV (2011a) did not record evidence of these species in the Survey area and indicated a lack of potential habitat within the proposed action footprint. The species however, is known to occur within the Rockingham area with species recorded by Birds Australia and historical surveys within 10 km of the Proposal area (ENV 2011a). The potential habitat distribution, within and surrounding the Proposal area for this species is similar to the Forest Red-tailed Black Cockatoo described above.
Diomedea exulans gibsoni (Gibson's albatross)	Schedule 1	Vulnerable	Gibson's Albatross is marine, pelagic and aerial and breeds on Adams Island and Auckland New Zealand (DSEWPaC 2011d). On breeding islands, this species nests on coastal and inland ridges, slopes, plateaux and plains, often on marshy ground (DSEWPaC 2011d).			Unlikely to occur. Only occurs in Australia between Coffs Harbour and Wilson's Promontory (Environment Australia 2001). The ENV fauna survey (2011a) did not record this species during the survey and did not identify this species in either Birds Australia, DEC or NatureMap database searches and previous fauna survey records within 10 km of the Proposal area. It is unlikely that this species would be found within or surrounding the Proposal area as the area does not support ideal habitat for this species.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Macronectes giganteus (southern giant-petrel)	Schedule 1	Endangered	The Southern Giant Petrel occurs mainly in Antarctic waters and during summer, it possibly concentrates north of 50° S in winter, as it is rare in waters of the southern Indian Ocean, but common off South America, South Africa, Australia and New Zealand. It occurs in both pelagic and inshore waters and is also attracted to land at sewage outfalls and scavenges ashore.		*	Likely. The species was not recorded during the ENV 2010 survey however is listed as occurring in the Rockingham area and SIMP (NatureMap). The species may potentially occur within the Proposal area but is likely only an infrequent visitor.
Macronectes halli (northern giant-petrel)	-	Vulnerable	The Northern Giant-Petrel is marine and oceanic, occurring mainly in sub-Antarctic waters, but also regularly occurs in Antarctic waters of the south western Indian Ocean, the Drake Passage and west of the Antarctic Peninsula. Its range extends into subtropical waters mainly between winter and spring and it frequents both oceanic and inshore waters near breeding islands and in the non-breeding range. During its first year, it occurs mainly on continental shelves, slopes and cold eastern boundary currents off South America, South Africa, Australia and New Zealand. It may be more oceanic from its second year. It is attracted to land at sewage outfalls and scavenges at colonies of penguins and seals.		*	Likely. The Northern Giant Petrel was not recorded during the ENV 2010 survey however is recorded as occurring in the Rockingham area by NatureMap. Given the availability of suitable habitat, it is possible that this species occurs in the Proposal area during the winter months of May to October however it is likely to be an infrequent visitor.
Thalassarche cauta cauta (shy albatross, Tasmanian shy albatross)	Schedule 1	Vulnerable	The Shy Albatross is a marine species occurring in sub-Antarctic and subtropical waters. Its preference for sea surface temperatures is not well known and it has been observed over waters ranging from 6.4 to 13.5º C. During the non-breeding season, it occurs around continental shelves around continents. It occurs both offshore and inshore and is known to enter harbours and bays.		*	Likely. The Shy Albatross was not recorded by the ENV 2010 survey however is recorded by NatureMap as occurring in the coastal Metropolitan area. It is potentially only an infrequent visitor to the Proposal area.
Ardea sacra (eastern reef egret)	Schedule 3	Migratory	The Eastern Reef Egret occurs in coastal areas along the entire Western Australia coast, although it is more common in the warmer regions to the north. The species inhabits beaches, rocky shores, tidal rivers and inlets, mangroves, and exposed coral reefs. Although it is listed as migratory, the Eastern Reef Egret is largely sedentary in nature (Johnstone and Storr 1998).		*	Likely. The beaches and rocky shores of the Proposal area are typical habitat for this bird and it is likely to occur there.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Plegadis falcinellus (glossy ibis)	Schedule 3	Migratory	The Glossy Ibis is listed as Migratory under the EPBC Act and inhabits areas of freshwater wetlands, estuaries and creeks, with occasional foraging in dry grasslands. This species is generally uncommon, but has a widespread and erratic distribution.		*	Likely. The area dry grassland within the Proposal area contains suitable foraging habitat for the Glossy Ibis and it is likely to reside there from time to time.
Falco peregrinus (peregrine falcon)	Schedule 4	Migratory	The Peregrine Falcon occurs mainly along coastal cliffs, rivers and ranges as well as wooded watercourses and lakes (Johnstone and Storr 1998). The Peregrine Falcon nests primarily on cliffs, granite outcrops and quarries, and feeds mostly on birds (Johnstone and Storr 1998). The coastal cliffs provide some potential nesting habitat and there is plentiful supply of prey items in the area.		*	Likely. Peregrine Falcon is likely to only forage within the Survey area and only as part of a larger home range.
Limosa limosa (black-tailed godwit)	Schedule 3	Migratory	The Black-tailed Godwit is an uncommon summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia (Geering *et al.* 2007). It inhabits fresh and brackish wetlands as well as intertidal mudflats (Geering *et al.* 2007).		*	Likely. Fresh water and intertidal regions of the Survey area provide an adequate habitat for this species and it is likely to occur during its migration.
Limosa lapponica (bar-tailed godwit)	Schedule 3	Migratory	The Bar-tailed Godwit is a relatively common summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia, including Garden Island which is situated just north of the Survey area. It inhabits mudflats, sandy and sea-weedy beaches (Johnstone and Storr 1998).		*	Likely. The habitat around the Survey area is well suited for the Bar-tailed Godwit and it is likely to occur there during its migration.
Numenius phaeopus (whimbrel)	Schedule 3	Migratory	Whimbrel is a large non-breeding migratory shorebird, found commonly along the north coast of Western Australia and intermittently found on the south coast (Johnstone and Storr 1998). It inhabits mudflats of estuaries or lagoons, particularly those with Mangroves where it often roosts (Geering *et al.* 2007).		*	Likely. The Survey area contains habitat suitable for the Whimbrel and as such it is possible the Whimbrel may be found in this area on its migratory route.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Numenius madagascariensis (eastern curlew)	Schedule 3	Migratory	Occurs commonly along the north coast of Western Australia, but is known to migrate south to Bunbury along the South Coast (Johnstone and Storr 1998). It inhabits a range of coastal habitats, but primarily intertidal mudflats, particularly on exposed seagrass beds or mudflats with burrowing crabs or shrimps (Geering *et al.* 2007).		*	Likely. The Survey area does contain habitat suitable for the Eastern Curlew and it is possible the Eastern Curlew may be found in this area on its migratory route.
Tringa stagnatilis (marsh sandpiper)	Schedule 3	Migratory	A summer non-breeding migratory shorebird that occurs in Western Australia along the coast, coastal plains, and less frequently inland (Johnstone and Storr 1998). It inhabits freshwater or saltwater wetlands but avoids open beaches and mudflats unless well protected (Geering *et al.* 2007).		*	Likely. The marine and freshwater environments of the Survey area are possible habitats for the Marsh Sandpiper during its migratory routes.
Tringa nebularia (common greenshank)	Schedule 3	Migratory	A non-breeding migratory shorebird, common along most of the coast of Western Australia (Geering *et al.* 2007). It inhabits intertidal mudflats, as well as fresh and saltwater wetlands of the coast or inland (Geering *et al.* 2007).		*	Likely. The shorelines of the Survey area are a suitable habitat for the Common Greenshank. As such it is likely to inhabit this area on its migratory route. Also likely to occur on Lake Richmond, which is located outside the Proposal area.
Tringa glareola (wood sandpiper)	Schedule 3	Migratory	A summer non-breeding migratory shorebird that occurs along the coastal as well as inland regions of Western Australia (Geering *et al.* 2007). It primarily inhabits freshwater wetlands and rarely on intertidal mudflats (Geering *et al.* 2007).		*	Unlikely. The closest suitable habitat for the Wood Sandpiper is Lake Richmond, which is outside the Proposal area.
Xenus cinereus (terek sandpiper)	Schedule 3	Migratory	The Terek Sandpiper is a summer non-breeding migratory shorebird that occurs along the north coast of Western Australia, but intermittently found as far south as Bunbury and Albany (Johnstone and Storr 1998). It inhabits exposed seagrass beds in estuaries and bays or on intertidal mudflats fringed by mangroves (Geering *et al.* 2007).	*		Confirmed. Recorded by ENV (2011a) Occurs on sandy beaches around the Survey area.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Tringa brevipes (grey-tailed tattler)	Schedule 3	Migratory	A non-breeding migratory shorebird, common on the north and west coasts of Western Australia, rare on the south coast. It has been recorded on Garden Island which is situated just north of the Survey area (Johnstone and Storr 1998). It inhabits sheltered coasts with reef and rock platforms or with intertidal mudflats (DSEWPaC 2011d). It often roosts in mangroves or artificial structures such as piers and breakwaters (Geering *et al.* 2007).		*	May inhabit the small areas of rocky coast within the Proposal area that area suitable for the Grey-tailed Tattler on its migratory route.
Arenaria interpres (ruddy turnstone)	Schedule 3	Migratory	Summer non-breeding migratory shorebird that occurs on the coast of Western Australia and has been recorded on Penguin Island which is situated just south of the Survey area (Johnstone and Storr 1998). It occurs primarily on rocky coasts and rocky reefs, as well as tidal mudflats and beaches and pebbly shores of near-coastal salt lakes and salt-work ponds (Johnstone and Storr 1998).		*	The Survey area only has small areas of rocky coast with seaweed, suitable for the Ruddy Turnstone. As such it may inhabit this area on its migratory route.
Calidris canutus (red knot)	Schedule 3	Migratory	Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia with records from Garden Island which is situated just north of the Survey area (Johnstone and Storr 1998). It inhabits larger intertidal mud and sand flats (Geering *et al.* 2007).		*	The tidal sands of the Survey area are a suitable habitat for the Red Knot. As such it is likely to inhabit this area on its migratory route.
Calidris tenuirostris (great knot)	Schedule 3	Migratory	Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia with records from Garden Island which is situated just north of the Survey area (Johnstone and Storr 1998). It inhabits larger intertidal mud and sand flats (Geering *et al.* 2007).		*	The tidal sands of the Survey area are a suitable habitat for the Great Knot. As such it may inhabit this area on its migratory route.
Calidris alba (sanderling)	Schedule 3	Migratory	Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia with records from Garden Island which is situated just north of the Survey area (Johnstone and Storr 1998). This species inhabits sandy beaches, inlets, estuaries and coastal salt lakes (Johnstone and Storr 1998).		*	The sandy coastal beaches of the Survey area are suitable habitats for the Sanderling. As such it may inhabit this area on its migratory route.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Calidris ruficollis (red-necked stint)	Schedule 3	Migratory	Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia with records from Penguin Island which is situated just south of the Survey area (Johnstone and Storr 1998). It inhabits a wide range of fresh and saltwater habitats (Geering *et al.* 2007).		*	The coastal waters of the Survey area are suitable habitat for the Red-necked Stint. As such it may inhabit this area on its migratory route.
Calidris subminuta (long-toed stint)	Schedule 3	Migratory	Summer non-breeding migratory shorebird that occurs along the mid West coast of Western Australia as far south as Busselton (Johnstone and Storr 1998). This species prefers coastal and inland swamps for habitat (Simpson and Day 2004).			Unlikely. Only Lake Richmond and other wetlands located outside the Proposal area are suitable habitat for the Long-toed Stint. No wetlands are located within the Proposal area.
Calidris acuminata (sharp-tailed sandpiper)	Schedule 3	Migratory	Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia as far south as Busselton, and in well-watered parts of the interior and casually in the arid east south of Lake Gregory.			Unlikely. It inhabits both coastal and inland areas but prefers non-tidal fresh or brackish wetlands, which occur outside the Proposal area. No wetlands are located within the Proposal area.
Calidris ferruginea (curlew sandpiper)	Schedule 3	Migratory	Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia (Geering *et al.* 2007). It inhabits exposed tidal mudflats, and less frequently on inland freshwater wetlands (Geering *et al.* 2007).			Unlikely. Only Lake Richmond and other wetlands located outside the Proposal area are suitable habitat for the Curlew Sandpiper. No wetlands are located within the Proposal area.
Philomachus pugnax (ruff)	Schedule 3	Migratory	Summer non-breeding migratory shorebird that occurs along the south-west coast of Western Australia (Johnstone and Storr 1998). It inhabits tidal mudflats, sewerage farms and freshwater wetlands (Pizzey and Knight 2007).			Unlikely. Only Lake Richmond and other wetlands located outside the Proposal area are suitable habitat for the Ruff. No wetlands are located within the Proposal area.
Pluvialis fulva (Pacific golden plover)	Schedule 3	Migratory	A summer non-breeding migratory shorebird that occurs along the coast of Western Australia (Johnstone and Storr 1998). The Pacific Golden Plover inhabits marine waters such as beaches, mudflats and among rocky areas, sometimes inland (Simpson and Day 2004).		*	Likely. The beaches and rocky areas of the Survey area are suitable habitats for the Pacific Golden Plover. As such it may inhabit this area on its migratory route.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Pluvialis squatarola (grey plover)	Schedule 3	Migratory	Summer non-breeding migratory shorebird that occurs along the coast of Western Australia with records from Penguin Island which is situated just south of the Survey area (Johnstone and Storr 1998). The Grey Plover inhabits coastal areas, preferring marine shores of estuaries or lagoons on broad open mudflats, sandy bars or beaches and rocky coasts as well as coastal salt lakes and swamps (Morcombe 2000). They occasionally are found in drying freshwater lakes (Johnstone and Storr 1998).		*	Likely. The beaches and rocky areas of the Survey area are suitable habitats for the Grey Plover. As such it may inhabit this area on its migratory route.
Charadrius mongolus (lesser sand plover)	Schedule 3	Migratory	summer non□breeding migratory shorebird that occurs on the north and west coast of Western Australia as far south as Albany Johnstone and Storr 1998). It inhabits exposed sand and mud flats and often intermingles with flocks of the Greater Sand Plover (Geering *et al.* 2007).		*	Likely. The exposed sand of the Survey area is suitable habitat for the Lesser Sand Plover. As such it may inhabit this area on its migratory route.
Charadrius leschenaultii (greater sand plover)	Schedule 3	Migratory	Summer non-breeding migratory shorebird that occurs along the coast of Western Australia (Johnstone and Storr 1998). It inhabits exposed sand and mud flats (Geering *et al.* 2007).	*		Confirmed. Recorded by ENV (2011a) The exposed sand of the Survey area is suitable habitat for the Greater Sand Plover. As such it may inhabit this area on its migratory route.
Haliaeetus leucogaster (white-bellied sea-eagle)	Schedule 3	Migratory	Distributed along the coast, islands and estuaries of Western Australia (Johnstone and Storr 1998). They feed on fish, sea snakes and nesting seabirds. Nests are usually placed on high ground such as rock pinnacles, rigid shrubs or in tall trees.	*		Confirmed. Recorded by ENV (2011a)
Ardea modesta (eastern great egret, white egret)	Schedule 3	Migratory (and marine)	Inhabits mostly shallow fresh lakes, pools in rivers, lagoons, lignum swamps, claypans and samphire flats, large dams and sewage ponds (Johnstone and Storr 1998). It also inhabits shallow saltwater habitat such mangrove creeks, tidal pools, samphire swamps and salt work ponds. It breeds colonially at wooded swamps and river pools, nesting in various riparian trees (Johnstone and Storr 1998).			Unlikely. The Eastern Great Egret was recorded during the survey a number of times forging at Lake Richmond, which is outside the Proposal area.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Ardea ibis (cattle egret)	Schedule 3	Migratory (and marine)	The Cattle Egret occurs in the wetter parts of Western Australia, in particular the Kimberley and the south-west. The species inhabits short grass, in particular damp pastures and wetlands, usually in the company of cattle and occasionally other livestock. In Western Australia it is an irregular visitor, occurring mostly in autumn, and is not thought to breed within the State (Johnstone and Storr 1998).			Unlikely. The only suitable habitat that exists in the Survey area was at Lake Richmond, which is located outside the Proposal area.
Apus pacificus (fork-tailed swift)	Schedule 3	Migratory (and marine)	Summer migrant (October-April) to Australia, that has not been recorded breeding in Australia (DSEWPaC 2011d). This species is an aerial species, which forages high above the tree canopy and rarely lower so it is independent of terrestrial habitats in Australia (Johnstone and Storr 1998). It usually occurs in flocks of up to 2000 and is often seen accompanying Tree Martins and Masked Woodswallows (Johnstone and Storr 1998		*	Likely. This species forages over the site from time to time, high in the airspace.
Acrocephalus australis (Australian reed-warbler)	-	Migratory	sedentary and migratory species that inhabits tall dense vegetation such as bulrushes, sedges, rushes, reeds and long grass at the edges of lakes, springs, streams, claypans and dams, as well as sewage ponds and other artificial freshwater wetlands (Johnstone and Storr 1998). The Australian Reed-warbler was recorded during this survey. The bulrushes (Typha sp.) and reeds along the edge of Lake Richmond are typical habitat for this species.			Unlikely. The only sighting of this species was outside the Proposal area, adjacent to Lake Richmond. No suitable habitat occurs within the Proposal area.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Merops ornatus (rainbow bee-eater)	Schedule 3	Migratory	Migrates to south-western Australia to breed in spring and summer (Johnstone and Storr 1998). The Rainbow Bee-eater is a common and widespread species in Western Australia (Johnstone and Storr 1998). It occurs in lightly wooded, often sandy country, preferring areas near water. The Rainbow Bee-eater feeds on airborne insects, and nests throughout its range in Western Australia in burrows excavated in sandy ground or banks, often at the margins of roads and tracks (Johnstone and Storr 1998). During the survey it was recorded near Lake Richmond, and this is where it is most likely to forage. Contrary to the EPBC listing, this species is not included as a migratory species on the JAMBA agreement between the Government of Australia and Japan.		*	Likely to occur. Although the only sighting of this Species was outside the Proposal area near Lake Richmond, suitable habitat occurs in the sandy ground within the Proposal area.
Pandion cristatus (eastern osprey)	-	Migratory (and marine)	Distributed along the coast, islands and lower river courses of Western Australia. They feed on fish and other marine animals (Johnstone and Storr 1998), nesting in trees, cliffs and sometimes structures such as radio towers, often close to the water. A single Eastern Osprey was recorded during the survey at different locations throughout the Survey area. A nest was also located on a small rocky island in Shoalwater Bay which is off the southern side of the Survey area.	*		Confirmed. One Osprey recorded by ENV (2011a), believed to be nesting in an offshore island.
Actitis hypoleucos (common sandpiper)	Schedule 3	Migratory (and marine)	Occurs along the coast of Western Australia, and in much of the interior. It inhabits sheltered salt and fresh waters such as estuaries, mangrove creeks, rocky coasts, salt lakes, river pools, lagoons, claypans, drying swamps, flood waters, dams and sewage ponds (Johnstone and Storr 1998). They occasionally occur inland in a variety of wetlands (Geering *et al.* 2007). They are a non-breeding migrant to Western Australia occurring at any time of year, but mostly September to March in the south-west (Johnstone and Storr 1998).	*		Confirmed. Recorded by ENV (2011a). Rocks and sandy beaches of the Survey area are the preferred habitat for the Common Sandpiper.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Sterna anaethetus (bridled tern)	Schedule	Migratory (and marine)	A migratory shore bird that breeds off the Western Australian coast from September to May. It inhabits blue water seas generally close to breeding sites, which are located on the many small rocks islands around Cape Peron (Johnstone and Storr 1998).			Unlikely. It was recorded as part of an opportunistic survey during the current survey outside the Proposal area on the very tip of Cape Peron. The coastal islands around the Survey area are suitable breeding habitat for the Bridled Tern during its migration.
Reptiles						
Lerista lineata (lined skink)	Priority 3	-	*Lerista lineata* occurs in sandy coastal heath and shrubland areas in disjunct and isolated populations in the south-west and mid-west coast of Western Australia (Wilson and Swan 2008). This burrowing species is found in loose soil or sand beneath logs and termite mounds, where it feeds on termites and other small insects (Cogger 2000).	*		Confirmed. The Lined Skink (Lerista lineata) was recorded thirty one times, at all six sites within the Survey area. The coastal heath and loose sand of the Survey area is ideal habitat for this skink (ENV 2011a).
Ctenotus gemmula (jewelled ctenotus)	Priority 3	-	The skink *Ctenotus gemmula* occurs in two disjunct populations, one in the southern section of the Swan Coastal Plain, the other along the south coast from Albany to Bremer Bay. It inhabits heathland located over pale sand-plains that are associated with Banksia or Mallee woodlands (Wilson and Swan 2008).		*	Likely. It is possible that the Jewelled Ctenotus resides within the Survey area as suitable habitat exists and the Proposal area is within this species' known distribution. None were recorded during the survey.
Morelia spilota imbricata (carpet python)	Schedule 4	-	The south-western population of the Carpet Python has a wide distribution in the south-west, but is generally uncommon, having been recorded from semiarid coastal and inland habitats, Banksia woodland, eucalypt woodlands, and grasslands. It commonly utilises hollow logs for shelter (Wilson and Swan 2008). Local populations in the south-west have suffered because of extensive clearing and removal of its habitat. Lack of habitat makes the species vulnerable to predation and severely limits the potential for radiation.		*	Likely. The Carpet Python has been recorded in coastal areas similar to that found within the Survey area and there is also a population on Garden Island. It is possible that the carpet python resides in the Survey area. However, none were recorded during the survey.

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011a)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Neelaps calonotos (black-striped snake)	Priority 3	-	The Black-striped Snake is typically found in sandplain habitat in association with Banksia species, having a very limited distribution exclusive to the Swan Coastal Plain. This taxon is particularly difficult to locate, and is infrequently collected during biological surveys on the Swan Coastal Plain.		*	Likely. The Survey area contains preferred habitat and lies within this species' known distribution, therefore this species may occur.

Mammals of conservation significance

As listed in Table 21, no conservation significant mammals have been recorded (ENV 2011a). One mammal of conservation significance Quenda (Priority 5; WA DEC) has been identified as potentially occurring within the Proposal area.

Birds of conservation significance

As listed in Table 21, of the 40 species of conservation significant bird species potentially occurring, five were recorded within the Proposal area, 26 species are likely to occur in the Proposal area, as suitable habitat was found to be present, nine species are unlikely to occur within the Proposal area.

The five recorded species of conservation significant bird species are:

- *Pandion cristatus* (eastern osprey) (Migratory)
- *Actitis hypoleucos* (common sandpiper) (Migratory)
- *Xenus cinereus* (terek sandpiper) (Migratory)
- *Charadrius leschenaultii* (greater sand plover) (Migratory)
- *Haliaeetus leucogaster* (white-bellied sea-eagle) (Migratory).

Reptiles of conservation significance

As listed in Table 21, one reptile of conservation significance Perth lined skink (Priority 3; WA DEC), was recorded as occurring within the Proposal area (ENV 2011a). Two other reptiles of conservation significance may occur within the Proposal area. These are jewelled ctenotus (Priority 3; WA DEC) and carpet python (Priority 4; WA DEC).

9.2.4 Occurrence of invertebrate fauna

A desktop study of potential invertebrate fauna abundance was undertaken by Bamford (2005) as a component of the terrestrial fauna assessment. No threatened invertebrates were identified within the search area investigated (Bamford 2005). Despite the absence of species, Bamford (2005) identified the following five species of conservation significant invertebrate fauna as having been recorded east of the study area:

1. *Synemon gratiosa* (graceful sun-moth) – Schedule 1 (WC Act); Endangered EPBC Act 1999 (C'wlth).
2. *Neopasiphae simplicio*r (native bee) – Schedule 1 (WC Act); .Critically Endangered EPBC Act 1999 C'wlth).
3. *Leioproctus douglasiellus* (native bee) – Schedule 1 (WC Act).
4. *Throscodectes xiphos* (cricket) – Priority 1 (WA DEC).
5. *Hylaeus globuliferus* (bee) – Priority 3 (WA DEC).

With the exception of the GSM, all species appear to be associated with understorey species of Banksia woodland that is not present within the study area (Bamford 2005). One species of butterfly (*Vanessa itea* – Yellow Admiral) (not listed as Threatened or Priority) was also identified as having the potential to utilise the Proposal area for mating (Bamford 2005).

The GSM is discussed further in Section 9.2.5.

Occurrence of short range endemic (SRE) terrestrial invertebrates

SREs are defined as terrestrial and freshwater invertebrate species, which have naturally small distributions of less than approximately10 000 km^2 (EPA 2009a). SREs are usually invertebrates, as these animals are more likely to have poor dispersal capabilities and possess a more defined or restrictive biology. Such species may be at greater risk of becoming threatened or endangered as a result of habitat loss or other threatening processes than species with larger ranges (EPA 2009a).

A desktop assessment was undertaken by Subterranean Ecology (2010d). Three groups of terrestrial invertebrates were identified that are known to include SRE species and that may possibly occur within the Proposal area:

1. Scorpion: a rare and undescribed species of *Lychas*, referred to as *Lychas 'majerourm'*.
2. Millipedes: two species of *Antichiropus, Antichiropus* 'G1' and *Antichiropus* 'UBS2'.
3. Land snails within the families of *Bulimulidae* and *Camaenidae*.

Sampling for scorpions, millipedes and snails, require different survey methods and are ideally undertaken in different seasons (EPA 2009a). For this reason a targeted survey for SREs was undertaken in two phases:

- Phase 1 Scorpions – 6 and 7 April 2010
- Phase 2 *Antichiropus* millipedes and land snails – 12 August 2010.

Survey methodologies followed guidelines outlined in EPA Guidance Statement No. 20 (EPA 2009a), and were also undertaken by Subterranean Ecology (2010d).

No conservation significant scorpions, millipedes or land snails were found during the surveys and it was considered that the area contained a paucity of SRE species due to previous disturbance and low diversity of habitats for invertebrates (Subterranean Ecology 2010d).

9.2.5 Occurrence of conservation significant terrestrial invertebrate fauna – Graceful Sun-Moth

Conservation significant invertebrate fauna species indicated from searches of the DEC NatureMap Database or DSEWPaC EPBC Act Protected Matters Database as potentially occurring in the Proposal area are summarised in Table 23.

Synemon gratiosa (GSM) is an endangered day-flying moth endemic to Western Australia, known to occur between Beekeepers National Park (10 km North of Leeman) and Preston Beach (Bishop *et al.* 2010).

Targeted GSM surveys were undertaken of the site in March 2010 and March 2011 by ENV (2011b). The targeted survey was conducted to determine the presence and abundance of the GSM in the Proposal area, and followed the desktop study of potential invertebrate fauna abundance undertaken by Bamford (2005), which identified the presence of the GSM habitat with the Proposal area.

The targeted GSM survey was carried out in accordance with the criteria set by the DEC in relation to GSM surveys (Bishop *et al.* 2010). During the GSM survey in March 2010 one GSM was found within the Proposal area and two outside of this area (approximately 125 m and 500 m from the Proposal area boundary), indicating that the species is represented locally outside the Proposal area (Figure 55) (ENV 2011b). No GSMs were observed or caught during the March 2011 survey (ENV 2011b).

Lomandra maritima densities were found to vary significantly across the Proposal area, with quadrats in close proximity to one another varying from 0%-50% density (ENV 2011b). Indicative *Lomandra* density across the Survey area is illustrated in Figure 56, with the areas of habitat mapped and to be cleared outlined in Table 22.

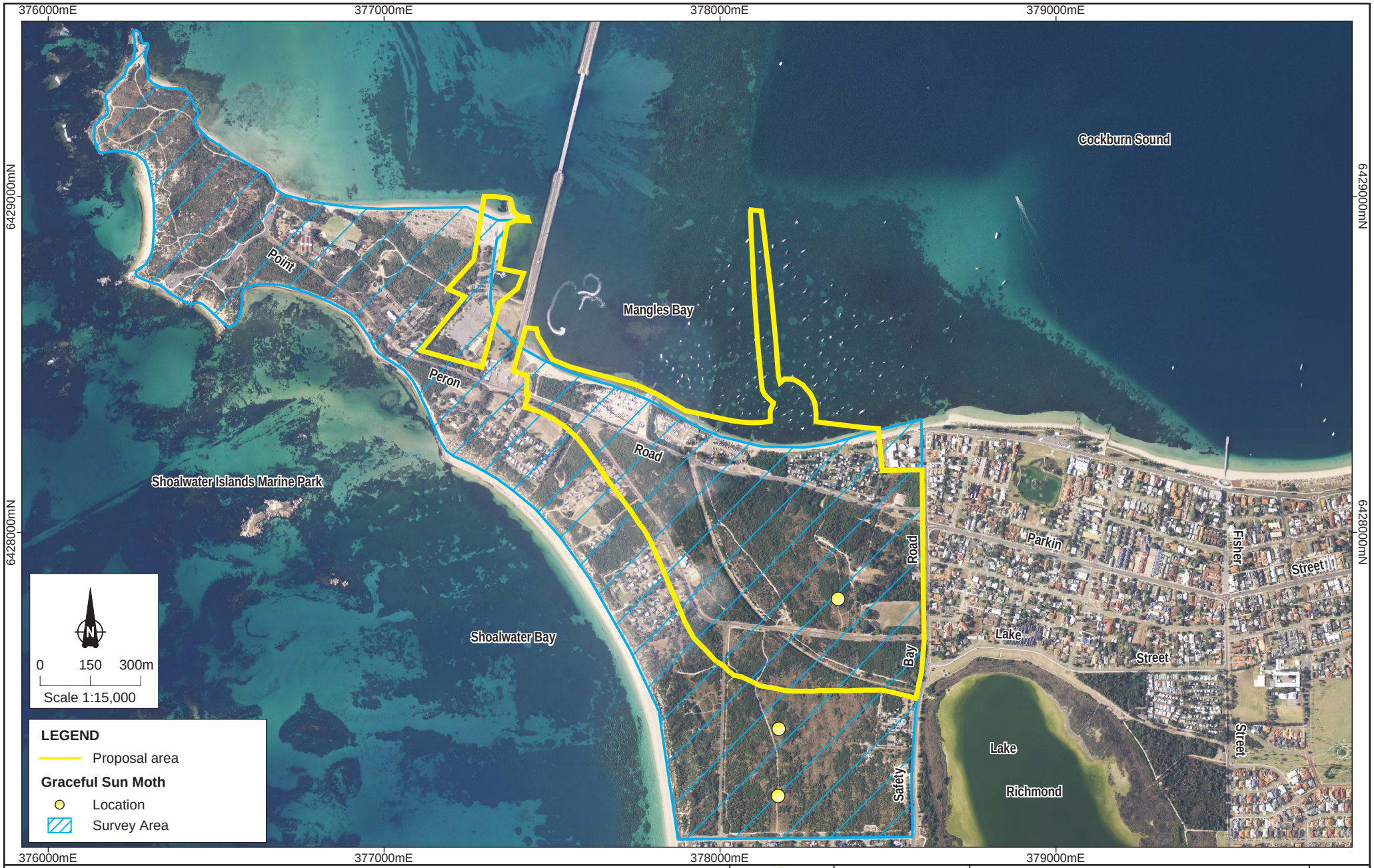
Table 22 Areas of Lomandra surveyed in the vicinity of the Proposal area

Density	Area surveyed (ha)	Area to be cleared (ha)	Percentage of mapped habitat to be removed (%)
High	11.18	6.54	58.5
Low	55.35	23.66	42.8
Medium	10.34	0.45	4.3
Total	76.88	30.65	39.9

The greatest threat to this species is through habitat loss, as this region is experiencing urban development. Other factors that make the species future uncertain are the ongoing threats of track maintenance, inappropriate fire regimes and damage to habitat from the recreational use of four wheel drive vehicles (DSEWPaC 2011d).

Table 23 Likelihood of occurrence of conservation significant invertebrate fauna species

Species	Conservation Status WA	EPBC Act Conservation Status	Preferred habitat (After ENV 2011b)	Recorded / sighted / evidence of presence within the Proposal area	Not recorded but suitable habitat present	Likelihood of occurrence within Proposal area
Insects						
Synemon gratiosa (GSM)	Schedule 1	Endangered	GSM is associated with coastal heath on Quindalup dunes and Banksia woodland on Spearwood and Bassendean dunes; in both cases it is associated with its preferred host plants, *Lomandra maritima* or *Lomandra hermaphrodita* (Bishop *et al.* 2010). The adults lay their eggs on the base of the plants and when the larvae hatch they burrow into the leaf bases, growing tip and rhizomes where they pupate for the next eleven months. It is thought that males are sedentary and females disperse less than 1 km from their birth location and are unlikely to cross unsuitable habitat (CALM 2005).	*		Confirmed. A total of three individual GSM were recorded during the 2010 survey (ENV 2011b). One GSM was found within the Proposal area and two outside of this area (approximately 125 m and 500 m from the Proposal area boundary), indicating that the species is represented locally outside the Proposal area. However the regional population is unlikely to be impacted.



Source:
Imagery supplied by Landgate
Graceful Sun Moth Data supplied by ENV (2010)
Coordinate System: MGA94 Zone 50
Date: 8/2/2012

NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F012.dgn

Recorded Graceful Sun Moth individuals

Figure No:
55

Source:
Cadastral Data supplied by Landgate
Lomandra Data supplied by ENV (2010)
Coordinate System: MGA94 Zone 50
Date: 8/2/2012
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F008.dgn

Lomandra maritima **density and locations recorded within Proposal area and surrounds**

Figure No: **56**

9.3 Evaluation of options or alternatives to avoid or minimise impact

There are limited options to avoid clearing of vegetation from this Proposal.

The Proposal has been designed to minimise impact to / avoid the TEC located near the corner of Memorial Drive and Safety Bay Road, which forms part of the woodland habitat classification. Most of the vegetation within the Proposal area will be cleared, however rehabilitation has been planned for the surrounding areas, reducing the net habitat loss.

The Proposal has been designed to reduce the potential for ingress of saline groundwater into Lake Richmond and reduce the impact of saline groundwater on the woodland habitat. As described in Section 3.3, the Proposal has been amended to shorten the length of the canal that originally came close to the TEC *Callitris preissii*. Two different construction options for the Proposal have been considered in order to reduce groundwater drawdown and hence limit the potential impact on habitat. Groundwater modelling has identified that wet construction will have the smallest impact on groundwater levels (Section 6.3). This will limit the potential for short-term vegetation stress resulting from groundwater drawdown.

9.4 Assessment of likely direct and indirect impacts

The following aspects of the Proposal may affect terrestrial fauna values:

- clearing of vegetation for the Proposal will directly disturb fauna habitat, create fragmentation of fauna linkages and may result in the loss of individual terrestrial fauna
- vehicle movements and construction activities in the Proposal area may result in the loss or disturbance of individual terrestrial fauna
- predation on terrestrial fauna species from domestic pets from the land development
- indirect impacts from an increase in population degrading habitat quality over time thereby reducing habitat quality for terrestrial fauna
- indirect impacts from increase in saltwater interface as a result of the land based marina impacting groundwater-dependent vegetation.

Approximately 40 ha of fauna habitat will be cleared as a result of the Proposal.

9.4.1 Clearing of vegetation

Up to 40 ha of fauna habitat will be cleared for the development, as outlined in Figure 51. Of the total surveyed extent, 30.2% of the Coastal Heath habitat, 0.2% of the Shoreline habitat and 6.1% of the Woodland habitat will be cleared (Table 24). Wetland habitat will not be cleared as a result of the Proposal.

Table 24 Habitat areas within survey area and to be cleared

Habitat Type	Total in Survey area (ha)	Total to be cleared for the Proposal (ha)	Percentage of total habitat to be cleared (%)
Shoreline	4.15	0,9	21
Coastal Heath	113.37	35.2	31
Woodland	19.29	2.18	10.8
Wetland	16.93	0	0
Cleared/degraded	54.26	22.24	41
Total	208.01	60.52 (38.28 ha not cleared or degraded)	23%

The three habitat types identified as occurring within the Proposal area also occur beyond the Proposal area in both the Cape Peron area and broader Swan Coastal Plain region. The relatively small area of clearing required for the Proposal is not likely to present an impact to the regional significance of these habitat types and the fauna assemblage they support. The removal of 0.01 ha of Shoreline, 34.2 ha of Coastal Heath and 1.18 ha of Woodland is likely to have localised impacts on the less mobile species present, however this can be effectively mitigated through staged clearing and translocation (Section 9.6).

In addition to the direct removal of potential habitat, clearing may result in fragmentation of habitats and disruption of the linkages between areas of habitat, as well as increasing predation events as individuals move across cleared areas. The fauna habitats in the vicinity of the Proposal area are already in a fragmented state due to previous developments and recreational use of the area (Table 19).

The fragmentation of habitat caused by clearing within the Proposal area and the upgrade of Memorial Drive has the potential to create a barrier for some species that typically move between the Cape Peron and Lake Richmond areas to access the food, water and habitat resources of the lake. However the linkage to Lake Richmond is already fragmented by Safety Bay Rd, Memorial Drive, the Water Corp Reserve and other previously disturbed areas (Figure 49). Rehabilitation activities in the vicinity of the Proposal area will be targeted to effect an improvement of connectivity of viable fauna habitat in the area, and may reduce the fragmentation that is already present in these areas.

Clearing may also result in direct impacts due to fauna deaths. These are more likely to occur if the clearing happens during winter, when reptiles may be hibernating, and unable to move away from the impact, or in spring when birds may be nesting in the vegetation.

As discussed in Section 9.6, management actions will be implemented during the construction phase of the Proposal to mitigate the direct and indirect impacts of clearing on fauna and habitat within the Proposal area.

9.4.2 Impacts upon fauna of conservation significance

Predicted impacts of vegetation clearing and associated habitat disturbance to species of conservation significance identified in Table 21 and Table 23, as likely to occur within the Proposal area), are outlined in Table 25 below.

Impacts on Matters of NES are discussed in Section 14.

Table 25 Potential impact on terrestrial fauna of conservation significance likely to occur within the Proposal area

Species	Potential Impact
Mammals	
Isoodon obesulus fusciventer (quenda)	Quenda favour dense, low vegetation and is likely to cross roads in the area, making it vulnerable to vehicle strike (Bamford 2005). Because of the preference for dense vegetation, it may benefit from revegetation programs. The species is likely to occur within the Proposal area. The Proposal will result in a small reduction in Quenda habitat due to clearing of 34.2 ha of Coastal Heath habitat. Up to 47 ha of the Coastal Heath habitat is proposed to be rehabilitated in the vicinity of the Proposal area, which will provide viable habitat for this fauna. The proximity of this rehabilitation area to Lake Richmond and improvement of linkages to the water body is likely to benefit this species which favours the wetland habitat surrounding the lake.
Birds	
Calyptorhynchus banksii naso (forest red-tailed black cockatoo)	Two black cockatoo species, the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) and Carnaby's Cockatoo (*Calyptorhynchus latirostris*) have been identified as to potentially occur within the Proposal area. The Proposal will not result in the direct clearing of tuart species identified by ENV (2011b). Investigations undertaken by ENV (2010b) did not record evidence of

Species	Potential Impact
Calyptorhynchus latirostris (Carnaby's cockatoo, short-billed black-cockatoo)	these species in the Proposal area and indicated a lack of potential habitat within the proposed action footprint. The Proposal area does not contain foraging species such as Banksia, Marri or Jarrah trees and no suitable hollows were identified within trees within the area. Due to the lack of habitat available for these species, potential impacts from the Proposal from direct clearing will not result in a significant impact to the potential black cockatoo habitat or the population of black cockatoo species that may potential occur. Indirect impacts however, may occur to the tuart species as a result of the hydrological changes incurred as a result of the inland marina. These potential impacts are addressed in Section 14.
Macronectes giganteus (southern giant-petrel)	Southern Giant-Petrels cover a broad range of habitats and locations in Antarctic to subtropical waters. Their wintering areas include waters off South America, South Africa, Australia and New Zealand (Environment Australia 2001). There is no evidence that south western Australia is an important area for this bird, but it is considered likely to occur in the marine and coastal parts of the Proposal area as an infrequent visitor. The Proposal area and surrounding areas, including Lake Richmond, is not considered to be critical habitat for this species (Environment Australia 2001) as the species mainly occurs in Antarctic waters and during summer and concentrating north of 50° S in winter. While this species may occur as an infrequent visitor to the area, the potential habitat within and surrounding the Proposal is highly unlikely to be critical to its survival. The Proposal is considered highly unlikely to result in the introduction of invasive species or bird diseases within the marine or coastal zones or increase in trawler fishing that may impact upon this species. As this species is a non-breeding visitor to Australia, breeding only on the Antarctic continent, Peninsula and islands and on sub-Antarctic islands and South America, the Proposal will not disrupt the breeding cycle of this species.
Macronectes halli (northern giant-petrel)	This species may occur in the Proposal are as an infrequent visitor. The Proposal is highly unlikely to result in the decrease in size of the population of these species due to their broad range of existence. The Proposal will not significantly impact on the Northern Giant Petrel's range. The species occurs mainly in sub-Antarctic waters, but also regularly occurs in Antarctic waters of the south western Indian Ocean, the Drake Passage and west of the Antarctic Peninsula. The Northern Giant Petrel range extends into subtropical waters mainly between winter and spring. The home ranges of these species are very large, being estimated at 82 600 000 km^2 for the Northern Giant Petrel. The Proposal does not support critical breeding or feeding habitat for this species and is unlikely to reduce the size of the population of this species and unlikely to fragment the important population of this species, causing the species to decline. The Northern Giant Petrel mainly occurs in sub-Antarctic and Antarctic waters which are outside of the Proposal area. The species breeds on sub-Antarctic islands and South Georgia between 46º and 54º S, which are outside of the Proposal area. This Proposal will not disrupt the breeding cycle of this species. The key threats to the Northern Giant-Petrel is longline fishing which causes the direct loss of seabirds as bycatch and predation by black rats, feral cats and habitat degradation by rabbits. Disease is not a known threat to this species and the Proposal is unlikely to introduce disease to the Proposal area. The Proposal will not interfere with the recovery of the species. The species is likely to be an infrequent visitor to the area as its preferred breeding and feeding habitat occurs outside of the Proposal area. The Proposal is also unlikely to increase any of the key threatening process to this species.
Thalassarche cauta cauta (shy albatross, Tasmanian shy albatross)	The Proposal is unlikely to result in the decrease in size of the population, significantly impact on the range of the Shy Albatross or fragment the population due to their broad range of existence. The species occurs across all Australian coastal covers below 25º S and is most commonly found in south eastern Australia and Tasmania. The home range of this species is also very large, being estimated at 23 900 000 km^2 (BirdLife International 2011). This species occurs across all Australian coastal waters below 25º S, with breeding of the species known to occur on Albatross Island, Bass Strait, Mewstone and Pedra Branca off southern Tasmania. As the breeding site outside of the Proposal area, the Proposal will not disrupt the breeding cycle of this species and is unlikely to impact habitat to the extent that the species is likely to decline. This Proposal will not interfere with the recovery of this species as it preferred habitat is located outside of the Proposal area. In addition, the Proposal will not introduce any new or exacerbate any key threatening processes to this species.

Species	Potential Impact
Haliaeetus leucogaster (white-bellied sea-eagle)	The Proposal is unlikely to result in a significant impact to the White Bellied Sea Eagle as a result of clearing and edge effects associated with the Proposal. This species is known to inhabit coastal areas, with nests placed on high ground rock pinnacles and within wetland habitat of Lake Richmond (ENV 2011a). The Proposal however, will not impact rocky coastal habitat, as only a small section of the Mangles Bay shore line will be cleared with rocky areas associated with Cape Peron and the SIMP not impacted by the Proposal. The Proposal will not clear potential foraging habitat at Lake Richmond, as clearing will be confined to the Proposal area itself, 200 m northwest of Lake Richmond. Significant impact to this species will not occur as the potential habitat surrounding the Proposal area of the White bellied Sea Eagle will not be significantly impacted therefore not resulting in decline of the species or fragmentation of its potential habitat.
Apus pacificus (fork-tailed swift)	The Proposal is unlikely to result in a significant impact to the Fork-tailed Swift as the bird rarely lands and its' occurrence is likely to be spasmodic within the Proposal area.
Actitis hypoleucos (common sandpiper) *Limosa limosa* (black-tailed godwit) *Limosa lapponica* (bar-tailed godwit) *Numenius phaeopus* (whimbrel) *Numenius madagascariensis* (eastern curlew) *Tringa stagnatilis* (marsh sandpiper) *Tringa nebularia* (common greenshank) *Tringa glareola* (wood sandpiper) *Xenus cinereus* (terek sandpiper) *Tringa brevipes* (grey-tailed tattler) *Arenaria interpres* (ruddy turnstone) *Calidris canutus* (red knot) *Calidris tenuirostris* (great knot) *Calidris alba* (sanderling) *Calidris ruficollis* (red-necked stint) *Pluvialis fulva* (Pacific golden plover) *Pluvialis squatarola* (grey plover) *Charadrius mongolus* (lesser sand plover	The Proposal is unlikely to result in a significant impact to the 19 species of migratory bird as a result of clearing and edge effects associated with the Proposal. Important habitat for migratory shorebirds is defined in the *Draft EPBC Act Policy Statement 3.21 Significant Impact Guidelines for 36 Migratory Shorebird Species* (2009), as: • an internationally important habitat for migratory bird species or • supports at least 0.1% of the flyaway population of a single species or • supports at least 2000 migratory shorebirds or • supports at least 15 shorebird species. The Proposal will therefore not result in a significant impact to this species as the Proposal area does not support important habitat for these migratory species. Whilst more than 15 shorebird species have been identified as occurring within the Proposal area (ENV 2011a) the Proposal will not result in a significant impact as: • there is widespread shoreline habitat outside the Proposal area • the small section of shoreline within the Proposal area is highly impacted by access (4WD and boating) • important habitat (Lake Richmond) in close proximity to the Proposal area will not be impacted.

Species	Potential Impact
Charadrius leschenaultii (greater sand plover)	
Ardea sacra (eastern reef egret)	The Proposal is unlikely to result in a significant impact to the species, as the Eastern Reef Egret is likely to only forage within the shoreline within the Proposal area and there is widespread habitat outside the Proposal area.
Plegadis falcinellus (glossy ibis)	The Proposal is unlikely to result in a significant impact to the species, as the Glossy Ibis is likely to only forage within the dry grassland areas within the Proposal area, and there is widespread habitat occurring outside the Proposal area.
Merops ornatus (rainbow bee-eater)	The Proposal is unlikely to cause a significant impact to the Rainbow Bee-eater. The species was recorded at Lake Richmond, adjacent to the Proposal area. Lake Richmond provides the suitable wetland habitat for this species providing woodland and shrubland foraging habitat for this species. The Rainbow bee-eater is more likely to visit and forage at Lake Richmond, rather than the Proposal area. The Proposal will not clear potential foraging habitat at Lake Richmond, as clearing will be confined to the Proposal area itself, 200 m northwest of Lake Richmond. Therefore no impact to the foraging habitat of this species is to occur and therefore no significant impact to this species from clearing is to occur as the Proposal will not result in species decline or fragment habitat. The Proposal may disrupt the lifecycle of some Rainbow Bee-eaters surrounding the Proposal area if clearing and earthmoving occurs during the September-October breeding season. These potential impacts however are restricted to the Proposal area itself with potential edge effects from construction managed through a CEMP.
Pandion cristatus (eastern osprey)	The Proposal is unlikely to result in a significant impact to the Eastern Osprey. A species nest was recorded within the rocky areas of the Shoalwater Bay, where the small islands and bays of the area provide suitable habitat for this species. The Proposal will not be impacting Shoalwater Bay (approximately 250 m south west of the Proposal area) as clearing will be restricted to the Proposal area. Significant impact to this species will not occur as the potential habitat surrounding the Proposal area of the Eastern Osprey will not be impacted therefore not resulting in decline of the species or fragmentation of its potential habitat.
Falco peregrinus (peregrine falcon)	The Proposal is unlikely to result in a significant impact to the species, as the Peregrine Falcon is likely to only forage within the shoreline within the Proposal area and there is widespread habitat outside the Proposal area.
Reptiles	
Lerista lineata (lined skink)	The Lined Skink persists even in small remnants of native vegetation and may exist in gardens where soils are sandy (Bamford 2005). The Skink is also found in the Port Kennedy Scientific Park (DEC 2010a). The Proposal will remove 34.2 ha of the Skink's preferred Coastal Heath Habitat. However, extensive areas of this habitat will remain adjacent, within the RLRP and at Port Kennedy Scientific Park, approximately 5 km to the south of the site. It is therefore considered that the Proposal will have a minor impact on the Skink. Up to 47 ha of the Coastal Heath habitat is proposed to be rehabilitated in the vicinity of the Proposal area, which will increase the potential habitat for this fauna.
Ctenotus gemmula (jewelled ctenotus)	The species has not been recorded but may possibly reside within the Survey area as suitable habitat exists and is within this species' known distribution (ENV 2011a). The clearing of this area may potentially have a small impact on Jewelled Ctenotus numbers due to the reduction in habitat. The Proposal will involve the removal of up to 1.18 ha of Woodland habitat, however approximately 3 ha of this habitat type will be rehabilitated in areas adjacent to the Proposal area, reducing the net loss of potential habitat for this fauna.
Morelia spilota imbricata (carpet python)	The species occurs in undisturbed remnant bushland near Perth and the Darling Ranges, Yanchep National Park and Garden Island (DEC undated publication). It is considered unlikely that Carpet Pythons from Garden Island would travel to the mainland, unless transported in a vehicle or boat. The clearing of the area may potentially have a small impact on Carpet Python numbers due to the reduction in potential habitat. Up to 54 ha of native vegetation is proposed to be rehabilitated in the vicinity of the Proposal area.
Neelaps calonotos (black-striped snake)	The species has not been recorded but may possibly reside within the Survey area as suitable habitat exists and is within this species' known distribution (ENV 2011a). The clearing of this area may potentially have a small impact on Black-striped snake numbers due to the reduction in habitat. The Proposal will involve the removal of up to 1.18 ha of Woodland habitat, however approximately 3 ha of this habitat type will be rehabilitated in areas adjacent to the Proposal area, reducing the net loss of potential habitat for this fauna.

Species	Potential Impact
Insects	
Synemon gratiosa (GSM)	In response to the DEC recommendations within the latest report findings (Bishop *et al.* 2010) the DSEWPaC significant impact guidelines developed for the Golden Sun moth (*Synemon plana*) will be applied together with the latest DEC conservation advice (DEC 2011b) in determining the significance of impact of vegetation clearing on the GSM. The Proposal will result in GSM habitat loss through direct clearing of up to 30.7 ha of the 76.9 ha of the mapped habitat (Table 22). The total clearing of habitat includes clearing of approximately 6.5 ha of high density habitat (58.5 %), 0.45 ha of medium density (4.3%) and 23.66 ha of low density (42.8%) of GSM habitat. The Proposal includes clearing of an area greater than 0.5 ha within a contiguous GSM habitat of greater than 10 ha. This is considered to represent a significant impact to the GSM (Bishop *et al.* 2010). The potential habitat within the Proposal area is highly fragmented and cut off by unsuitable habitat which includes degraded and/or cleared areas, development and other anthropogenic influences. The Proposal area does not provide a linkage between GSM populations and as such, the habitat and recorded population within the Proposal area is considered to be isolated. The GSM has limited dispersal ability and sites greater than 200 m apart may be considered to be disjunct populations (Bishop *et al.* 2010). The Proposal area and adjacent bushland represents small, isolated and degraded patches of habitat. The bushland within the Mangles Bay area is at least 3 km from the nearest large area of vegetation and is such us not likely to contribute to the overall ecological health of the species. The Proposal may introduce barriers to dispersal however is unlikely to significantly impact upon GSM population due to the existing habitat fragmentation. Regionally, habitat exists within the Port Kennedy Scientific Park (Strategen 2011).

9.4.3 Impacts on short range endemic species

No conservation significant scorpions, millipedes or land snails were found during the surveys, and due to the paucity of SRE species in the area (Subterranean Ecology 2010d), it is considered unlikely that the Proposal will significantly impact SRE populations.

9.4.4 Impacts of vehicle movements and construction activities

Operational and construction phases of the Proposal are predicted to result in increased traffic flow on local roads, particularly with the upgrade of Memorial Drive (Section 19). Vehicle movements have the potential to directly injure or kill fauna through collisions, or disturb fauna through noise and pollution generation. Some loss of fauna on the surrounding roads may occur, however this will be mitigated through use of appropriate signage (speed and occurrence) and landscaping practices (Section 9.6). Movements of construction vehicles and earthmoving machinery within the Proposal area will be managed according to the CEMP (Appendix 1).

Construction activities for the Proposal will require the excavation of trenches onsite for the laying of services such as water, gas and electricity. Trenches may act as a linear barrier to the movement of terrestrial fauna and may entrap individual animals, potentially resulting in injury or death. Construction of trenches will be conducted in accordance to the CEMP (Appendix 1) and will include management as outlined in Section 9.6.

9.4.5 Impacts of predation on terrestrial fauna species

Domestic as well as feral animals (cats, dogs and foxes) may prey on native fauna and be responsible for fauna deaths. There is a risk that increased numbers of domestic animals in the area associated with urban development may result in increased predation of native species.

The Proposal is within part of the RLRP. Domestic animals are generally not permitted in the RLRP, but dogs are allowed to be exercised within defined Dog Exercise Areas at Cape Peron (DEC 2010a). Dog walking is a common activity in the RLRP through cleared areas and the numerous tracks in the areas (DEC 2010a).

Domestic cats can prey on native animals, if not kept inside. The City of Rockingham requires that outside rural areas and specialist premises (e.g. pet shops), no more than two cats over the age of three months may be kept on any property (CoR 2009). It is recommended by the City of Rockingham that all cats are sterilised and kept indoors from dusk until dawn (CoR 2009).

The development will result in an increased number of residents around the RLRP, and hence a likely increase in the number of pets, particularly cats. This increase in the number of residential dwellings may also result in an increase in the fox population due to a greater number of rubbish bins from which to scavenge from (foxes were recorded within the Proposal area by ENV 2011a). Therefore a risk of increased pet predation of native mammals, birds, frogs and reptiles is likely in the area. This risk will be managed where possible through additional signage, access control in rehabilitation areas and raising awareness with purchasers.

In addition to the increase in domestic animals present in the area, the clearing of native vegetation within the Proposal area will reduce the available cover, and thus may increase the risk of predation on native fauna.

9.4.6 Increase in human population

RLRP is currently impacted by human activities, including (DEC 2010a):

- uncontrolled vehicular access
- vandalism and anti-social behaviour (graffiti; burn-outs; damaged pagodas etc.)
- unauthorised rubbish dumping
- uncontrolled pedestrian and dog access.

These activities can result in habitat degradation, through removal or damage of native vegetation, introduction of weeds and creating situations in which weed species can thrive. Uncontrolled vehicular access and anti-social behaviour may also result in animal deaths. Much of the existing habitat is considered to be 'degraded' because of such activities (ENV 2010).

Development will result in an increased human population in the area by 1500 to 2000 residents, which is likely to result in increased pedestrian and bicycle movements in the RLRP. The Proposal will result in passive surveillance of parkland areas, in line with the *Liveable Neighbourhoods* Policy (WAPC and DPI 2009). *Liveable Neighbourhoods* requires that parks are overlooked by neighbouring houses to limit anti-social activities (WAPC and DPI 2009). Passive surveillance of bushland may reduce the potential for activities such as uncontrolled vehicle access and rubbish dumping, which are likely to be noticed by adjacent residents.

Rehabilitation areas will be monitored on a regular basis and fenced where required to restrict access.

9.4.7 Impacts from groundwater quality and quantity

The change in groundwater saltwater interface and groundwater levels is minimal and is considered unlikely to impact upon terrestrial fauna as:

- the salinity of Lake Richmond will not be impacted
- vegetation outside the area to be cleared is not expected to be impacted (Section 8.4).

The impact of the Proposal on surface water levels and quality is also expected to be minimal (Section 7.4) and therefore fauna utilising Lake Richmond and the Lake Richmond Outlet Drain are not expected to be impacted by the Proposal.

9.5 Potential for and nature of any cumulative impacts

Clearing of fauna habitat within the Proposal area, will further increase the fragmentation of fauna habitat within the Proposal area. Disruption of fauna linkages may result in an isolation and subsequent decline of the fauna population at Cape Peron (particularly less mobile species). Cumulative impact of this fragmentation will be substantially offset by the proposed rehabilitation of remnant vegetation in the vicinity of the Proposal area (Section 9.6).

The region surrounding the Proposal has been heavily urbanised, with only small patches of remnant vegetation scatted throughout areas of development. Although the removal of vegetation from the Proposal area will further reduce regional remnant vegetation, only a relatively small proportion of each habitat type will be cleared.

Clearing associated with this Proposal is not considered likely to have a significant cumulative impact on the regional habitat, especially when proposed rehabilitation activities are taken into account.

9.6 Management measures and performance standards

The following management measures will be implemented to minimise the impact of both the construction and operation phases of the Proposal on fauna:

- clearing within authorised areas only
- relocating mammals, reptiles and amphibians prior to clearing where practicable
- conducting clearing in stages to allow for the movement of any remaining fauna
- limiting noise and vibration that may disturb fauna during construction
- restricting the time and length excavated trenches are opened/exposed
- preventing vehicle access outside authorised areas during construction, and limiting vehicle speeds inside the construction area
- providing suitable areas as conservation offsets
- rehabilitating habitat areas in the vicinity of the Proposal area
- landscaping median strips of Memorial Drive and verges of Safety Bay Road.

A Fauna Management Plan will be developed as part of the CEMP (Appendix 1), to implement the required management measures associated with the construction and operational activities of the Proposal.

9.7 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

After application of mitigation measures described in Section 9.6, the Proposal is expected to result in the following impacts on terrestrial fauna:

1. Loss of 38.28 ha of habitat, of which 35.2 ha is coastal heathland, 0.9 ha is shoreline and 2.18 ha is woodland.
2. A reduction in potential Quenda habitat within the Proposal area due to clearing of coastal heathland.
3. Improvement in habitat condition through rehabilitation of existing coastal heath and woodland and coastal heath habitat outside the Proposal area.
4. A small reduction in numbers of Perth Lined Skink, Jewelled Ctenotus and Carpet Python.
5. Unlikely to have any impact on SRE terrestrial invertebrate fauna.
6. Reduction in area of available GSM habitat through clearing of up to 3.06 ha of habitat.
7. The Proposal area and adjacent bushland represents small, isolated and degraded patches of habitat. The bushland within the Mangles Bay area is at least 3 km from the nearest large area of vegetation and is such us not likely to contribute to the overall ecological health of the species. The Proposal may introduce barriers to dispersal, but is unlikely to significantly impact upon GSM population due to the existing habitat fragmentation.
8. The Proposal is not expected to result in a significant impact to migratory species as the Proposal area does not support important habitat for migratory species.
9. The Proposal will not result in a significant impact to the potential black cockatoo (Carnaby's and Forest Red-Tailed) habitat or the population of black cockatoo species that may potentially occur. This is due to the lack of habitat currently available for these species and potential impacts from the Proposal from direct clearing.

Overall, there are likely to be some local reductions in fauna populations within the Proposal boundary; but the Proposal is unlikely to significantly affect the regional diversity or abundance as the habitats are well distributed locally and regionally.

Potential impacts will be managed through implementation of the Fauna Management Plan within the CEMP (Appendix 1). The Proposal will not conflict with the WC Act, as no species will cease to exist as a result of the Proposal.

10. Marine water and sediment quality impact assessment

10.1 Relevant environmental objectives, policies, guidelines, standards and procedures

10.1.1 EPA objectives

The EPA environmental objectives for marine water quality and sediment quality are:

To maintain the integrity, ecological functions and environmental values of the seabed and coast.

To ensure that emissions do not adversely affect environmental values or the health, welfare and amenity of people and land use by meeting statutory requirements and acceptable standards.

10.1.2 Legislation, policy and guidance

State environmental policy (Cockburn Sound)

The *State Environmental (Cockburn Sound) Policy 2005* (Cockburn Sound SEP) establishes the framework within which Cockburn Sound and the adjacent land (the Cockburn Sound catchment) are managed to protect environmental quality in Cockburn Sound. The Cockburn Sound SEP establishes a risk-based approach to environmental management, which is underpinned by Environmental Values (EVs) and spatially defined Environmental Quality Objectives (EQOs) (Government of Western Australia 2005b), shown in Table 26. The CSMC has the responsibility for managing the environmental quality of Cockburn Sound.

Table 26 Environmental quality values and environmental quality objectives for Cockburn Sound

Environmental values	Environmental quality objectives
Ecosystem health	Maintenance of ecosystem integrity in terms of structure (such as biodiversity, biomass and abundance of biota) and function (such as food chains and nutrient cycles).
Seafood safe for eating	Maintenance of aquatic life for human consumption, such that seafood is safe for human consumption when collected or grown.
Aquaculture	Maintenance of aquaculture, such that water is of a suitable quality for aquaculture purposes.
Recreation and aesthetics	Maintenance of primary contact recreation values, such that primary contact recreation (e.g. swimming) is safe. Maintenance of secondary contact recreation values, such that secondary contact recreation (e.g. boating) is safe. Maintenance of aesthetic values, such that the aesthetic values are protected.
Industrial water supply	Maintenance of industrial water supply values, such that water is of suitable quality for industrial water supply purposes.

Environmental Quality Criteria (EQC) have been specifically developed for Cockburn Sound to provide the quantitative benchmarks for measuring success in achieving the EQOs set in the SEP (Government of Western Australia 2005b). EQCs are defined below:

1. Environmental Quality Guidelines (EQGs): threshold numerical values that, if met, indicate a high degree of certainty that the associated EQO has been achieved. If the EQG is exceeded it triggers a more detailed assessment process against an environmental quality standard to provide more certainty about whether the EQO is likely to be met or not.
2. Environmental Quality Standards (EQSs): threshold numerical values that, if met, indicate the EQO is likely to be achieved. If the EQS is exceeded, it indicates a significant risk that the associated EQO has not been achieved, and a management response is triggered.

The ecological EV of ecosystem health has different EQC for zones of high, moderate and low ecological protection. The area of Mangles Bay adjacent to the Proposal area lies within the area zoned for high ecological protection. The social EVs (Seafood Safe for Eating, Aquaculture, Recreation and Aesthetics, and Industrial Water Supply) have the same EQC applied throughout Cockburn Sound. The SEP has EQC for both water quality and sediment quality for the EV of Ecosystem Health and water quality EQC for the social EVs.

The operational effects of the Proposal on the marine waters of Cockburn Sound will need be assessed in terms of EQC for key water quality and sediment quality indicators for the EVs of Cockburn Sound, particularly Ecosystem Health (such as nutrient-related water quality, contaminants), and Recreation and Aesthetics (such as water clarity, faecal bacteria). Some temporary effects associated with construction (turbidity, contaminant release during dredging and disposal) will need be managed and monitored differently (although still using the same indicators), as they are likely to take place outside the summer monitoring season targeted by the Cockburn Sound SEP (outlined in Section 10.2.2).

The waters within the marina are an artificial inland waterway, and therefore not expected to be zoned for ecological protection under the SEP (the area is presently land and has no marine ecological value). It is, however, anticipated that the marine waters offshore of the existing shoreline that will be bounded by the proposal breakwaters (an area about 50 m by 180 m; refer Figure 7) will be zoned for moderate ecological protection under the SEP, and relevant EVs and EQOs will apply. The objective for marina waters entering the high ecological protection area of Mangles Bay will be to ensure that the relevant EVs and EQOs are not compromised. Water quality within the marina comes under WA Planning Commission (WAPC) Policy Number DC1.8 which provides Guidelines for approval of canal estates and other artificial waterway developments.

WAPC Policy Number DC1.8

WAPC Policy Number DC1.8 provides general guidelines that apply to artificial waterways and to their adjacent natural waters and/or source water. If the source water does not meet these requirements, a canal estate proposal for that location is considered inappropriate. General guidelines for water quality are:

1. Stormwater runoff or drainage to artificial waterways, particularly from vegetated or vehicle use areas, is a potential source of nutrient or contaminant input to artificial waterways and adjacent source waters. Developments must include appropriate design features and management strategies to minimise any inputs to an artificial waterway which may adversely affect water quality.
2. Water quality within artificial waterways must be such that the following beneficial uses should not be adversely affected:
   - occasional human immersion and wading
   - boating
   - adjacent development
   - passive recreation (which can be affected by odour, insects, rubbish).
3. A canal estate should not be permitted where the source water has a beneficial use or water quality that is a lower standard than the beneficial uses identified above.
4. The presence of one or several canal estates should not be permitted to measurably reduce the quality of the natural water body.
5. An artificial waterway should not have an unacceptable impact on the passage of fauna in the natural water body.
6. No industrial or residential waste or effluent of any nature (including air conditioner bleed off) should be discharged directly or indirectly into artificial waterways.
7. Parameters regarded as being significant for assessing water quality are: suspended solids, chemical constituents, pH, DO, bacteriological counts, nutrients and contaminants (particularly hydrocarbons). Other factors, such as salinity or biota may be significant in some instances.

8. It is apparent that boat toilets which can discharge into the waters are not compatible with artificial waterway uses. Action to prohibit this form of discharge will be necessary. Pump out or toilet facilities at service sites may therefore be required in each artificial waterway project.
9. The maintenance of artificial waterway water quality should be largely dependent on natural processes.

WAPC Policy Number. DC1.8 also provides general aesthetic guidelines that are desirable for waters within and adjacent to an artificial waterway development. These require that waters should be:

- free from substances which will settle to form putrescent or otherwise objectionable sludge deposits
- free from floating debris, oil, grease, scum, foam and other floating materials in amounts sufficient to be unsightly or otherwise objectionable
- free from materials which will produce colour, odour, turbidity, or other conditions to such a degree as to be unsightly or otherwise objectionable.

National Health and Medical Research Council Guidelines

The aim of the NHMRC Guidelines for Managing Risks in Recreational Water (NHMRC 2008) is to protect the health of the public from threats posed by the recreational use of coastal, estuarine and fresh waters. The guidelines cover risks due to physical hazards (rips, sandbars, breaking waves); sun, heat and cold; microbial water quality (faecal contamination); cyanobacteria and algae; dangerous aquatic organisms (such as stingers and sharks); chemical hazards (such as industrial outfalls and fuel spills); and aesthetics (such as transparency, surface scums, litter, odour and noise).

The guidelines are not mandatory, but are a tool to be used by State and Territory Governments to assist in developing legislation, policy and standards appropriate for local conditions. These guidelines therefore support the Cockburn Sound SEP and WAPC Policy NumberDC1.8, with a focus on microbial water quality (faecal contamination); cyanobacteria and algae; chemical hazards; and aesthetics.

Contaminated Sites Act 2003

The Proposal will involve the dredging of sediments in Mangles Bay to create the marina access channel. These sediments may contain contaminants from past or present boating activities. Marine sediment contamination in state waters (as well as contamination in terrestrial soils) is addressed under the *Contaminated Sites Act 2003* (CS Act). Relevant guidance on contaminated sites investigations is provided in the DEC Contaminated Sites Management Series (CSMS) (DEC 2010b), but sampling requirements for marine sediments are also typically guided by the National Assessment Guidelines for Dredging (NAGD).

The CSMS was developed to provide guidance for risk assessments prior to activities governed under the CS Act. Land disposal of dredged material is not dealt with specifically in the guidelines but falls under the CS Act for 'created land', and potential human and environmental impacts must be subject to a risk assessment.

Ecological Investigation Levels (EILs) and Health Investigation Levels (HILs) for soil, defined in the CSMS 'Assessment Levels for Soil, Sediment and Water' (DEC 2010b), are used as an initial screening assessment to determine whether there is potential risk to the environment. Contaminated soils disposed to land can pose a risk to human health through direct exposure (such as ingestion and inhalation) or indirect exposure (such as through groundwater contamination). HILs classified as 'D' (residential with minimal opportunities for soil access: includes dwellings with fully or permanently paved yard space such as high-rise apartments and flats), 'E' (parks, recreational open space and playing fields, includes secondary schools) and 'F' (commercial/industrial, includes premises such as shops and offices as well as factories and industrial sites) are typically deemed the most appropriate to use when spoil material is used in a development.

National Assessment Guidelines for Dredging (NAGD)

Although sea dumping of dredged material is not planned as part of the Proposal, the NAGD (Commonwealth of Australia 2009) provide a reference for the assessment and management of dredging operations, i.e. the potential impacts on the receiving marine environment from the disturbance of the sediment and the sediment metals, nutrients and hydrocarbons. The NAGD criteria for sediment quality are based on the national environmental quality criteria for sediments (ANZECC/ARMCANZ 2000).

Shoalwater Islands Marine Park Management Plan

SIMP borders Mangles Bay at the Garden Island Causeway (Figure 57). The SIMP covers an area of approximately 6545 hectares and contains the waters of Shoalwater Bay, Warnbro Sound and a part of Cockburn Sound off Cape Peron. The SIMP is vested to the MPRA, and managed by the DEC, apart from recreational fishing which is managed by the DoF in close cooperation with DEC. The Shoalwater Islands (i.e. the terrestrial portion) are managed under the 1992 Shoalwater Islands Management Plan.

The SIMP Management Plan 2007–2017 (the management plan) was formally approved by the Minister for the Environment in August 2007 (DEC 2007). The management plan sets out a zoning scheme and a 'best practice' model for managing the identified ecological and social values of the SIMP. Under the zoning scheme the areas to the north of Cape Peron (to the west of the Causeway) are within a 'General Use Zone'. Shoalwater Bay (on the southern side of Cape Peron) is a recommended 'Special Purpose Zone' for wildlife conservation, and further south are two sanctuary zones (at Second Rock and Becher Point), and a 'Special Purpose Zone' for scientific reference at Murray Reef.

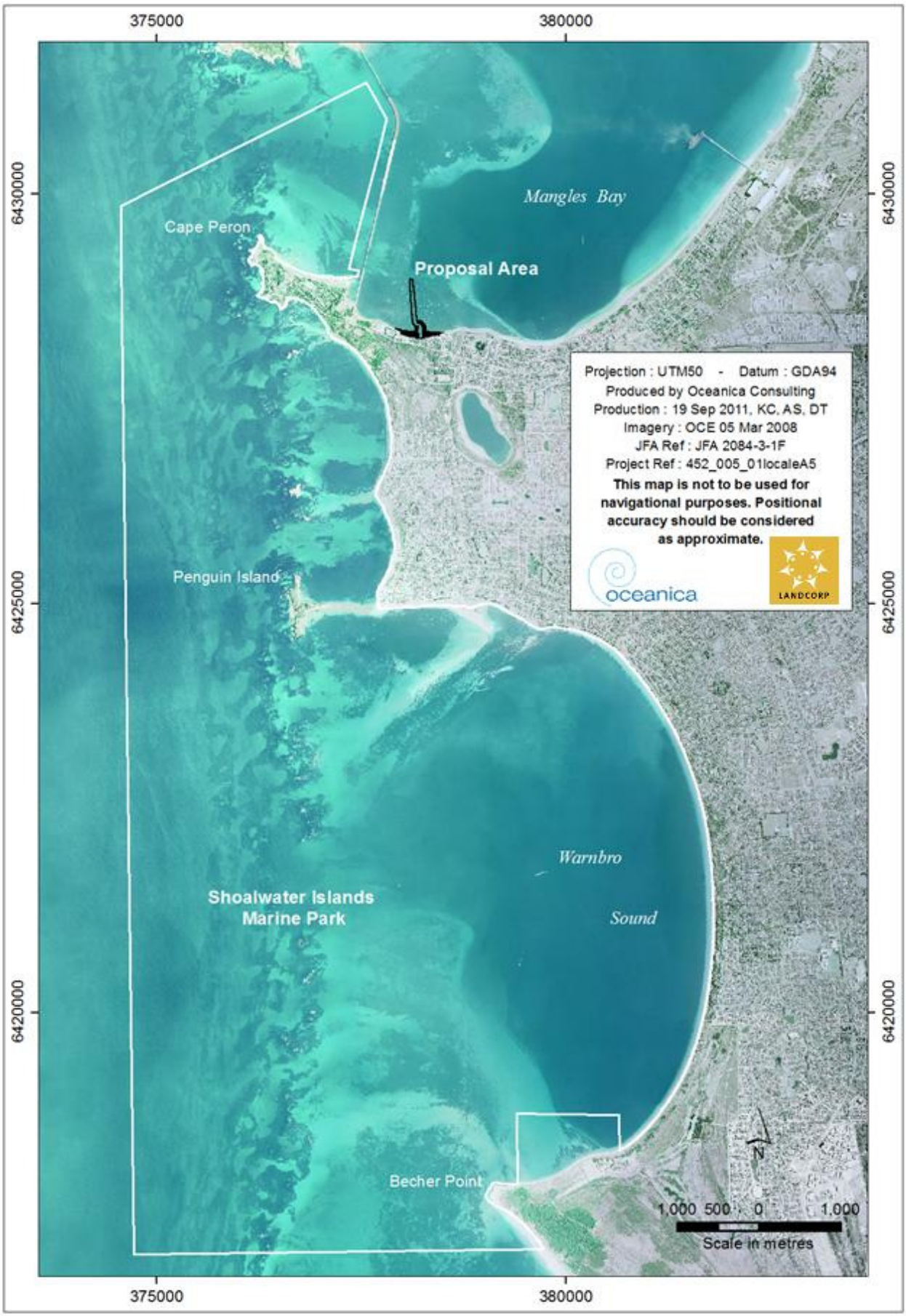
Each ecological and social value for the SIMP has identified management objectives, strategies, performance measures and targets to achieve. The management objective for marine water and sediment quality is:

To ensure the water and sediment quality of the marine park is not significantly impacted by future human activities.

The management plan places a high priority on maintaining a high level of water and sediment quality, and performance measures for marine water quality (DEC 2007) include:

- nutrients (chlorophyll a and inorganic nitrogen concentration in seawater)
- toxicant concentrations in seawater
- pathogens (faecal coliform concentrations in seawater)
- litter (mass [kg] of litter at selected monitoring sites).

Short-term targets will be developed as required, while long-term targets include maintaining water quality at the present level, except for designated areas where a different level of acceptable change is approved by the appropriate Government regulatory authority (DEC 2007). The SIMP is presently characterised by high water quality, with sites monitored in Warnbro Sound providing the reference data used to generate nutrient related water quality criteria for Cockburn Sound.



STRATEGEN

Mangles Bay Marina Based Tourist Precinct

Shoalwater Islands Marine Park

Figure 57

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10.2 Findings of surveys and investigations

10.2.1 Historical water quality in Cockburn Sound

Cockburn Sound

Water quality is one of the two primary marine environmental issues relevant to the Proposal identified in the EPA's Bulletin 1237 in its strategic advice to the Minister for the Environment, under section 16(e) of the EP Act (EPA 2006b). The water quality of Cockburn Sound is due, in part, to its enclosed nature (by Parmelia Bank to the north, Garden Island to the west, and the Garden Island Causeway to the south), which reduces exchange (flushing) with the water of Owen Anchorage to the north and the open ocean to the west and south. Flushing times affect the dilution of nutrient and contaminant inputs, and in turn affect a variety of ecological processes (such as plant growth rates and toxicity responses) that depend on the concentrations of these substances.

The first comprehensive environmental study of Cockburn Sound between 1976 and 1979 (the Cockburn Sound Environmental Study, DCE 1979) identified a large variety of contaminants in industrial discharges entering Cockburn Sound (CSMC 2006). The study recorded deterioration of water quality and widespread loss of seagrass on the eastern margin of Cockburn Sound, largely attributed to shading caused by nutrient-stimulated growth of epiphytes and phytoplankton. Industry in the area responded by reducing contaminant and nutrient discharges (particularly nitrogen). As a result, the water quality in Cockburn Sound improved by the early 1980s (CSMC 2006).

Nutrient-related water quality depends mainly on two factors:

- nitrogen inputs to the area (nitrogen is the main nutrient determining marine plant growth in Perth's coastal waters)
- how well the area is flushed with marine water.

By the late 1980s, nutrient related water quality had declined again, which triggered the second comprehensive study from 1991 – 1994 (the Southern Metropolitan Coastal Waters Study, DEP 1996). This study found that nutrient-related water quality was only slightly better than in the late 1970s, with nutrient-rich groundwater from industrial sites (mainly Kwinana and Jervoise Bay) replacing direct industrial pipeline discharge as the main nutrient input to Cockburn Sound. The EPA subsequently provided Strategic Environmental Advice on the Marine Environment of Cockburn Sound in Bulletin 907 (EPA 1998), which included:

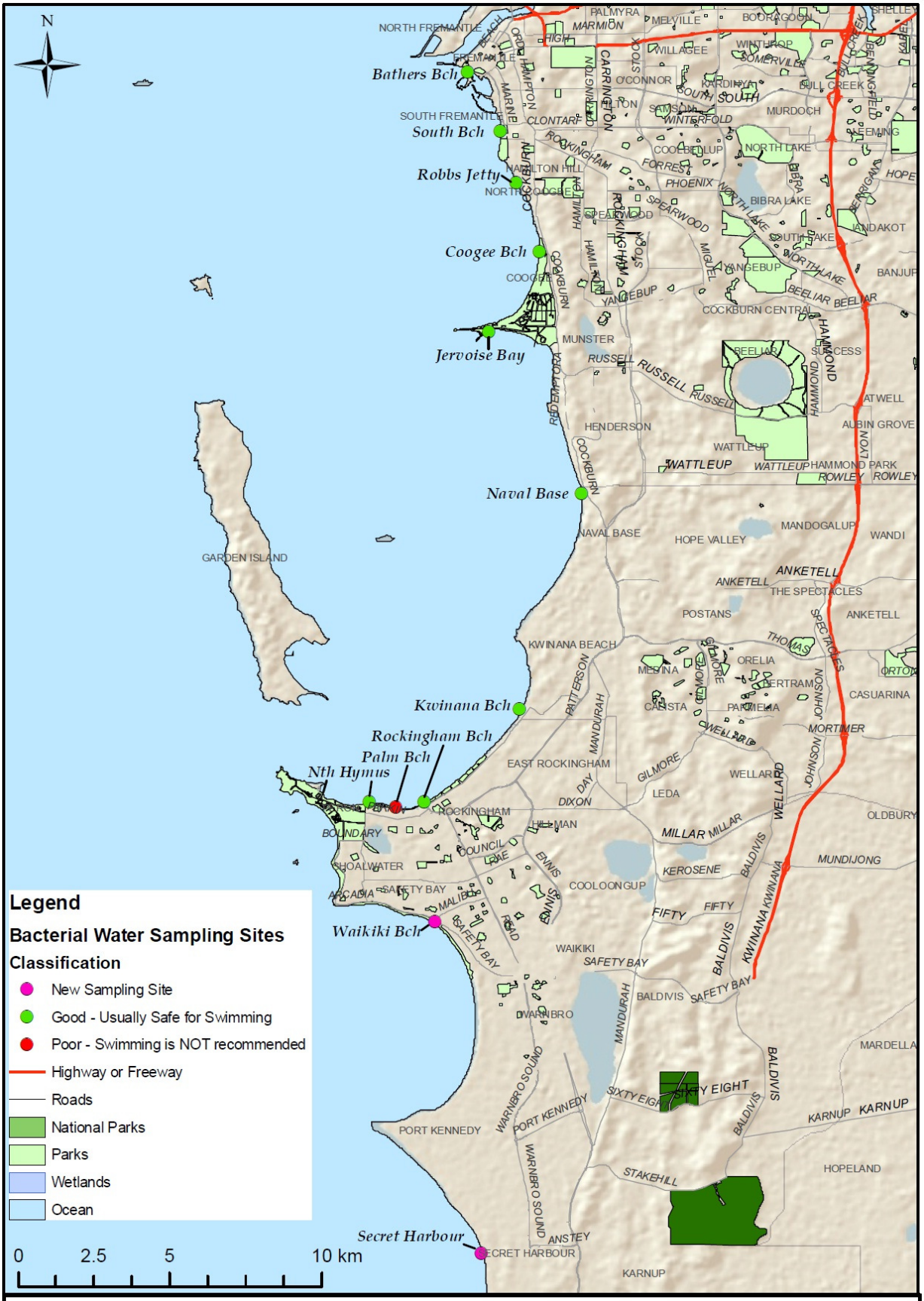
- the environmental issues that needed to be addressed through coordinated management action, including the reduction in sources of wastes from point sources and groundwater
- the need for a statutory management structure to coordinate management in Perth's coastal waters, especially Cockburn Sound and its catchment (which led to the formation of the CSMC)
- the EPA's statement of advice on long-term harbour scenarios (including the Mangles Bay marina), infrastructure issues (e.g. the Causeway, and shipping channels) and seagrass.

Subsequent management reduced groundwater nutrient inputs, and it was estimated that nutrient inputs from human activities had declined from an estimated 2000 tonnes/year in 1978 to about 300 tonnes/year in 2000, with 70% from groundwater (CSMC 2005).

Nutrient related water quality has been monitored in Cockburn Sound since 1977 by means of summer surveys (CSMC 2005). Nutrient concentrations in Cockburn Sound have reduced significantly since the late 1970s, as have chlorophyll-'a concentrations – a measure of the amount of phytoplankton growth that is fuelled by the available nutrient supply. Recent data indicate further significant decreases in chlorophyll-a concentrations for the years 2005 to 2010, compared with the 1990s and early 2000s (Wienczugow *et al.* 2010). Water quality monitoring remains the focus of management attention today due to the large number of multiple uses in Cockburn Sound. The CSMC coordinates water quality monitoring of Cockburn Sound, with a focus on nutrient related effects, especially chlorophyll-a levels. Water clarity (measured as light attenuation) is also measured, as it is affected by phytoplankton levels. The CSMCs water quality

surveys involve weekly measurements from December to March inclusive, as required under the Cockburn Sound SEP, which targets the period unaffected by river flow and the most likely to show effects due to nutrient enrichment (EPA 2005a).

The Department of Health and the City of Rockingham also undertake fortnightly surveys of indicators of faecal contamination (measured as enterococci levels, in colony forming units per 100 ml) at popular beaches in the main bathing season (October to April) to ensure that waters are safe for recreation. The levels in Cockburn Sound are generally safe for recreational use (Figure 58), but exceedances of recreational guidelines (NHMRC 2008, also used as EQG under the Cockburn Sound SEP) occur in some areas of the Rockingham foreshore, especially after rainfall stormwater discharge into Cockburn Sound (Strategen 2006).



STRATEGEN

Mangles Bay Marina Based Tourist Precinct

Department of Health recreational beach classification: bacterial water

Figure 58

strategen
Oct-2011

Flushing of waters in Cockburn Sound

Current speeds and circulation patterns (determined by wind and horizontal pressure gradients) determine the flushing of Cockburn Sound. Horizontal pressure gradients are the result of differences in water pressure between two areas, and may be grouped into those driven by:

- wind, tides, waves, seiches and atmospheric pressure (which cause differences in water level between areas)
- horizontal differences in water density (cold, salty water is denser than warm, freshwater).

Waves and currents in Cockburn Sound are primarily wind-generated. Wind is also the main driving mechanism of circulation within the Sound when the wind speed is above 5 metres/second. During calm periods (wind speed <5 m/s), circulation becomes complex and is driven by a combination of wind and horizontal pressure gradients.

Three distinct hydrodynamic regimes have been identified in Cockburn Sound based on the relative importance of wind and pressure gradients in determining circulation patterns and flushing: 'summer', 'autumn' and 'winter-spring' (DEP 1996). The key characteristics of the three seasons are as follows:

- summer: during summer, winds are the most important factor controlling hydrodynamics. Circulation is wind-driven and the waters within both the Sound and adjacent waters are vertically well mixed (and therefore well oxygenated)
- autumn: during autumn the wind subsides and pressure gradients determine the circulation. The waters in Cockburn Sound are of greater density (cooler and more salty) compared to adjacent water due to evaporation that has occurred during the summer and rapid cooling during autumn. The gradient between the denser waters of Cockburn Sound and the lighter adjacent water controls the flushing of Cockburn Sound to the greatest extent. Stratification (distinct vertical layering of water) also occurs due to movement of lighter water into Cockburn Sound. Flushing of the bottom waters of Cockburn Sound during autumn depends on wind events that vertically mix the whole water column (generally requiring wind speeds >5 m/s for 2-3 days or more), followed by re-establishment of density gradients. Such wind events are rare in autumn, and so the deep basin waters of Cockburn Sound are poorly flushed in autumn
- winter-spring: circulation is primarily driven by pressure gradients, punctuated by periods of wind-driven circulation due to storm activity. The waters within the Cockburn Sound become progressively lighter than waters further offshore due to the relative lowering of salinity by freshwater inflow, particularly from rivers. The relatively rapid response of the shallow waters of Cockburn Sound (compared to offshore waters) to heating as spring progresses also contributes to the relative decrease in density. Denser water moves into the lower depths of Cockburn Sound during calm periods (wind speeds typically < 5 m/s), and stratification persists until broken down by the passage of winter low pressure systems about every 7-10 days (D'Adamo & Mills 1995).

There are many ways to measure the time over which Cockburn Sound is flushed. To be consistent with previous modelling of Cockburn Sound (DEP 1996) the e-folding time is used here, which estimates the time taken for 63% of Cockburn Sound to be flushed. The e-folding time for Cockburn Sound is roughly one month: 37 days in autumn, 22 days in winter and 44 days in summer (highest in summer because the prevailing winds set up circulation gyres that tend to confine water within Cockburn Sound). These are flushing times for Cockburn Sound as a whole: flushing times for localised areas within Cockburn Sound are much less (about a day along the eastern margins of Cockburn Sound).

Nutrient inputs to Cockburn Sound

Approximately 300 tonnes/year of nitrogen enter Cockburn Sound from industrial outfalls, groundwater discharge, surface drainage (stormwater runoff) and the atmosphere. Of these, groundwater discharge is the largest contributor (about 75%) (DAL & PPK 2001).

The cycling of nutrients between sediments and the water column also plays an important role in determining water quality, particularly under conditions of low oxygen. The waters of the Sound are generally well oxygenated, although if calm weather persists for more than a week (which occurs most often in autumn), the deep waters at the southern end of Cockburn Sound may become low in oxygen. This is due to stratification and bacteria in the organic-rich sediments that use up oxygen faster than that supplied by diffusion down the water column. Oxygen levels in the bottom waters sometimes become so low that the release of nutrients from sediments to the water column increases.

Water movement plays a major role in determining sediment characteristics (including nutrient cycling) within Cockburn Sound. In calmer and/or deeper areas the sediments tend to be finer and siltier, while shallower/more exposed areas experience more wave and current action and so have sandier sediments (the finer particles are easily suspended and swept away). Calmer/deeper areas accumulate fine organic particles (such as dead plankton and faecal material), and so are more organically enriched than shallower/more exposed areas. Contaminants discharged to marine environments (and any increased production of organic matter due to a nutrient enrichment) typically accumulate in the sediments, especially in sheltered, relatively deep areas.

Mangles Bay

Mangles Bay is sheltered by the Garden Island Causeway and Cape Peron, and is therefore relatively calm and poorly flushed by marine waters under most circumstances, but is exposed to storms from the north (Strategen 2006). Chlorophyll-a levels in Mangles Bay are generally higher than most other sites in Cockburn Sound: this is believed to be largely due to the reduction in flushing of the area by the construction of the Garden Island Causeway in 1971–73, although the area would have been naturally calm and sheltered before this time.

Nutrient inputs

Nutrient inputs to Mangles Bay are from groundwater discharge (occurring all year round but largely in late winter, in response to rainfall recharge; refer Section 6.2.4) and stormwater drainage (occurring mainly in winter and early spring; refer Section 7.2.2). Appleyard (1994) has estimated groundwater discharge to the Mangles Bay area to be 53 Megalitres/year/km, and to contribute between 0.048 to 0.573 tonnes nitrogen/year/km along the 4 km of coast east of the Garden Island Causeway. The nitrogen is largely in dissolved inorganic forms readily available for aquatic plant growth (ammonia and nitrate). The variation in estimated loads is due to the variation in groundwater flows and nitrogen concentrations in groundwater bores in the region. More recent estimates by ERM (2011) indicate annual dissolved inorganic nitrogen (DIN) loads of 0.11 tonnes for a shoreline length of about 700 m, based on APASA's (Asia Pacific Applied Science Associates) model boundary. This value equates to 0.16 tonnes DIN/year/km entering the shoreline adjacent to the Proposal area. Little groundwater discharge is expected west of the Causeway, as the groundwater flow path to Mangles Bay or Shoalwater Bay is much shorter (Strategen 2006).

There are seven stormwater drains entering Mangles Bay (DoW 2007). The largest stormwater flow is from the Lake Richmond drain (R. Mort, City of Rockingham, pers. comm.), comprising overflow from Lake Richmond, which in turn receives surface water inputs from large urban catchments to the east, south and west of the lake (e.g. refer Figure 109 and Figure 110). There is little data for volumes of stormwater outflow from the drains, but outflow from Lake Richmond drain was measured between 1978 and 1986 and found to be highly variable, averaging 2,270 ML/year (DMH 1992). Based on water quality data for stormwater, DMH (1992) estimated the Lake Richmond drain contributed 0.25–8.3 tonnes/year TN, 32 kg/year copper, 98 kg/year lead and 104 kg/year zinc. More recent estimates indicate a lesser load of 0.122 tonnes nitrogen/year in the three months of winter 2002 (Water and Rivers Commission, cited Natural Resource Management Office, Naragebup Rockingham Regional Environment Centre [Inc.] 2003a), likely due to rainfall in recent years being below the historical long-term average. The Department of Water (DoW 2007) has also estimated nutrient loads from a minor Rockingham drain over approximately seven weeks in winter 2006 (0.416 ML of discharge) as 0.0018 tonnes TN, 0.003 tonnes TP, 0.029 kg copper and 0.108 kg zinc (lead concentrations were too low to estimate). These data indicate that even allowing for disparity in monitoring periods - the contribution from minor drains entering Mangles Bay is likely to be one to two orders of magnitude lower than from the Lake Richmond drain.

Water quality data for Lake Richmond drain and the minor drains (Table 27) also suggest that in years of low to average rainfall the major input of nitrogen to Mangles Bay is from groundwater. The importance of groundwater inputs is also due to the fact that discharge occurs all year round (albeit at reduced levels in summer and autumn compared to winter and spring), and nitrogen is largely in the dissolved inorganic forms readily available for aquatic plant uptake. Stormwater flows mainly in the winter months, with the majority of nitrogen present as organic nitrogen, and not as readily available for plant uptake. The stormwater quality data in Table 27 are consistent with more recent data (September 2010) for water quality in the Lake Richmond stormwater outlet (refer MWH 2011d), which found total nitrogen concentrations 0.75 mg/L, total phosphorus concentrations of 0.03 mg/L and low levels of dissolved inorganic nutrients, and metals.

Table 27 Concentrations of contaminants in stormwater draining into Mangles Bay

Statement of Planning Policy 2.8 requirement	Lake Richmond Drain 2002, 2003*	Lake Richmond Drain 2004, 2005***	Minor drains, 2005**	Minor drains, 2005***
Total nitrogen	0.65–1.00 mg/L	0.506 mg/L	0.400–0.780 mg/L	0.150–0.586 mg/L
Kjeldahl nitrogen (organic nitrogen)	> 90% of total nitrogen	0.44 mg/L	53–85% of total nitrogen	0.124–0.390 mg/L
Nitrate-plus-nitrite	0.012–0.043 mg/L	0.064 mg/L	0.100–0.380 mg/L	0.028–0.200 mg/L
Ammonium	No data	0.068 mg/L	0.093–0.110 mg/L	0.038–0.102 mg/L
Total phosphorus	0.012–0.200 mg/L	0.016 mg/L	0.051–0.800	0.038–0.110 mg/L
Orthophosphate	0.005–0.028 mg/L	0.01 mg/L	0.036–0.047	0.021–0.057 mg/L
Total suspended solids	No data	~30 mg/L	3–8 mg/L	~30 mg/L
Copper	0.001 mg/L	<0.005 mg/L	0.006 mg/L	0.006–0.012 mg/L
Lead	0.001 mg/L	<0.010 mg/L	0.010 mg/L	<0.010 mg/L
Zinc	0.016– 0.062 mg/L	0.007 mg/L	0.021 mg/L	0.029–0.042 mg/L

* Natural Resource Management Office, Naragebup Rockingham Regional Environment Centre (Inc.) (2003a, b) for routine monitoring in winter 2002 and winter2003.
** Snapshot survey data provided courtesy of D. Mort, City of Rockingham, for Bell Park and Hymus St drains for winter 2005.
***DoW 2007 for monitoring of stormwater quality entering Perth beaches in winter 2004 and winter 2005 (site RMD = Lake Richmond Drain, and site ROC12, ROC14 and ROC16 = minor drains)

Contaminant inputs

Studies for the Proposal have found low concentrations of metals in groundwater (MWH 2011a), suggesting that in relative terms (i.e. compared to groundwater) stormwater contributes more of these contaminants to Mangles Bay than previously thought. There are no data for hydrocarbons in groundwater, and although these types of contaminants are more common in road runoff, the Department of Water's study of stormwater quality discharging at Perth beaches (DoW 2007) found hydrocarbon levels below laboratory detection limits in stormwater discharging at Rockingham beaches, so it is also unlikely that stormwater is a significant source. Nor do there appear to be significant amounts of herbicides or pesticides entering Mangles Bay from stormwater (Natural Resource Management Office, Naragebup Rockingham Regional Environment Centre [Inc.] 2003a, 2003b). However stormwater drains often discharge high loads of faecal bacteria (from animal and bird faeces), and the DoW (2007) found faecal bacterial concentrations (enterococci) that exceeded secondary contact recreation guidelines in stormwater and the adjacent swash zone of several drains to the west of Hymus Street, although guidelines were met in the stormwater and swash zone of the Lake Richmond Drain. The Cape Peron area west of Hymus St is on septic system, so there is also the possibility that groundwater is carrying faecal bacteria into Mangles Bay from the various leasehold sites.

In addition to groundwater and stormwater inputs of nutrients and contaminants to Mangles Bay, anecdotal evidence of inputs from boats moored in Mangles Bay was provided during the community consultation for this Proposal. These included fuel spills during informal refuelling, illegal sullage disposal and rubbish disposal. There would also be an assumed degree of contaminant input from moored boats and boat clubs.

Whilst places where boats are permanently moored, or there is heavy boating traffic, are generally not major diffuse sources of contamination to water bodies when compared to groundwater and stormwater runoff from industrial, commercial, urban, or agricultural areas, they can be locally significant sources of:

- fuel and oil (spills during refuelling; bilge discharge; stormwater runoff from areas where launching, maintenance and repair of boats takes place)
- copper and tin in antifoulants; aluminium, iron and chromium in the boats themselves; arsenic in pesticides, paint pigments and wood preservatives; zinc in boat anodes, oil and tyres; and mercury in float switches for bilge pumps and, shower water storage tank pumps and air-conditioning/heating thermostats; nickel in brake linings and pavements; cadmium in brake linings and batteries. There is some leaching while the boats are moored, but most metal is dislodged during boat cleaning either directly during 'in-water' cleaning, or indirectly if washing/maintenance occurs onshore and wash water is not directed to appropriate stormwater treatment areas
- solvents such as tetrachloroethane, trichloroethene and trichloroethylene (in degreasing agents, varnishes, paint removers and lacquers) in stormwater runoff from areas where launching, maintenance and repair of boats takes place
- acid from batteries (often also contains containing high levels of lead too) or cleaning compounds
- surfactants (detergents), either directly from 'in-water' cleaning, or indirectly if cleaning occurs onshore and wash water is not directed to appropriate stormwater treatment areas
- sewerage (due to illegal disposal of sullage) and other waste discharges (including fish cleaning waste, debris and litter).

10.2.2 Current nutrient-related water quality

Cockburn Sound 2009/2010, 2010/2011

The most recently available CSMC report on the water quality of Cockburn and Warnbro Sound (December 2009 to March 2010) provides monitoring data for 20 sites (outlined in Figure 59, 18 within Cockburn Sound and 2 within Warnbro Sound) (Wienczugow *et al.* 2010). This report included monitoring at a new site in the shallows of Mangles Bay (site MB) undertaken specifically for the Proposal, to see if water quality in the shallows was similar to that of the CSMC's routine monitoring site in the deep basin of Mangles Bay (site 11). Site MB has subsequently been included in the CSMC's routine monitoring program.

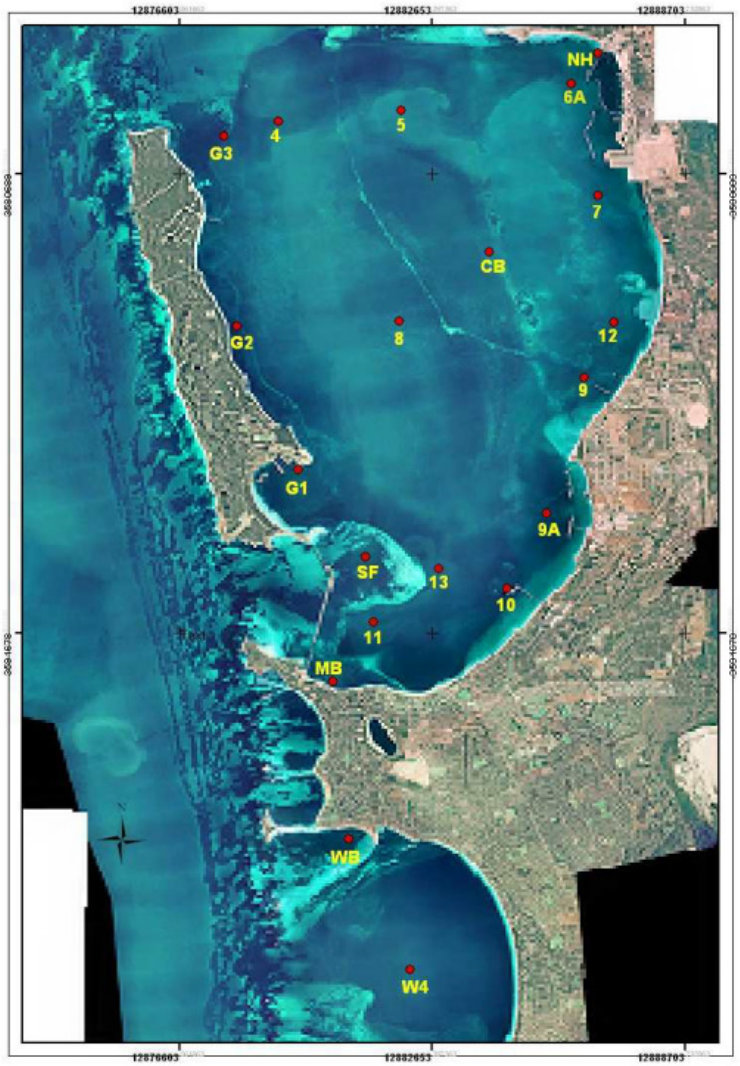


Figure 59 CSMC water quality monitoring sites for 2009/2010.

As noted earlier, Cockburn Sound water quality results for the years 2005 to 2010 showed a significant improvement in chlorophyll-a concentrations compared with the 1990s and early 2000s (Wienczugow *et al.* 2010). Light attenuation also showed some improvement over the last few years, while inorganic nutrient concentrations were similar to those of reference sites in Warnbro Sound (Wienczugow *et al.* 2010). However data for December 2010 to March 2011 (provided courtesy of the CSMC) showed a marked regional increase in chlorophyll-a, potentially related to the 'marine heat wave' recorded in February and March 2011, which saw water temperatures off the majority of the coast of Western Australia rising to unprecedented levels (2–4°C above average) (Pearce et al. 2011).

The data of Wienczugow *et al.* (2010) also illustrate the spatial differences in nutrient and phytoplankton distribution across Cockburn Sound. Higher concentrations of ammonia, nitrate+nitrite and orthophosphate (also known as filterable reactive phosphate) were recorded at sites along the eastern shore than in the centre of Cockburn Sound and Warnbro sound reference sites (although all concentrations were low, close to laboratory detection limits). Phytoplankton biomass (measured as chlorophyll-a concentration) was generally higher at the southern sites (especially along the eastern shore) than in the centre of Cockburn Sound and Warnbro Sound. , evident in the data for 2009/2010 (Wienczugow *et al.* 2010) and 2010/2011 (provided courtesy of the CSMC) in Table 28.

Table 28 Chlorophyll-a concentrations at monitoring sites

Monitoring site	Median chlorophyll-a concentration, 2009/2010	Median chlorophyll-a concentration, 2010/2011
Central Cockburn Sound		
4	0.60 µg/L	0.90 µg/L
5	0.60 µg/L	0.80 µg/L
8	0.65 µg/L	0.90 µg/L
Eastern shore		
MB10	1.65 µg/L	2.60 µg/L
9A	1.45 µg/L	1.50 µg/L
9	1.40 µg/L	1.50 µg/L
12	1.20 µg/L	1.20 µg/L
7	0.85 µg/L	1.10 µg/L
6	0.90 µg/L	0.70 µg/L
Southern Cockburn Sound		
11	1.15 µg/L	1.30 µg/L
13	1.40 µg/L	1.50 µg/L

Notes: * Source: 2009/2010 data from Wienczugow et al. (2010), and 2010/2011 data provided courtesy of the CSMC

Median chlorophyll-a concentrations in the centre of Cockburn Sound (sites 4, 5 and 8) met the high ecological protection zone EQG (0.8 µg/L) in 2009/2010, but only site 5 met the EQG in 2010/2011. In 2009/2010 all the eastern shore sites and southern sites exceeded the high ecological protection zone EQG (0.8 µg/L) and four sites exceeded the moderate protection zone EQG (1.3 µg/L). In 20010/2011 all eastern shore sites and southern sites exceeded the high ecological protection zone EQG (0.8 µg/L) and five sites exceeded the moderate protection zone EQG (1.2 µg/L). This comparison with the nutrient-enrichment EQG for chlorophyll-a is for information only, as the EQG are meant to be applied to the median of the combined data for all monitoring sites in each ecological protection zone, not the median of individual sites.

The focus of routine water quality monitoring in summer means there are few data for other times of the year. Recent data collected at seven sites in the region of the proposed Port Rockingham marina site are provided in RPS (2009), and are reproduced in Table 29 along with summer data collected at the same site, and relevant (summer) EQG and EQS. Winter and summer had similar levels of dissolved inorganic nutrient but chlorophyll-a concentrations in winter were about half of those in summer. The lower growth of phytoplankton in winter (reflected in lower chlorophyll-a levels) was attributed to the lower temperatures and lower available light. Summer water quality at the proposed Port Rockingham marina site also exceeded the high ecological protection zone EQG.

Table 29 Nutrient-related water quality data (median values) adjacent to the proposed Port Rockingham marina in summer and winter-spring

Date	Ammonia (µg/L)	Nitrate + nitrite (µg/L)	Ortho-phosphate (µg/L)	Chlorophyll 'a' (µg/L)	Light attenuation (/m)
Summer* (12 weeks, Jan - March 2007)	3	2	4	1.1	0.105
Winter-spring* (5 weeks, Sept – Oct 2007)	3	2	4	0.6	0.093
EQG for nutrient-related water quality (**summer**)	N/A	N/A	N/A	0.8 (high protection) 1.3 (moderate protection)	0.09 (high protection) 0.10 (moderate protection)
EQS for phytoplankton biomass (**summer**)	N/A	N/A	N/A	1.7 (high protection) 2.4 (moderate protection)	NA

Notes: * Source: RPS (2009)

Mangles Bay 2009/2010 and 2010/2011

As part of the environmental work for the Proposal, water quality measurements were undertaken in the shallows of Mangles Bay to establish baseline water quality prior to development, and to see if water quality was similar to that of the CSMC's routine monitoring site in the deep basin of Mangles Bay (site 11). A baseline survey of nutrient-related water quality was undertaken adjacent to the Proposal area during summer 2009/10 in accordance with protocols used by the CSMC Standard Operating Procedures (EPA 2005b). These data were made available to the CSMC, and are included as the 'MB' site (refer Figure 59) in the CSMC 2009/10 report (Wienczugow *et al.* 2010; Oceanica 2012).

CSMC's routine water quality monitoring is undertaken by Murdoch University's Marine and Freshwater Research Laboratory (MAFRL). As MAFRL was initially uncertain whether the MB site could be included in their routine program (due to logistic constraints), shore-based sampling was initially undertaken (December 2009 and January 2010) at the MB site by Oceanica Consulting Pty Ltd (Oceanica). Samples were collected each Monday morning (the same day as the MAFRL's monitoring program), and delivered to MAFRL for analysis the same morning. Collection methods later changed to boat-based sampling by MAFRL in February and March 2010. Results of the 2009/2010 sampling are shown in Table 30. Site MB has subsequently been included in the CSMC's routine summer water quality monitoring program, and so 2010/2011 data for chlorophyll-a (provided courtesy of the CSMC) are included in Table 30 (a final report incorporating nutrient data for 2010/2011 are not yet available).

Inorganic nutrient data are compared to the default national (ANZECC/ARMCANZ 2000) trigger values for nearshore marine waters in southwest Australia and chlorophyll data to Cockburn Sound EQGs and EQSs. For chlorophyll-a data there are both nutrient-related EQG and phytoplankton biomass EQG and EQS. The nutrient-related EQG are shown for information only, as they are intended for comparison to the median of all monitoring sites in each ecological protection zone, not the median of individual sites. The phytoplankton biomass EQG/EQS can be applied on a site basis according to the percentage of occasions in a summer monitoring period that the EQG/EQS value is exceeded. In the high ecological protection zone, if the phytoplankton biomass EQG/EQS value is exceeded on more than 25% of occasions in any year then the EQG is exceeded, and if this occurs in two consecutive years the EQS is exceeded. For the moderate protection zone, , if the phytoplankton biomass EQG/EQS value is exceeded on more than 50% of occasions in any year then the EQG is exceeded, and if this occurs in two consecutive years the EQS is exceeded. . It is noted that the waters of Mangles Bay are zoned for high ecological protection and therefore only high protection EQC are presently applicable, but moderate protection EQC are included in

Table 30 due to the moderate protection zoning anticipated for marine waters bounded by the Proposal breakwaters (refer Section 10.1.2).

The median chlorophyll-a concentration for site MB (1.65 µg/L) exceeded the nutrient enrichment EQG for high protection and for moderate protection in both 2009/2010 and 2010/2011 (Table 30), as did several other of the CSMC's routine monitoring sites (refer Table 28). Chlorophyll-a concentrations for site MB also exceeded the phytoplankton biomass EQG/EQS value for high protection for more than 25% of the time in both 2009/2010 and 2010/2011 (Table 30), exceeding both the EQG and EQS. The phytoplankton biomass EQG/EQS value for moderate protection was not exceeded in 2009/2010 but was in 2010/2011 (Table 30), exceeding the EQG in 2010/2011 but not the EQS.

Table 30 Water quality data for Mangles Bay shallows, December 2009 to March 2010 and December 2010 to March 2011

Date	Ammonia (µg/L)	Nitrate+nitrite (µg/L)	Ortho-phosphate (µg/L)	Chlorophyll-a (µg/L)	Total suspended solids (TSS) (mg/L)
Reporting Limit	**<3**	**<2**	**<2**	**<0.1**	**<0.5**
National trigger value[1]	**5**	**5**	**5**	**1.0**	**N/A**
EQG, nutrient-related water quality **- High protection** **- Moderate protection**	N/A	N/A	N/A	**0.8** (2009/10) **0.8** (2010/11) **1.3** (2009/10) **1.2** (2010/11)	N/A
EQG/EQS, phytoplankton biomass **- High protection** **- Moderate protection**	N/A	N/A	N/A	**1.7** (2009/10) **1.8** (2010/11) **2.4** (2009/10) **2.4** (2010/11)	N/A
Site MB Median[2], 2009/10 Site MB Median[3] 2010/11	4 Not available	2 Not available	5 Not available	1.65 2.40	2.2 Not available
% occasions site MB exceeded EQC[2], 2009/10 - High protection - Moderate protection % occasions site MB exceeded EQC[3], 2010/11 - High protection - Moderate protection	N/A	N/A	N/A	50% 12% 94% 69%	N/A

Notes: [1] Default trigger values for inshore marine waters in southwest Australia (ANZECC/ARMCANZ 2000).[2] For values reported as <LoR, the LoR was used to calculate the median. Data from Wienczugow et al. (2010)

[3] Chlorophyll-a data provided courtesy of CSMC. Data for nutrients and TSS not yet available.

The median chlorophyll-a concentrations at site MB in 2009/2010 and 2010/2011 were higher than at CSMC routine monitoring site 11 (refer Table 28), and site 11 did not exceed the phytoplankton biomass EQS for high protection (19% of occasions in 2009/2010 and 38% in 2010/2011),, indicating that:

- water quality data from CSMC routine monitoring site 11 (deep basin of Mangles Bay) cannot be used to predict water quality in the shallow flats adjacent to the proposed marina
- site-specific monitoring of water quality adjacent to the Proposal will be needed before and after development, to ascertain the degree to which outflow of water from the marina affects water quality in the Mangles Bay region.

10.2.3 Modelling approach used to assess impacts of the Proposal on marine water quality

Modelling approach for turbidity generated during construction

Modelling of the turbidity due to dredging and disposal of sediments was undertaken using an advanced sediment fate model; SSFATE (Suspended Sediment FATE), operating within the ASA DREDGEMAP system (Appendix 5). To represent the wave-induced effects on settlement and re-suspension of dredged sediment released during dredging of the approach channel, a wave model was established using the Simulating Waves Nearshore (SWAN) model. The wave model was run for the conditions required for the sediment fate analysis (winter of 2003): model output was stored hourly for input to the sediment fate model, DREDGEMAP.

SSFATE is a computer model developed by the US Army Corps of Engineers' Engineer Research and Development Centre and Applied Science Associates (ASA) which has been applied and validated against observations of sedimentation and suspended sediments at multiple locations in Western Australia, including Cockburn Sound for Fremantle Ports and Mermaid Sound for the Pluto dredging project (Appendix 5). The model predicts dispersion and settlement of suspended sediments, and also allows for potential re-suspension of newly settled sediments (which have higher water content and are more easily resuspended by lower shear stresses).

Modelling of turbidity was undertaken based on the following assumptions:

- dredging will start in early June and run through to early August (nine weeks), with the dredge operating six days a week during daylight hours (nominally 6.00 AM to 6.00 PM)
- dredging will commence from the offshore end of the access channel and progress shorewards towards the site of the proposed marina development (with the dredge remaining longer in the shallower areas)
- the particle size distribution data for dredged sediments were those supplied by the sediment sampling program undertaken for the Proposal (Section 10.2.4), and as no rock was encountered during this sampling program it was assumed that no cutting will be required during the dredging program.

The extent of the visible plume in these relatively clear waters is expected to be where the combined TSS of the dredge-generated plume and background TSS is above approximately 4 mg/l. Previous studies (DEP 1996) have identified background TSS values for Perth Coastal Waters of the order of 2–3 mg/L, as did studies of water quality in Mangles Bay undertaken for the Proposal (refer Section 10.2.2); hence a dredge-generated TSS threshold of 2 mg/L was plotted as the extent of the visible plume.

Modelling approach for marina water quality

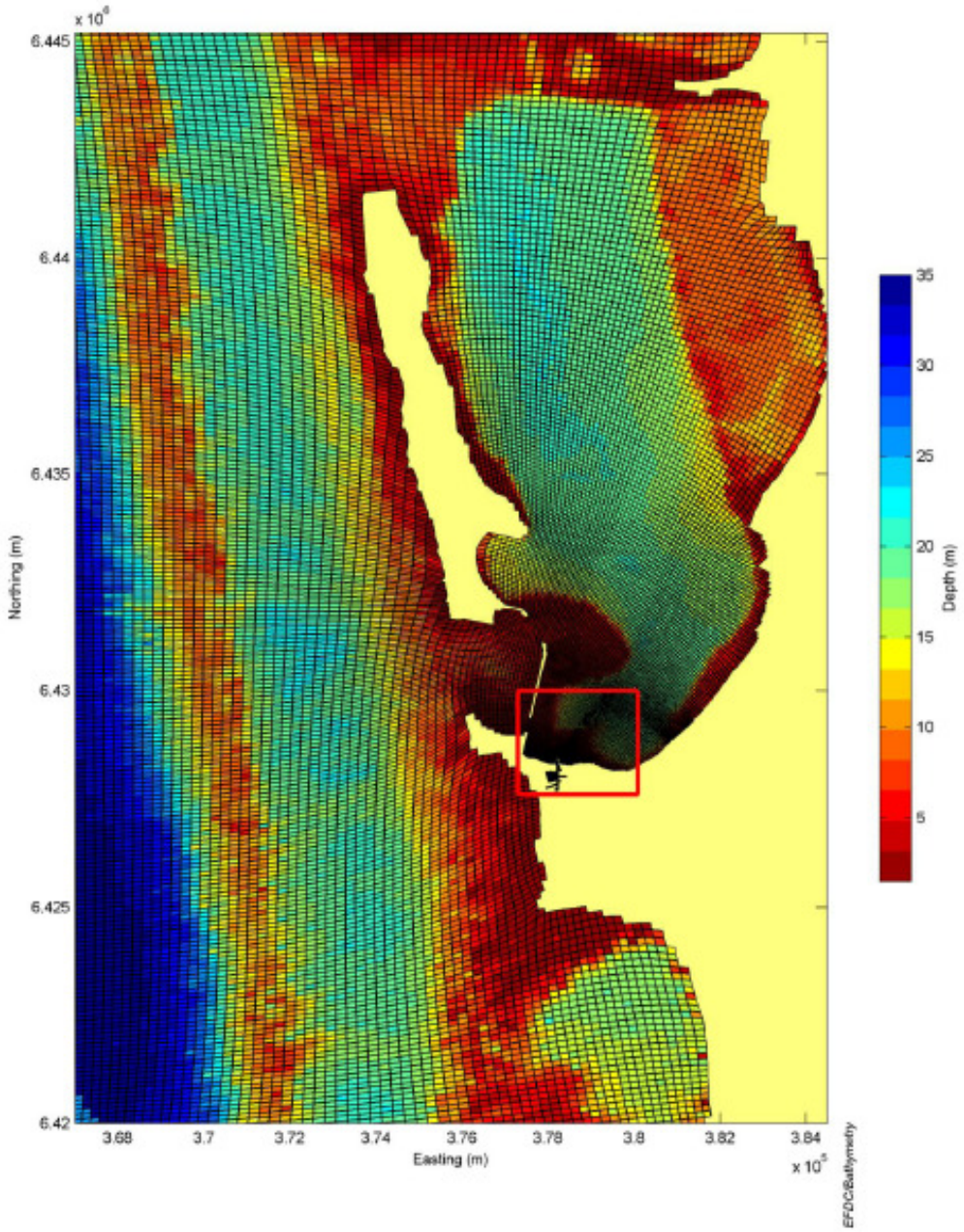
There were three models used in the Proposal assessment:

1. Environmental Fluid Dynamics Code (EFDC) model which simulates water movement (current velocity and direction) in relation to:
   - flushing (dye used as a conservative tracer)
   - nutrient concentration, with DIN used as a conservative tracer.
2. Simulating Waves Nearshore (SWAN) model: simulates settlement and suspension for sediments during dredging. The SWAN model was developed to simulate spatially-varying wave conditions over a wide domain, including the Cockburn Sound and Mangles Bay regions.
3. Equilibrium (box) model: used to predict the chlorophyll-a concentrations (and hence predict water quality) in the Proposal area based on flushing results from the EFDC flushing model component.

Modelling configuration and validation

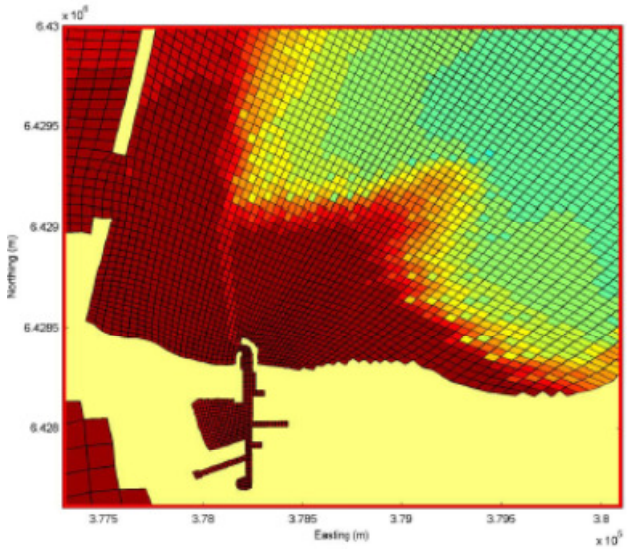
Due to the necessity to accurately simulate baroclinic (density-driven) current flows, wind, tide and groundwater inputs, modelling was undertaken using the EFDC model, applied within ASA's WQMAP framework. EFDC has been applied in numerous studies in Australia, including Cockburn Sound, Perth Coastal Waters, the Peel Inlet, Mermaid Sound, Port Hedland Harbour, Darwin Harbour, Hawkes Bay in New Zealand, and Caution Bay in Papua New Guinea (Appendix 5). Most of these studies involved rigorous validation of the hydrodynamic model performance, hence the model algorithms were considered robust and fit for the purposes of this study.

The model domain and computational grid developed for this study are shown in Figure 60 and . Horizontal model resolution was from 8-10 m within the marina and to 450 m at the outer edges of the domain. The model had six vertical layers, with middle layers specified as 20% of the local water depth, and the top and bottom layers as 10% of the local water depth to provide better resolution near the seabed and the water surface.



Note: Red area shown in more detail in Figure 61

Figure 60 Model domain, computational grid and bathymetry

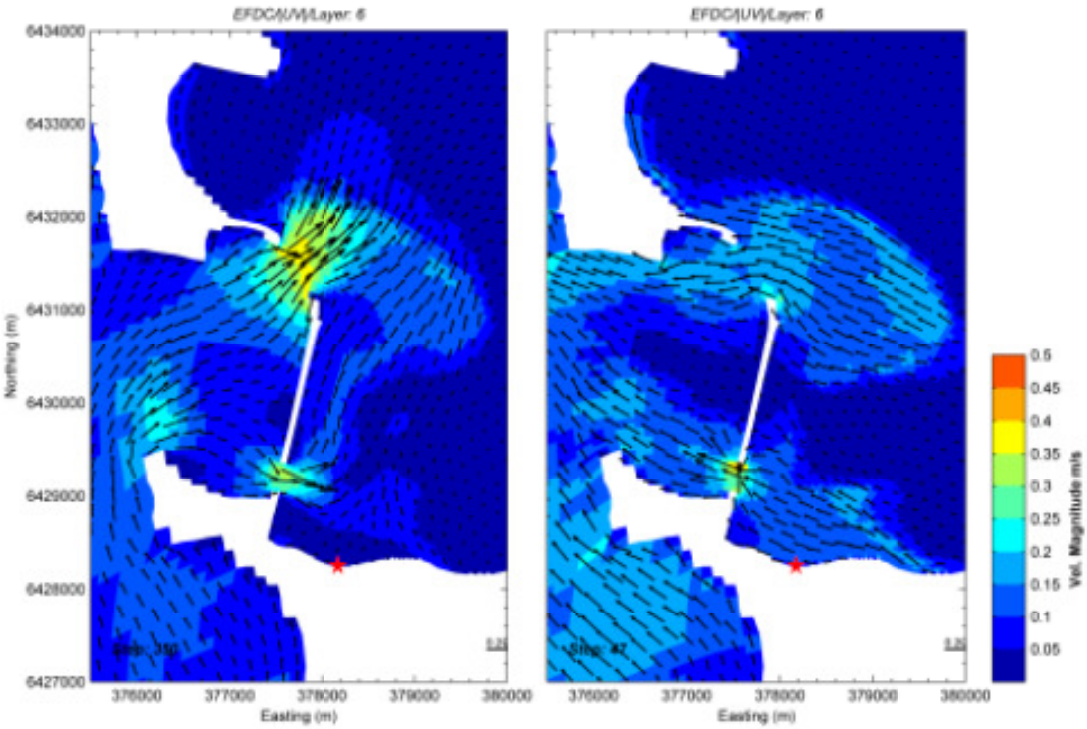


Source: APASA 2011

Figure 61 Model domain, computational grid bathymetry in region of proposed development

Model performance was validated using data collected from Acoustic Doppler Current Profilers (ADCPs) deployed in Mangles Bay from 10 February to 7 April 2011, and from 14 drogue deployments over the same period. Wind data were also collected at Mangles Bay (on Royal Australian Navy premises at the southern end of the Garden Island Causeway) to determine if wind measurements at the BoM site on the northern end of the Causeway were suitable for inclusion in the model. Wind speeds at Garden Island were consistently higher for winds from the southwest and east quadrant. In general, wind speeds at Mangles Bay were about 65% of those at Garden Island for south- easterlies, and 75% for easterlies. Wind directions for the two locations were generally similar, as were recorded wind speeds other than south-westerlies and easterlies (Appendix 5). This comparison suggested that winds in Mangles Bay will be slightly weaker from sheltered sectors than indicated in the long run records at the more exposed Garden Island location, and this was considered in the application of the wind data in the modelling.

Overall, model validation confirmed that the model provided a suitable basis for use in the assessment of the flushing performance of the proposed marina. Typical circulation patterns predicted by the model are shown in Figure 62. There is a region of strong currents to the east of the Garden Island Causeway, but this is highly localised and confined to the Garden Island Causeway openings and the relatively shallow area immediately adjacent. Current speeds are shown to reach around 0.35 m/s through both openings, consistent with the historical measurements of Pattiaratchi (2002). Calculated current speeds are significantly weaker adjacent to the proposed marina entrance and more variable in direction, as also indicated by field measurements (Appendix 5).

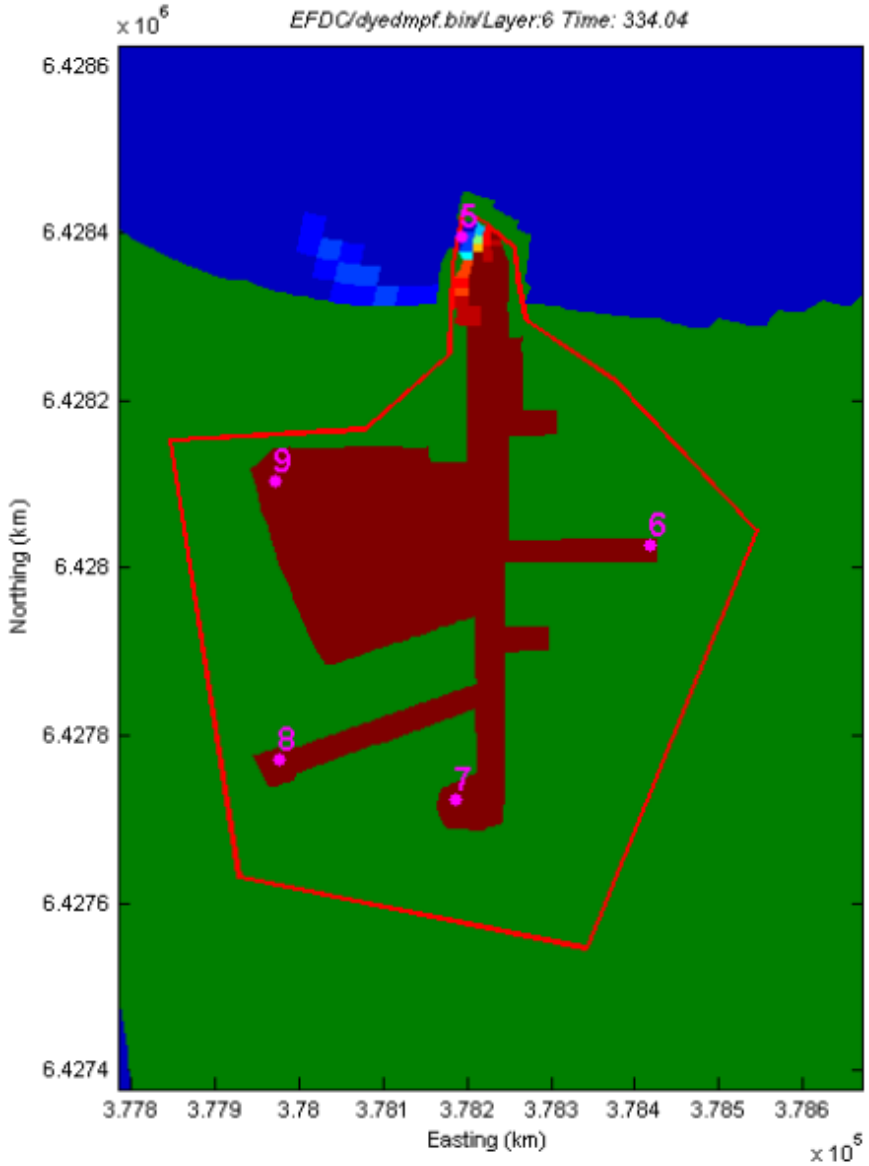


Note: From APASA (2011). The location of the proposed marina entrance is indicated by the red star. The colour scale reflects the relative current speed as per the scale, while the vector arrows point to where the current flow is going.

Figure 62 Typical current patterns in south western Mangles Bay during inflow (left) and outflow (right) conditions

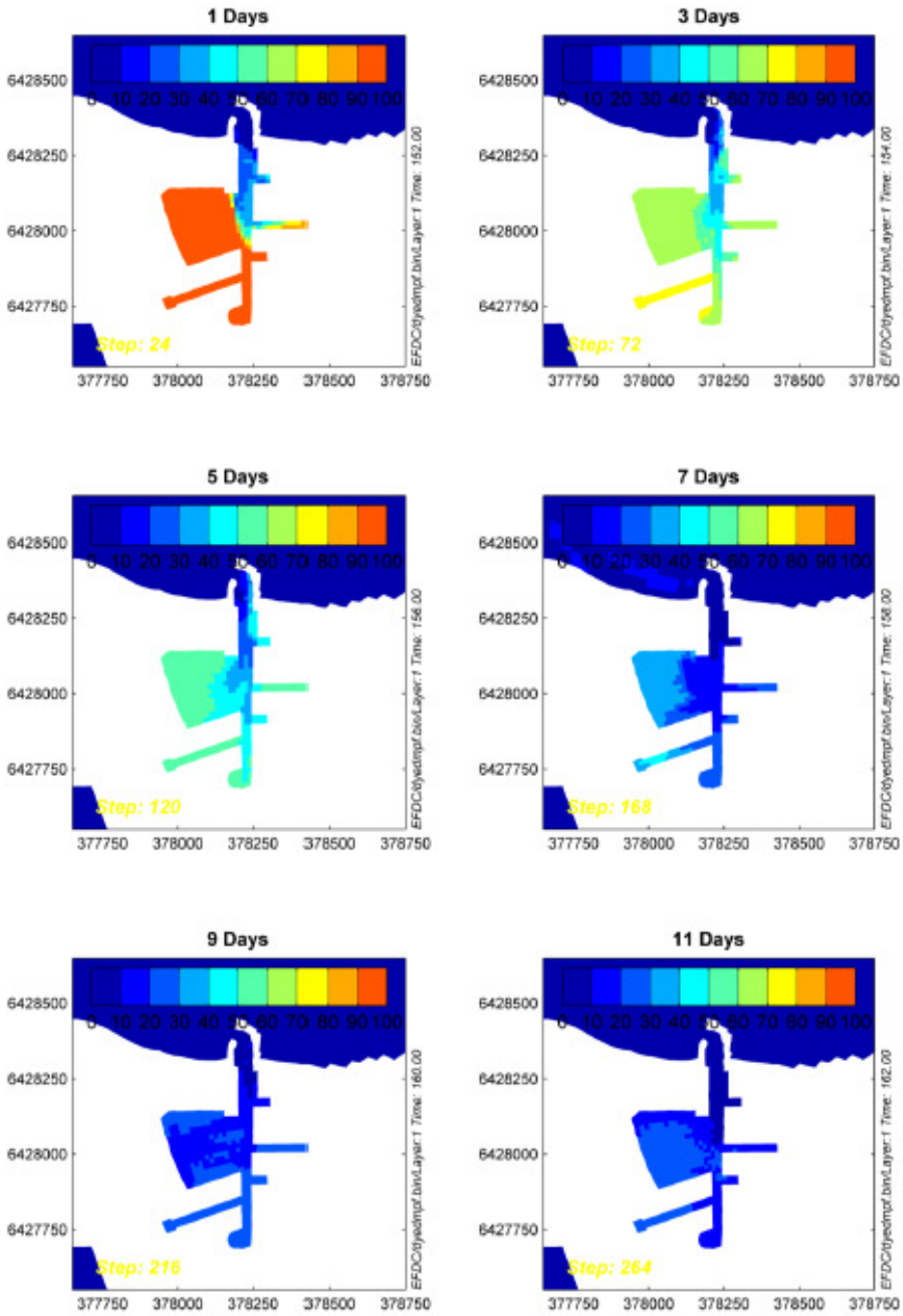
Flushing scenarios simulated

The flushing performance of the marina under different conditions of tides and winds was determined by seeding the marina waters with a conservative dye in the model (to ensure concentration only changes by dilution and dispersion) (Figure 63). The initial dye concentration was set to 100, representing 100% of an arbitrary contaminant. The flushing time was assessed as the time it takes for the concentration at a series of locations within the development to reduce to 1/e, or approximately 37% of the original concentration, also known as the e-folding time, consistent with the approach of DEP (1996). An example of model output is shown in Figure 64.



Note: The red boundary shows the marina precinct defined in the model.

Figure 63 Initial tracer dye within the marina and locations of the five assessment points used in water quality modelling



Source: APASA 2011

Figure 64 Illustrative snapshots of the surface layer dye concentration for winter scenario 1 at 1, 3, 5, 7, 9 and 11 days after the initialisation of the initial tracer distribution

Simulations were conducted to represent the three identified hydrodynamic regimes in Cockburn Sound/Mangles Bay: summer, autumn and winter/spring. The selection of representative conditions for each regime was based on an analysis of more than 10 years of wind data measured at Garden Island by the BoM. Simulations of each season were completed for the Proposal over a period of 60 days. As the flushing time depends on the prevailing conditions during each of the seasons, a range of model flushing tests was completed over differing tidal and wind conditions. Seven scenarios were modelled for each

season (Table 31), ensuring a wide range of typical environmental conditions was covered. A further set of simulations for summer was completed to assess the sensitivity of results to the potential wind sheltering that may occur in Mangles Bay, with wind speeds from the southwest and the east factored, as discussed above.

Table 31 Flushing scenarios undertaken for water quality modelling (APASA 2011)

Season	Scenario	Conditions
Summer	**1**	**Tides** Moderate tides rising to spring range of 0.8 m then dropping to 0.2 m on neaps after 7 days. **Winds** Strong sea breeze cycle, SW dominated with weak easterlies. **Mean wind speed** 6.6 m/s.
	2	**Tides** Moderate tides rising to spring range of 0.6 m then dropping to 0.2 m on neaps after 7 days. **Winds** SW dominated with sea breeze pattern and stronger winds at end of period. **Mean wind speed** 6.9 m/s.
	3	**Tides** Spring tides with a range 0.9 m falling to neaps after 5 days. **Winds** Strong sea breezes to start followed by weaker and variable direction winds. **Mean wind speed** 7 m/s.
	4	**Tides** Moderate tides with range of 0.6 m progressing to neaps with a generally falling mean water level. **Winds** Weak winds at beginning before strong consistent sea breeze pattern. **Mean wind speed** 7.7 m/s.
	5	**Tides** Neap tides at the start rising to 0.8 m range after 7 days. **Winds** Persistent SW winds through most of the period with some sea breeze events. **Mean wind speed** 6.1 m/s.
	6	**Tides** Neap tides at the start rising to 1.0 m range after 8 days. **Winds** Early SW dominance then very strong winds after 9 days before a variable strength sea breeze cycle. **Mean wind speed** 7.4 m/s.
	7	**Tides** Neap tides at the start quickly rising to 0.6 m range for next 10 days. **Winds** Consistent sea breeze before sustained easterlies and weaker winds. **Mean wind speed** 7.1 m/s.
Autumn	**1**	**Tides** 0.5 m range at start, falling to neaps after 7 days. **Winds** Moderate to strong sea breeze cycle then weakening winds. **Mean wind speed** 7.1 m/s.
	2	**Tides** 0.5 to 0.6 m range throughout most of the period. **Winds** Moderate sea breeze to variable and strong SW winds later in the period. **Mean wind speed** 6.6 m/s.
	3	**Tides** 0.4 m range at the start rising to 0.6 m. **Winds** Generally weaker winds for most of the period with some light sea breezes. **Mean wind speed** 5.1 m/s.
	4	**Tides** 0.4 m range at the start rising to 0.6 m. **Winds** Weak sea breezes then sustained NW for a period followed by persistent easterlies. **Mean wind speed** 5 m/s.
	5	**Tides** Neap tides at the start progressing to 0.6 m after 7 days. **Winds** Clear sea breeze pattern throughout with some scattered easterly events. **Mean wind speed** 5.5 m/s.
	6	**Tides** 0.4 m range at the start increasing to 0.6 m after 7 days. **Winds** Strong wind events with a periodicity of around 5 days, mostly from the SW with some N winds. **Mean wind speed** 7.1 m/s.
	7	**Tides** 0.6 m at the start reducing to 0.2 m after 10 days. **Winds** Weak and variable winds from NW to SW mainly. **Mean wind speed** 4.6 m/s.
Winter/ Spring	**1**	**Tides** Spring tides with range of 0.6 m at start, reducing to neaps with range of 0.2 m with generally falling mean water level. **Winds** Episodic strong winds from variable directions. **Mean wind speed** 5.2 m/s.
	2	**Tides** Moderate range of 0.7 m at start on a rising mean water level. **Winds** Weak and persistent easterlies for first 8 days, then shifting to W to NW during storms. **Mean wind speed** 6.8 m/s.

Season	Scenario	Conditions
	3	**Tides** Moderate range of 0.7 m at start with neaps after 6 days. **Winds** Episodic W to NW storms. **Mean wind speed** 7 m/s.
	4	**Tides** Generally low 0.2 to 0.3 m range for first 10 days, rising to springs thereafter. **Winds** Weak easterlies to start then strong storm from SW after 7 days. **Mean wind speed** 5.7 m/s.
	5	**Tides** Neap tides with rang of 0.2 m to start rising to 0.8 m springs after 7 days. **Winds** Variable then prolonged period of weak easterly winds. **Mean wind speed** 4.4 m/s.
	6	**Tides** Neap tides to start with a generally falling mean water level, reaching 0.6 m range after 7 days. **Winds** Relatively strong W to NW dominated winds for the most part. **Mean wind speed** 8 m/s.
	7	**Tides** 0.3 m neap tides at the start increasing to 0.9 m range after 6 days over a generally falling mean water level. **Winds** Strong NW winds over the first 3 days then variable including weak easterlies after 8 days. **Mean wind speed** 6.5 m/s.

Source: APASA 2011

Nutrient tracer modelling

Modelling of the potential long-term build-up of contaminants and nutrients provides a more realistic indication of the likely effects. By assessing the variation from background values, the likely nature and impact of any change in water quality can be inferred. A series of model tests was conducted to demonstrate the potential effect of the marina on DIN within the Proposal area and in the adjacent waters. A constant background concentration value of 6 µg/L was assumed (refer Section 10.2.2), and the flux of DIN from the local groundwater system was applied along the marina edges using data provided by ERM (2011) for groundwater modelling undertaken for the Proposal. Groundwater inputs of DIN to the marina that were used were:

- summer – DIN load of 0.1 kg/day, based on a groundwater flow of 270 m^3/day and a DIN concentration of 0.37 mg/L
- autumn - DIN load of 0.2 kg/day, based on a groundwater flow of 620 m^3/day and a DIN concentration of 0.33 mg/L
- winter - DIN load of 0.7 kg/day, based on a groundwater flow of 940 m^3/day and a DIN concentration of 0.78 mg/L.

Groundwater flux was not applied to the adjacent coastline to allow the potential build up within the marina to be clearly modelled. Although release by sediments and decaying organic matter is ignored in this approach, the uptake by biological processes is also excluded, and the results are generally suitable for initial water quality assessments and for providing context to the likely effect of hydrodynamic flushing on water quality (Appendix 5).

Prediction of increased chlorophyll-a concentrations in marina waters

An indication of water quality (in terms of phytoplankton growth potential as measured by chlorophyll-a concentrations) in the Proposal area was obtained with an equilibrium (box) model using DIN as the modelled constituent. Studies in Perth's coastal waters have conclusively shown that phytoplankton growth is limited by nitrogen (DEP 1996), and so incorporation of DIN into phytoplankton biomass provides a conservative estimate of potential phytoplankton growth.

The ratio of chlorophyll-a to carbon, and carbon to nitrogen in phytoplankton is relatively uniform (50C:1Chl a, and 41C:1N; by mass) and if it is conservatively assumed that all available DIN is utilised by phytoplankton, the chlorophyll-a concentration will be approximately 0.117 times the predicted DIN concentration. The accuracy of this approach is at best moderate, as the efficiency with which DIN is converted to chlorophyll depends on a range of other parameters such as availability of other nutrients, light, temperature, phytoplankton species, mixing and phytoplankton numbers. For the simulations

described below, it was conservatively assumed that all DIN was utilised by phytoplankton (DIN: chlorophyll conversion efficiency of 1.0) in summer and autumn (all DIN was converted to chlorophyll-a in the marina), but only half the DIN was utilised in winter, based on the results described in Section 10.2.2. This technique provides a guide to potential water quality (in terms of chlorophyll-a levels) in relative rather than absolute terms, and is best used to approximate chlorophyll levels in regions where they are likely to be moderate.

The input parameters for the equilibrium model are tabulated below. The model assumes that all input parameters remain constant in time. The flushing times chosen (six days and eight days) approximated typical values for the majority of marina waters in the three seasons (Table 32). Sediment nutrient inputs were based on Livery *et al.* (1993) for the Perth Coastal Waters study (and comparable to published rates for sandy, carbonate sediments). A zero sediment flux was also simulated as the work of Forehead (2006) in Cockburn Sound found that small rates of net uptake from sediments can occur as well as a small amount of net efflux.

Table 32 Input parameters used for equilibrium (box) modelling of water quality in the Proposal area (APASA 2011)

Parameter	Summer	Autumn	Winter
Volume of marina waters	Approx. 420 000 m^3	Approx. 420 000 m^3	Approx. 420 000 m^3
DIN load from groundwater	0.1 kg/day	0.2 kg/day	0.7 kg/day
DIN load from sediments (over 12 ha area of marina waters)	0 0.29 kg/day[1]	0 0.29 kg/day[1]	0 0.29 kg/day[1]
E-folding times	6 days 8 days	6 days 8 days	6 days 8 days
Conversion efficiency of DIN to chlorophyll	1	1	0.5
DIN concentration in source waters (Mangles Bay)	6 µg/L	6 µg/L	6 µg/L
Chlorophyll-a concentrations in source water (Mangles Bay)	1.3 µg/L(20th percentile) 1.7 µg/L (median) 2.1 µg/L (80th percentile)	1.3 µg/L(20th percentile) 1.7 µg/L (median) 2.1 µg/L (80th percentile)	0.6 µg/L(20th percentile) 0.8 µg/L (median) 1.0 µg/L (80th percentile)

Note: [1] Based on rate of 2.4 mg/m^2/day Livery *et al.* (1993).

10.2.4 Sediment quality

Sediment investigations and methods

The Proposal requires excavation of approximately 50 000 m^3 of marine sediments to create a marina access channel that is suitable for large (up to 25 m) power and sail craft. The excavation will result in some suspension of sediment, and any associated contaminants, into the water column. There is also potential for dissolved and particulate contaminants in the sediment to enter Mangles Bay through drainage from the settlement and infiltration ponds used for disposal of the dredged material. Accordingly, investigations were undertaken to assess the potential risk posed to the marine environment by any contaminants in the sediment in the area to be excavated.

Sediment sampling was undertaken on 28 February and 1 March 2011 as per NAGD (Commonwealth of Australia 2009), which requires sampling at 12 sites for the characterisation of 50 000 m^3 of dredged

material (Figure 65). For sites sampled within the vicinity of the proposed channel footprint[10], sediment cores were taken to the full depth of dredging[11] and split into layers of 0.5 m for analysis.

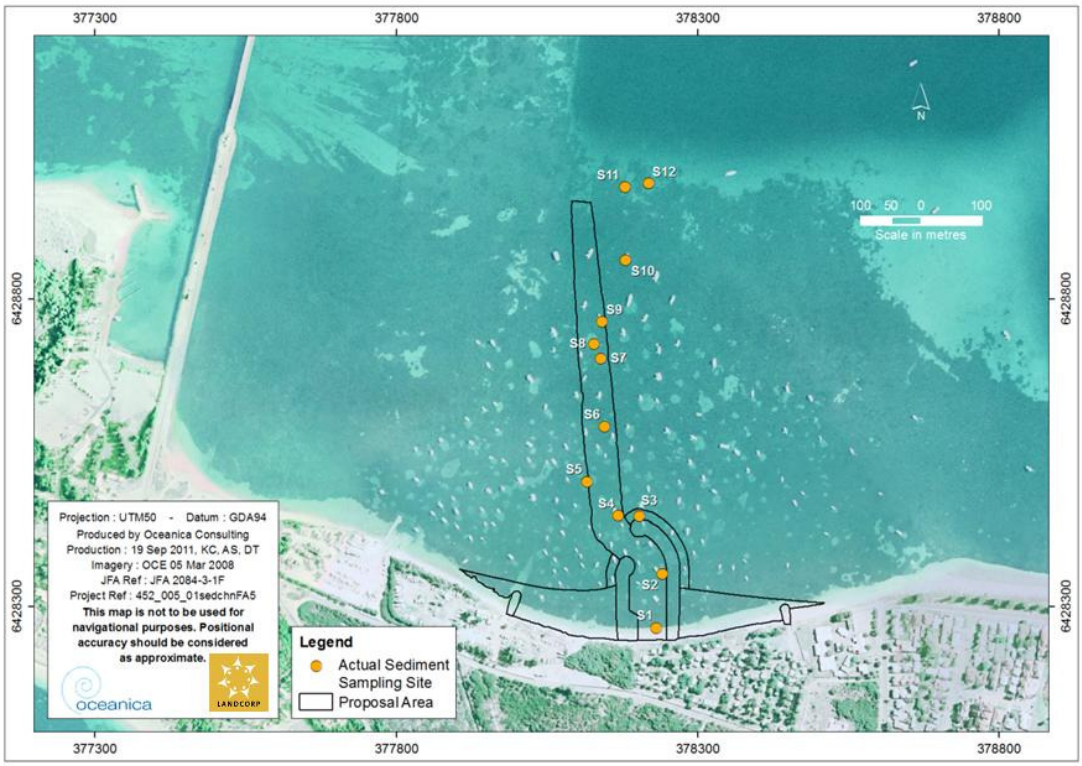


Figure 65 Sediment sampling sites within the vicinity of the proposed channel footprint

Sampling sites were located randomly within the area to be dredged; however, sites located closer to shore were slightly relocated to the closest mooring scar (the bare sand areas within seagrass meadows surrounding boat moorings). Site relocation within the mooring scars was undertaken for several reasons:

- it allowed for more straightforward sediment core extraction
- it provided a conservative approach to sediment assessment, as sediments in mooring scars (directly under moored boats) were more likely to be contaminated than sites under seagrass meadows
- it minimised damage to existing seagrass meadows.

In addition, four sites were sampled according to the methods specified in the Cockburn Sound SEP (EPA 2005b), in areas adjacent to the proposed access channel (Figure 66). This sampling was undertaken to provide baseline data on sediment contamination in the surface sediments of the region, to detect any future contamination should the Proposal proceed.

[10] The proposed channel design altered slightly after sediment sampling had been undertaken, resulting in several sampling locations being located outside of the proposed dredge channel. The sites sampled are still considered sufficiently representative of the region.

[11] The NAGD indicates that *"For capital dredging, samples are needed from the full depth of contaminated as well as potentially contaminated sediment. Full depth is taken to mean at least the top 1 metre of sediment, and more if contamination could be found deeper..."* consequently cores did not exceed a depth of 150 cm.

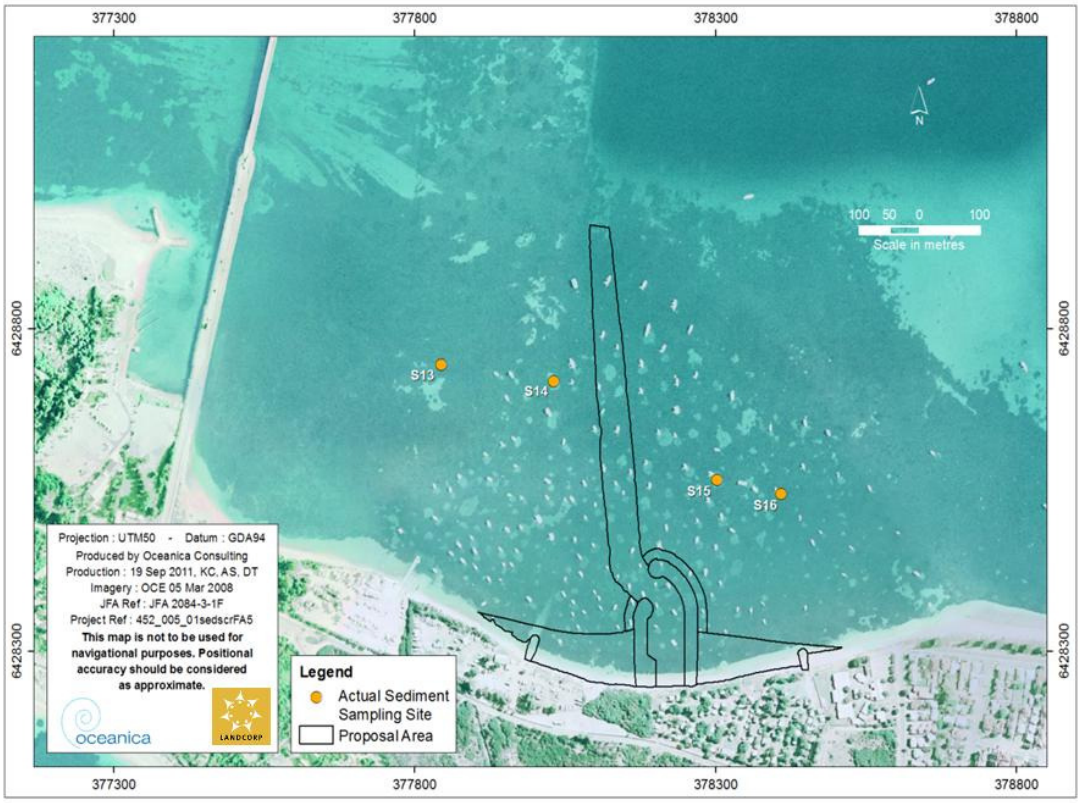


Figure 66 Baseline sediment sampling sites in adjacent mooring scars

Sampling methods and data are described in full in Appendix 5.

Particle size analysis

The sediments in the area to be excavated primarily comprised fine to median grained sands, with small percentages of silts and clays (Appendix 5). Representative data for the surface, middle and bottom layers of four sites are shown in (Figure 67). The particle size distributions in the 0-0.5 m layer (T), the 0.5-1 m layer (M) and the 1-1.5 m layer (B) of each site were generally similar with the exception of site S11, which had more silt and clay in the surface and middle sediment layers than in the bottom layer.

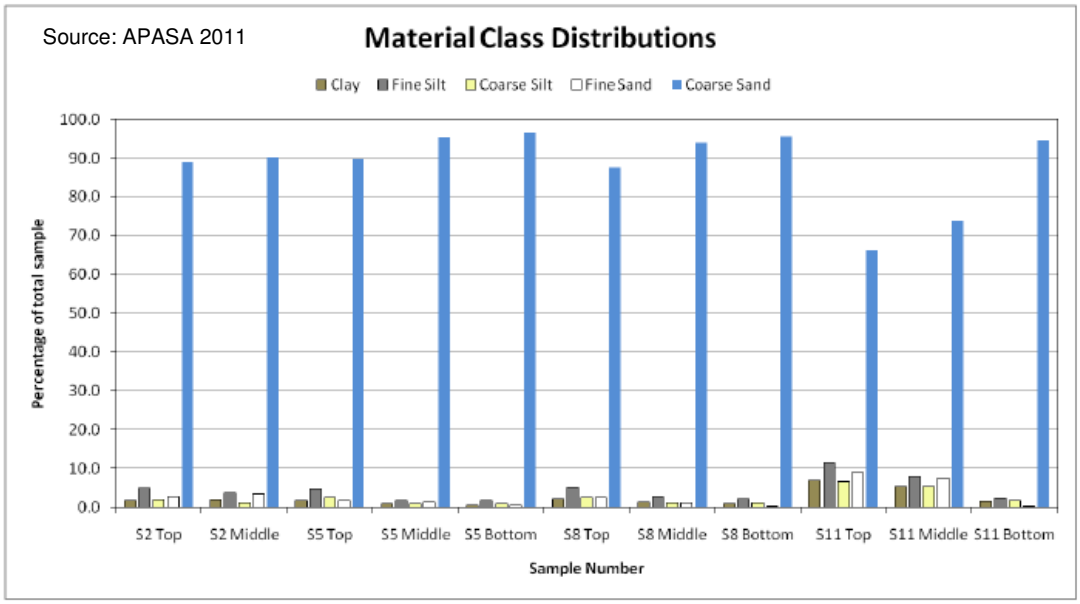


Figure 67 Particle size distribution data for sediments in area to be dredged

Metals

NAGD protocols require the 95% Upper Confidence Limit (UCL) of the mean (95% UCL) concentration of contaminants in dredged sediments to be compared to NAGD screening levels (Commonwealth of Australia 2009). A similar approach is typically used for comparison against EILs and HILs (DEC 2010b). Cockburn Sound SEP protocols require the median of sediment concentrations in a defined sampling are to be below the EQG value, and no single site to exceed the EQG re-sampling trigger (EPA 2005a).

Concentrations of metals within the sediments to be dredged did not exceed, EILs, HILs or EQGs (Table 33 and Table 34), indicating that there was a low risk of adverse ecological effects due to dredging or disposal, and that the material was suitable for use on land.

Table 33 Metal concentrations in Mangles Bay sediments S1-S12 (mg/kg)

Analyte	Silver (Ag)	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Mercury (Hg)	Nickel (Ni)	Lead (Pb)	Zinc (Zn)
NAGD screening levels / EQG value	**1**	**20**	**1.5**	**80**	**65**	**0.15**	**21**	**50**	**200**
EQG re-sampling trigger	**3.7**	**70**	**10**	**370**	**270**	**1**	**52**	**220**	**410**
EIL	**n/a**	**20**	**3**	**400**	**100**	**1**	**60**	**600**	**200**
HIL 'D' **HIL 'E'** **HIL 'F'**	**n/a** **n/a** **n/a**	**400** **200** **400**	**80** **40** **100**	**480 000** **240 000** **600 000**	**4000** **2000** **5000**	**60** **30** **75**	**2400** **600** **3000**	**1200** **600** **1500**	**28 000** **14 000** **35 000**
Sites sampled for dredged sediment characterisation									
S1 S S1 M S1 B	0.68 0.74 0.75	3.6 5.8 6.6	0.21 0.20 0.17	13 13 13	2.8 0.8 0.57	<0.01 <0.01 <0.01	0.93 0.97 0.88	2.5 1.0 0.61	5.6 1.5 0.96
S2 S S2 B	0.68 0.73	3.5 10	0.19 0.21	13 14	2.1 0.52	<0.01 <0.01	0.96 1.1	2.4 0.74	5.4 0.85
S3 S S3 M S3 B	0.70 0.72 0.70	7.7 12 12	0.20 0.22 0.20	14 14 14	32 3.6 2	0.03 <0.01 0.01	0.89 0.96 0.89	8.2 1.3 1.5	5.6 1.0 0.91
S4 S1 S4 M1 S4 B1#	0.67 0.70 0.68	6.7 10 12	0.25 0.19 0.20	13 13 14	2.8 0.42 0.39	<0.01 <0.01 <0.01	1.3 0.81 0.87	1.6 0.57 0.60	6 1.2 0.61
S5 S S5 M S5 B	0.68 0.69 0.67	5.8 8.2 12	0.19 0.22 0.25	13 14 14	2.1 0.48 0.36	<0.01 <0.01 <0.01	0.88 1.0 1.4	0.93 0.63 0.61	3.5 0.69 0.58
S6 S S6 M S6 B	0.69 0.81 0.65	4.4 7.8 9.2	0.16 0.2 0.25	13 14 14	2.4 0.44 0.42	<0.01 <0.01 <0.01	0.79 0.87 0.91	0.96 0.62 0.51	2.3 0.61 0.65
S7 S S7 M S7 B	0.67 0.66 0.64	5.5 7.5 9.4	0.17 0.17 0.21	14 13 14	0.69 0.36 0.31	<0.01 <0.01 <0.01	0.72 0.88 0.96	0.97 0.58 0.54	1.3 0.51 0.57
S8 S1# S8 M1 S8 B1	0.70 0.69 0.64	5.5 7.4 11	0.17 0.17 0.19	14 13 13	0.79 0.42 0.39	<0.01 <0.01 <0.01	0.83 0.74 1.0	0.80 0.60 0.52	1.5 0.59 0.53
S9 S S9 M# S9 B	0.66 0.78 0.77	6.7 8.6 8.7	0.20 0.21 0.22	14 13 12	1.5 0.52 0.47	<0.01 <0.01 <0.01	1.1 1.2 1.2	1.1 0.66 0.61	3.6 0.78 0.59
S10 S S10 M S10 B	0.72 0.74 0.72	4.0 7.1 11	0.21 0.19 0.25	13 13 14	6.7 0.42 0.39	<0.01 <0.01 <0.01	1.3 1.0 1.0	1.6 0.53 0.56	8.0 0.61 0.64
S11 S S11 M S11 B	0.75 0.73 0.72	4.7 6.0 5.4	0.17 0.18 0.17	13 13 14	0.96 0.52 0.40	<0.01 <0.01 <0.01	1.2 1.1 0.88	0.92 0.55 0.61	1.8 0.52 0.64
S12 S S12 M S12 B	0.74 0.74 0.72	5.0 5.4 7.3	0.17 0.17 0.18	12 13 13	0.99 0.6 0.4	<0.01 <0.01 <0.01	1.1 1.0 0.94	1.0 0.66 0.51	2.9 0.67 0.59
Mean	*0.71*	*7.5*	*0.20*	*13.4*	*2.0*	*<0.01*	*0.98*	*1.1*	*1.8*
Standard deviation	*0.04*	*2.5*	*0.02*	*0.6*	*5.4*	*n/a*	*0.15*	*1.3*	*1.9*
95% UCL of mean	*0.72*	*8.3*	*0.20*	*13.6*	*3.8*	*<0.01*	*1.03*	*1.5*	*2.4*

Notes: [1] Average of data for three field replicates
[#] Average of data for two laboratory duplicates
EIL = Environmental Investigation Level
HIL = Health Investigation Level. HIL 'D' (residential with minimal opportunities for soil access: includes dwellings with fully or permanently paved yard space such as high-rise apartments and flats), 'E' (parks, recreational open space and playing fields, includes secondary schools) and 'F' (commercial/industrial, includes premises such as shops and offices as well as factories and industrial sites)

Table 34 Metal concentrations in Mangles Bay surface sediments S13-S16 (mg/kg)

Analyte	Silver (Ag)	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Mercury (Hg)	Nickel (Ni)	Lead (Pb)	Zinc (Zn)
NAGD screening levels / EQG value	**1**	**20**	**1.5**	**80**	**65**	**0.15**	**21**	**50**	**200**
EQG re-sampling trigger	**3.7**	**70**	**10**	**370**	**270**	**1**	**52**	**220**	**410**
EIL	**n/a**	**20**	**3**	**400**	**100**	**1**	**60**	**600**	**200**
HIL 'D' **HIL 'E'** **HIL 'F'**	**n/a** **n/a** **n/a**	**400** **200** **400**	**80** **40** **100**	**480 000** **240 000** **600 000**	**4000** **2000** **5000**	**60** **30** **75**	**2400** **600** **3000**	**1200** **600** **1500**	**28 000** **14 000** **35 000**
Sites sampled for baseline sediment quality (surface sediments only)									
S13	0.72	4.2	0.15	13	1.1	<0.01	0.76	0.99	2.3
S14	0.79	4.3	0.16	13	1.7	<0.01	0.84	1.3	5.6
S15	0.76	4.2	0.15	15	19	<0.01	1.8	1.1	5.1
S16	0.78	3.4	0.15	13	1.3	<0.01	0.78	1	2.3
Median	*0.77*	*4.2*	*0.15*	*13*	*1.5*	*<0.01*	*0.81*	*1.1*	*3.7*

Notes: EIL = Environmental Investigation Level
HIL = Health Investigation Level. HIL 'D' (residential with minimal opportunities for soil access: includes dwellings with fully or permanently paved yard space such as high-rise apartments and flats), 'E' (parks, recreational open space and playing fields, includes secondary schools) and 'F' (commercial/industrial, includes premises such as shops and offices as well as factories and industrial sites)

Nutrients

Concentrations of TKN and TP in sediments were 56440 mg/kg and 370–420 mg/kg, respectively (Appendix 5). No trigger values exist for nutrients in sediments, however these values were within the ranges range previously reported for sediments of Cockburn Sound and Warnbro Sound: 80–2150 mg/kg for TKN and 350–500 mg/kg for TP, with the higher values associated with siltier sediments in the deep basins (DEP 1996).

Both NAGD protocols and Cockburn Sound SEP protocols require the 95th percentile of toxicant concentrations in water to be compared to relevant guidelines. Concentrations of ammonia in elutriates of Mangles Bay sediments did not exceed the toxicity guideline of the NAGD (Commonwealth of Australia 2009) or Cockburn Sound EQG for high ecological protection (EPA 2005a) (Table 35), indicating a low risk to marine biota from ammonia release during dredging.

Potential nutrient-enrichment effects (such as enhanced phytoplankton growth) may also occur due to release of ammonia, nitrate+nitrite and orthophosphate during dredging, but the mean concentrations of DIN (DIN = ammonia plus nitrate+nitrite) in Table 8 indicated a low risk as they represented minor loads (less than 0.04 kg/day potentially released during dredging, based on average DIN concentrations and 25% moisture content in sediments),compared to the estimated 0.7 kg DIN/day in groundwater presently discharged to the nearshore area during winter [Section 10.4.2]).

Table 35 Nutrient concentrations in elutriates of Mangles Bay sediments

Analyte	Ammonia	Nitrate+nitrite	Orthophosphate
Units	**µg.N/L**	**µg.N/L**	**µg.P/L**
NAGD screening level / EQG	**910**	**N/A**	**N/A**
S1 S S1 M S1 B	740 94 100	15 9 11	37 24 24
S2 S S2 M	200 120	10 9	73 38
S3 S S3 M S3 B	390 76 80	12 6 7	67 36 35
S4 S[1] S4 M[1] S4 B[1]	700 85 99	10 8 8	108 27 36
S5 S S5 M S5 B	670 81 55	6 5 6	42 41 38
S6 S S6 M S6 B	580 84 63	15 9 7	86 40 53
S7 S S7 M S7 B	490 34 12	10 6 7	62 30 23
S8 S[1] S8 M[1] S8 B[1]	270 63 51	12 7 6	85 39 31
S9 S S9 M S9 B	720 71 62	9 5 5	70 34 31
S10 S S10 M S10 B	1500 57 63	5 6 5	34 41 43
S11 S S11 M S11 B	340 77 53	7 4 7	96 41 30
S12 S S12 M S12 B	710 100 52	6 4 6	86 48 32
Mean	*255*	*8*	*47*
Standard deviation	*324*	*3*	*22*
95th percentile	*724*	*N/A*	*N/A*

Notes: [1] Average of data for three field replicates

Tributyltin (TBT) and total organic carbon (TOC)

Total Organic Carbon (TOC) values (0.1–0.5%) were within the range previously reported for sediments of Cockburn Sound and Warnbro Sound (DEP 1996) (Table 36).

EPA (2005a) and Commonwealth of Australia (2009) protocols require Tributyltin (TBT) data to be normalised to a 1% TOC content before comparison to guidelines. It should also be noted that the guideline for TBT differs slightly between EPA (2005a) and Commonwealth of Australia (2009), and there are no EILs or HILs for TBT. Concentrations of TBT were below laboratory reporting limits at nearly all sites and depths, and the 95% UCL concentration of TBT met the NAGD screening level (Commonwealth of Australia 2009), indicating a low risk of adverse ecological effects due to dredging or disposal. The

median TBT concentration at baseline sediment sampling sites also met the EQG, indicating a low risk of adverse ecological effects.

Although the NAGD screening level for dredged sediments was met, as a precautionary measure further testing was undertaken on the two individual samples that exceeded the NAGD Screening Level. Samples for the bottom layer of site S3 and the surface layer of site S6 were re-analysed for sediment TBT concentrations and elutriate TBT concentrations. Re-analysis of the bottom layer of site S3 found sediment TBT concentration and elutriate TBT concentrations below laboratory reporting limits (and NAGD screening levels). Re-analysis of the surface layer of site S6 confirmed the same sediment concentration of TBT, and an elutriate concentrations exceeded the EQG for high ecological protection (Commonwealth of Australia 2009, EPA 2005a). Although the dredged material will be placed in land-based infiltration ponds at the Proposal area (removed from the marine environment) and meets the TBT screening level, the results for site S6 surface sediment indicate it would be prudent for the CEMP to include monitoring of water in the infiltration ponds to confirm predictions that overall TBT concentrations will meet marine guidelines.

Table 36 TOC and TBT concentrations in Mangles Bay sediments S1-S12

Analyte	Sediment				Sediment elutriate TBT
	TBT - original analysis[1]	**TBT – re-analysis**	**TOC**	**TBT original analysis[1], normalised to 1% TOC[2]**	**TBT**
Units	**µgSn/kg**	**µgSn/kg**	**%**	**µgSn/kg**	**µgSn/L**
Laboratory limit of reporting	**0.5**	**0.5**	**0.01**	**N/A**	**0.005**
EQG	**N/A**	**N/A**	**N/A**	**5.0 (value) 72 (re-sampling trigger)**	**0.006**
NAGD screening level	**N/A**	**N/A**	**N/A**	**9.0**	**0.006**
Sites sampled for dredged sediment characterisation					
S1 S S1 M S2 B	<0.5 <0.5 <0.5	- - -	0.3 0.3 0.3	0.8 1.0 1.9	- - -
S2 S S2 M	<0.5 <0.5	- -	0.3 0.2	0.9 1.1	- -
S3 S S3 M S3 B	0.8 0.6 1.1	- - <0.50	0.3 0.2 0.2	2.5 2.7 ***6.9***	- - <0.005
S4 S[1] S4 M[1] S4 B[1#]	<0.5 <0.5 <0.5	- - -	0.5 0.2 0.2	0.5 1.3 1.3	- - -
S5 S S5 M S5 B	<0.5 <0.5 <0.5	- - -	0.2 0.2 0.1	1.0 1.3 1.3	- - -
S6 S S6 M S6 B	11 <0.5 <0.5	11 <0.5 <0.5	0.3 0.2 0.2	***34.4*** 1.3 1.3	***0.74*** **-** **-**
S7 S S7 M S7 B	<0.5 <0.5 <0.5	- - -	0.3 0.2 0.2	0.9 1.3 1.3	- - -
S8 S[1#] S8 M[1] S8 B[1]	<0.5 <0.5 <0.5	- - -	0.3 0.2 0.2	0.8 1.3 1.3	- - -
S9 S S9 M[#] S9 B	<0.5 <0.5 <0.5	- - -	0.5 0.2 0.2	0.5 1.3 1.3	- - -
S10 S S10 M S10 B	<0.5 <0.5 <0.5	- - -	0.5 0.2 0.2	0.5 1.3 1.3	- - -
S11 S S11 M S11 B	<0.5 <0.5 <0.5	- - -	0.5 0.3 0.2	0.5 0.7 1.3	- - -
S12 S S12 M S12 B	<0.5 <0.5 <0.5	- - -	0.4 0.4 0.2	0.6 0.7 1.3	 - -
Mean	*NA*	*NA*	*NA*	*2.3*	*NA*
Standard deviation	*NA*	*NA*	*NA*	*5.7*	*NA*
95% UCL of mean	*NA*	*NA*	*NA*	*4.2*	*NA*

Notes: [1] Average of data for three field replicates
[#] Average of data for two laboratory duplicates
[2] If TOC was <0.2%, TBT data were multiplied by five, as per Commonwealth of Australia (2009)
Exceedance of guidelines by individual samples highlighted in italicised bold text

Table 37 TOC and TBT concentrations in Mangles Bay sediments S13-S16

Analyte	Sediment				Sediment elutriate TBT
	TBT - original analysis[1]	**TBT – re-analysis**	**TOC**	**TBT original analysis[1], normalised to 1% TOC[2]**	**TBT**
Units	**µgSn/kg**	**µgSn/kg**	**%**	**µgSn/kg**	**µgSn/L**
Laboratory limit of reporting	**0.5**	**0.5**	**0.01**	**n/a**	**0.005**
EQG	**NA**	**NA**	**NA**	**5.0 (value) 72 (re-sampling trigger)**	**0.006**
NAGD screening level	**NA**	**NA**	**NA**	**9.0**	**0.006**
Sites sampled for baseline sediment quality (surface sediments only)					
S13	<0.5	-	0.4	0.6	-
S14	<0.5	-	0.4	0.7	-
S15	1.1	-	0.3	3.5	-
S16	<0.5	-	0.3	0.9	-
Median	*NA*	*NA*	*NA*	*0.8*	*NA*

Notes: [1] Average of data for three field replicates
[2] If TOC was <0.2%, TBT data were multiplied by five, as per Commonwealth of Australia (2009)
Exceedance of guidelines by individual samples highlighted in italicised bold text

Organics

Concentrations of total polycyclic aromatic hydrocarbons (PAHs) and each constituent PAH within sediments were all below the limits of reporting at all sites and depths (LOR 5 µg/kg and 100 µg/kg for individual PAH and total PAHs, respectively). Results are provided in Appendix 5.

Acid sulfate soils

The dredged sediments are to be disposed of on land, so testing for acid sulfate soil (ASS) potential was also undertaken (Table 38) (note: ASS is not a concern when sediments are disposed at sea).

At all sites and across all depths, values for sediment pHKCl (pH of potassium chloride suspension) were greater than 9, indicating none of the samples were acidic. This conclusion was supported by the Titratable Actual Acidity, which was zero at every site and depth. Just under half of the sediment layers analysed (16 of 35) had chromium reducible sulfur (%S_{CR}) values in excess of the Action Criteria value for soils (0.03%), and were therefore considered to be potential acid sulfate soils (PASS). However the net acidity data indicated that the potential acidity within the PASS samples would be buffered by alkaline components within the samples, as they had sufficient neutralising capacity to result in negative net acidity. Results therefore indicated that any acid produced following land disposal of sediments excavated to create the marina access channel would be effectively neutralised by the *in situ* buffering capacity of the sediments.

Table 38 ASS and acid base accounting (ABA) data for Mangles Bay sediments

Site	pHKCl	Potential Sulfidic Acidity			Acid Neutralising Capacity			Net Acidity
		%S (S_{CR})	**Equivalent Acidity (mol H+/tonne)**	**Existing Acidity**	**ANCBT (%CaCO3)**	**ANC (mol H+/tonne)**	**Fitness Factor**	**Net Acidity (mol H+/tonne)**
S1 S#	9.8	0.01	8.11	None	n/m	n/m	2	n/m
S1 M	9.8	0.03	17.46	None	n/m	n/m	2	n/m
S1 B	9.8	0.03	15.59	None	n/m	n/m	2	n/m
S2 S	9.8	**0.05**	28.69	None	86	17182.8	2	-8562.71
S2 M	9.8	**0.05**	31.81	None	84	16783.2	2	-8359.79
S3 S	9.8	**0.05**	28.07	None	85	16983	2	-8463.43
S3 M	9.8	**0.05**	32.43	None	86	17182.8	2	-8558.97
S3 B#	9.8	**0.05**	31.18	None	86	17282.7	2	-8610.16
S4 S	9.7	**0.04**	22.45	None	83	16583.4	2	-8269.25
S4 M	9.8	**0.04**	22.45	None	82	16383.6	2	-8169.35
S4 B	9.8	**0.05**	33.68	None	84	16783.2	2	-8357.92
S5 S	9.8	**0.04**	21.83	None	85	16983	2	-8469.67
S5 M	9.9	**0.04**	24.95	None	87	17382.6	2	-8666.35
S5 B	9.8	**0.04**	27.44	None	88	17582.4	2	-8763.76
S6 S	9.8	0.02	13.72	None	n/m	n/m	2	n/m
S6 M	9.9	0.02	11.85	None	n/m	n/m	2	n/m
S6 B	9.8	0.03	21.21	None	n/m	n/m	2	n/m
S7S#	9.8	0.02	10.30	None	n/m	n/m	2	n/m
S7 M	9.9	**0.04**	23.08	None	85	16983	2	-8468.42
S7 B	9.8	**0.05**	28.69	None	85	16983	2	-8462.81
S8 S	9.8	0.02	14.97	None	n/m	n/m	2	n/m
S8 M	9.9	0.03	18.71	None	n/m	n/m	2	n/m
S8 B	9.8	**0.05**	28.69	None	76	15184.8	2	-7563.71
S9 S	9.7	0.03	20.58	None	n/m	n/m	2	n/m
S9 M	9.8	0.03	20.58	None	n/m	n/m	2	n/m
S9 B	9.9	**0.05**	28.07	None	70	13986	2	-6964.93
S10 S	9.7	0.02	14.97	None	n/m	n/m	2	n/m
S10 M#	9.8	0.02	15.90	None	n/m	n/m	2	n/m
S10 B	9.8	0.04	27.44	None	69	13786.2	2	-6865.66
S11 S	9.8	0.02	12.47	None	n/m	n/m	2	n/m
S11 M	9.8	0.03	17.46	None	n/m	n/m	2	n/m
S11 B	9.9	0.02	11.23	None	n/m	n/m	2	n/m
S12 S	9.7	0.03	16.84	None	n/m	n/m	2	n/m
S12 M	9.8	0.03	16.22	None	n/m	n/m	2	n/m
S12 B	9.9	**0.04**	23.08	None	81	16183.8	2	-8068.82

Notes: # Average of data for two laboratory duplicates
$\%S_{CR}$ values in bold font exceed the Action Criteria value for soils (0.03%)
n/m = not measured

10.3 Evaluation of options or alternatives to avoid or minimise impact

10.3.1 Marina design and construction management

The Proposal has been designed to maximise the natural flushing of inner marina waters by wind and tide. Marina bathymetry does not have holes or sills, water depth increases towards the entrance. The marina configuration is simple, and the arms are largely oriented to take advantage of prevailing wind directions. This will reduce the extent of nutrient enrichment and anoxia within the marina, and the likelihood of poor quality waters entering Mangles Bay. Contaminant inputs to marina waters will be minimised using best practice measures for facility design and management (such as minimising stormwater contaminant inputs, implementing relevant water sensitive urban design, and state planning requirements), and strict regulations regarding general boating related activities. The proposed development will be internally draining with all stormwater being infiltrated onsite and high flood flows being designed to flow into the marina. The Proposal will be sewered (so there is no faecal contamination of groundwater beneath residences), and will also have sullage disposal facilities so vessels using the marina do not cause faecal contamination of marina waters.

The Lake Richmond stormwater drain (the major contributor of stormwater nutrients and contaminants to Mangles Bay) presently traverses the Proposal area, and is planned to be relocated as part of the development, to better flushed waters further east along the shoreline (Section 7).

A CEMP will be prepared to specify the proposed breakwater and other construction methods and proposed management measures. The CEMP will include monitoring of turbidity in the water of Mangles Bay and contaminant levels in the waters of the settling basins.

10.3.2 Dredging program

The proposed dredging program for the marina has been designed to avoid or minimise impact on water quality as follows:

- the short duration of the dredging program (three months) will reduce the period of elevated turbidity levels. Turbidity associated with dredging is also predicted to be minimal (Section 10.4.1) due to the low proportion of fine particles in the material to be dredged, and the relatively clean dredging method (a small cutter suction dredge)
- silt curtains will be used (weather and sea conditions permitting) during the dredging process, to further control turbidity release and dispersion, minimising potential impacts on water quality
- dredged sediment will be pumped to onshore infiltration basins via a floating pipeline, and water from the settling basins will be managed via infiltration, with some overflow discharged into Mangles Bay. The water quality and velocity levels at the overflow will be managed such that they do not impact on the marine environment (see Appendix 1)
- maintenance dredging is proposed to take place should trigger values indicate it is required. Appendix 1 further details maintenance dredging requirements.

10.4 Assessment of likely direct and indirect impacts

The Proposal will result in temporary impacts on marine water quality during construction, and ongoing impacts on marine water quality due to outflow of water from the marina. The following aspects of the Proposal may affect marine water quality and sediment quality values:

1. Construction of the marina will cause localised, temporary increases in turbidity:
    - dredging of the seabed during construction of the access channel into the Proposal area may temporarily affect water quality due to increased turbidity, nutrients and contaminants in dredged sediments (including the potential for ASS when the dredged material is temporarily stored in the Proposal area)

- seepage or discharge of return water from bunded areas used for temporary storage of dredged sediments, which may temporarily impact water quality through increased turbidity, nutrients and contaminants in dredged sediments
- placement of limestone for breakwaters, as well as leaching of fines from the limestone may cause temporary increases in turbidity both during and after the limestone is placed.

2. Operational impacts of the marina include:
   - outflow of lower quality water from within the Proposal area could result in reduced water quality and sediment quality in Mangles Bay and adjacent waters. Marinas are, by necessity, calm, sheltered environments therefore the waters of the proposed development will be less well flushed than the adjacent waters of Mangles Bay, thus may be of lower quality. There will also be effects on water quality in the Proposal area due to the concentration of boats in the area, plus any stormwater runoff from the development (both potential sources of a source of nutrients, contaminants and bacteria)
   - accidental spills of fuel or sullage within the Proposal area from sullage disposal facilities or refuelling facilities could cause temporary effects on water quality within the Proposal area, Mangles Bay, and adjacent waters of Cockburn Sound and the SIMP
   - increased boat numbers will increase the potential for diffuse pollution in the area, such as the slow leaching of antifoulants from boat hulls, and low level hydrocarbon emissions from boat engines.

It is not anticipated that the construction of the marina will cause any significant changes in water quality through changes in the overall water circulation patterns of Cockburn Sound, due to the small size of the marina breakwaters and their location in very shallow flats at the south eastern extreme of Cockburn Sound.

10.4.1 Impacts of turbidity and other contaminants

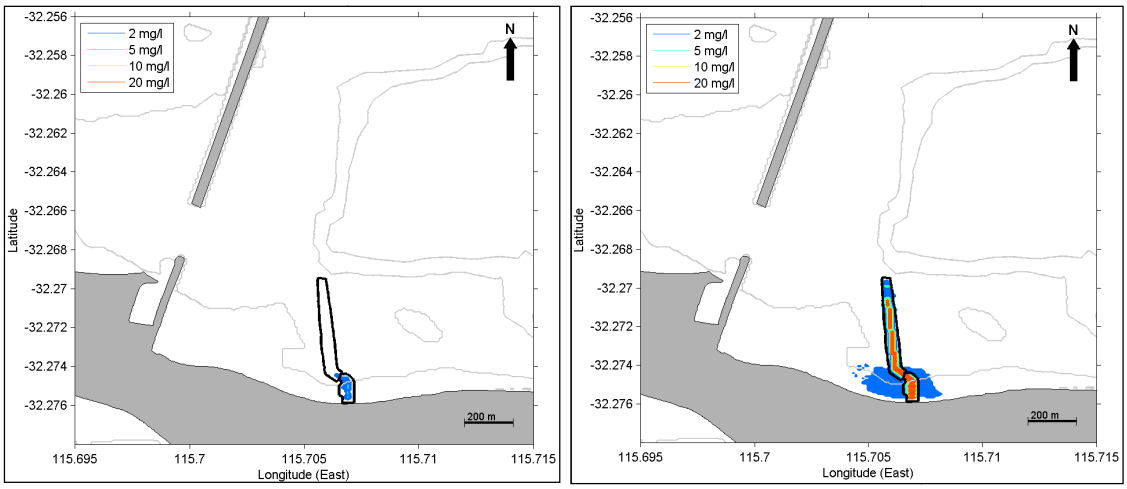
Turbidity

The results of turbidity modelling were interpreted using spatially-defined zones in accordance with Environmental Assessment Guideline No. 7 *Environmental Assessment Guideline for Marine Dredging Proposals* (EAG 7; EPA 2011):

- Zone of High Impact (ZoHI) - the area where impacts on seagrass meadows and associated benthic organisms were predicted to be irreversible (defined as lacking a capacity to return or recover to a pre-dredging state within a timeframe of five years or less)
- Zone of Moderate Impact (ZoMI) - the area where predicted impacts on seagrass and benthic organisms were expected to be sub-lethal, and/or the impacts were recoverable within a period of five years following completion of the dredging activities
- Zone of Influence (ZoI) - the area where changes in environmental quality associated with dredge plumes were predicted, but these changes were not expected to result in a detectible impact on benthic biota. The ZoI represents the predicted maximum extent of the dredge plumes, and beyond it there should be no dredge-generated plumes discernible from background conditions at any stage during the dredging campaign. EAG 7 (EPA 2011) notes that the ZoI can be large, but at any point in time the dredge plumes are likely to be restricted to a relatively small portion of the ZoI.

Predicted dredge-generated elevations in TSS were initially examined using values of 2, 5, 10 and 20 mg/L (Appendix 5), with 10 mg/L (the EQG for aquaculture under the Cockburn Sound SEP) conservatively representing a value protective of sensitive marine fauna, and 2 mg/L representing the approximate visible plume threshold. The 95th and 99th percentile contours for these values are shown Figure 68: TSS for the nominated values would be exceeded outside of 99th percentile contour for 1% of the time (a total of about six hours over the entire dredging program), and outside the 95th percentile for a total of up to three days over the entire dredging program. As seen in Figure 68 , the 5 and 10 mg/L threshold would be exceeded over an extremely restricted region within the access channel footprint. This

is attributed to the relatively coarse nature of the sediment to be dredged, the very small-scale of the dredging (less than 50 000 m^3) and the relatively clean dredging method used (cutter suction dredge) (Appendix 5).



Note: From APASA (2011). The TSS plume will not cover the entire area shown at any one moment in time, but represents the total 'footprint' for the entire dredging program. TSS concentrations represent values above background TSS concentrations. The black line denotes the access channel footprint.

Figure 68 Potential extent of the dredging plume, based on the 95th percentile (left image) and 99th percentile (right image) of total suspended solids (TSS) concentrations

Zones according to EAG 7 (EPA 2011) are shown in Figure 69, and were conservatively derived as follows:

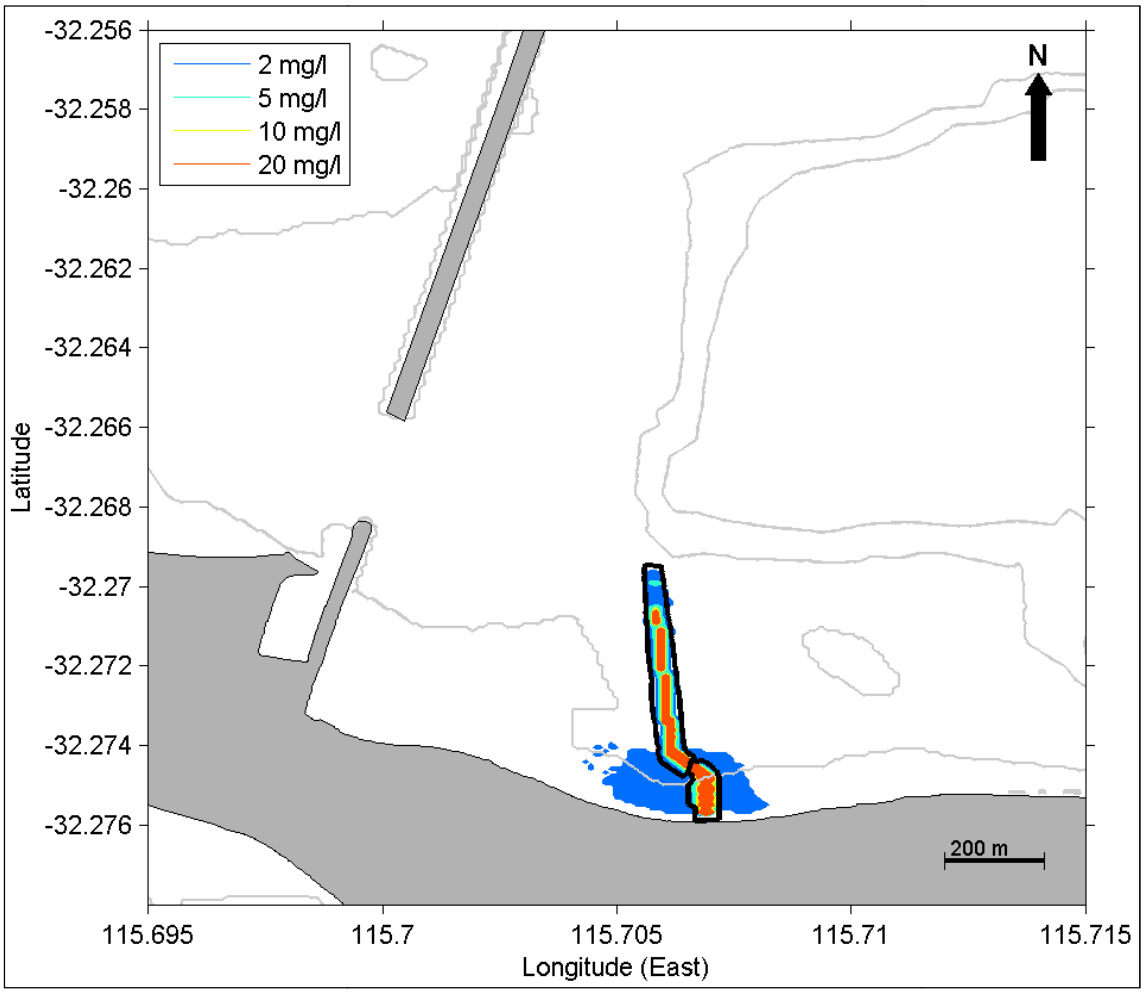
- Zone of High Impact (ZoHI) - comprising the development footprint (direct losses due to the access channel and batters, breakwaters and beach breakwaters, reclamation areas, and indirect loss due to a 15 m halo effect around the breakwaters
- Zone of Moderate Impact (ZoMI) – modelling results indicated the 99th percentile contour for a TSS concentration of 5 mg/L would be within the access channel footprint (Figure 69), indicating little risk of sublethal affects on benthic organisms outside the ZoHI, and implying an outer boundary of the ZoMI that coincides with the outer boundary of the ZoHI. Rather than having a boundary marking a change from 'irreversible loss of benthic biota' to 'no detectable impacts on benthic biota', an outer boundary for the ZoMI was notionally defined as extending 10 m beyond the ZoHI
- Zone of Influence (ZoI) - the outer boundary of the ZoI was defined using the 100th percentile of the area where a TSS threshold of 2 mg/L was exceeded at, representing the maximum extent of the visible plume. It should be noted that the zone does not represent the area within which a visible plume may be seen at any one moment in time, rather it represents the summation of conditions over the entire dredging program. The region where a visible plume is expected will generally be restricted to within the vicinity of the dredging channel, although a weakly concentrated plume may be visible up to 100-200 m away at times (refer Figure 69 and Appendix 5).

Note: The TSS plume will not cover the entire area shown at any one moment in time, but represents the total 'footprint' for the entire dredging program. The visible plume within the Zone of Influence at any one time will be much smaller.

Figure 69 Predicted zones of turbidity-related effects on the marine environment during dredging

Modelling results for turbidity

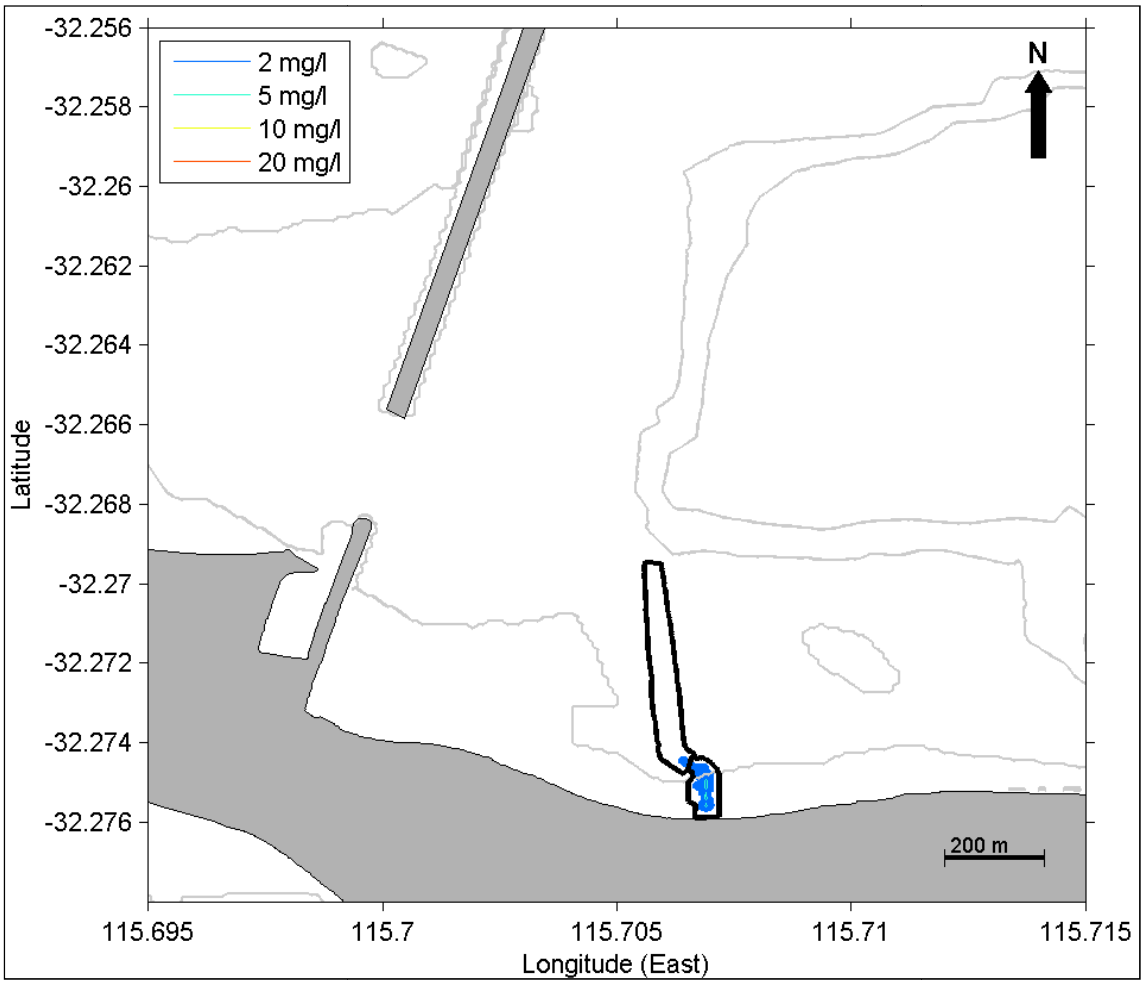
The predicted extent of the visible plume over the entire dredging period is presented by the 99th percentile TSS in Figure 70. The 99th percentile has been used to indicate the potential extent of the visible plume based on the EPA's Draft Environmental Assessment Guidelines for Marine Dredging Proposals (EPA 2010a). The 99th percentile shows the turbidity footprint where the dredge-generated TSS threshold of 2 mg/L is exceeded up to 99% of the time. Predicted TSS concentrations outside the footprint would only exceed the visible threshold for a total of about six hours over the entire dredging campaign. It should be noted that the 99th percentile plot does not show where the visible plume may be seen at one moment in time, rather it represents the summation of conditions over the entire dredging program. The region where a visible plume is expected to occur will generally be restricted to within the vicinity of the dredging channel, although a weakly concentrated plume may be visible up to 100-200 m away at times Appendix 5).



Note: From APASA (2011). The TSS plume will not cover the entire area shown at any one moment in time, but represents the total 'footprint' for the entire dredging program. TSS concentrations represent values above background TSS concentrations.

Figure 70 Potential extent of the visible plume, based on the 99th percentile of total suspended solids (TSS) concentrations

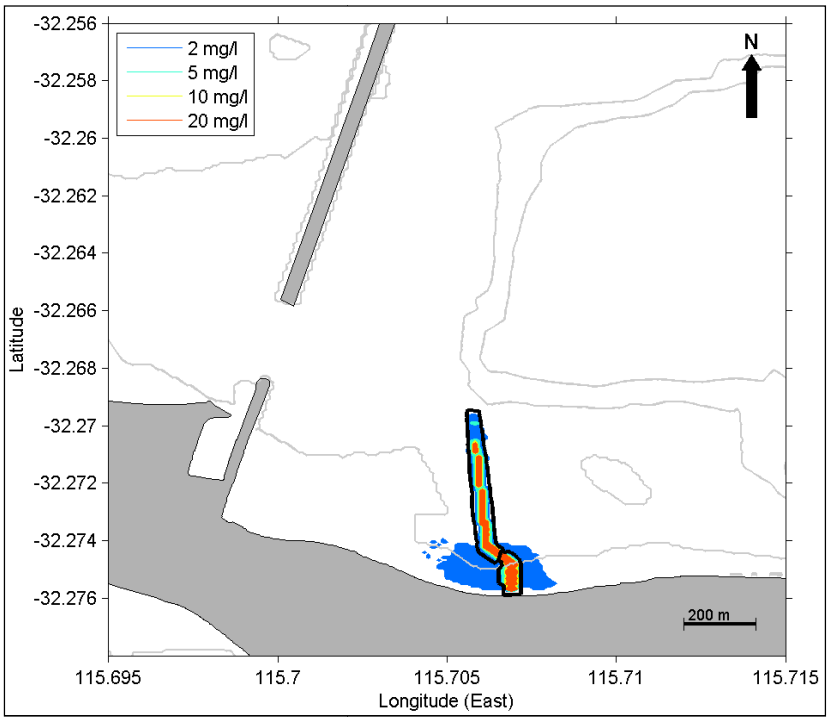
The predicted dredge-generated elevations in TSS were assessed against nominal threshold values of 5, 10 and 20 mg/L for the 50th , 80th and 95th percentiles throughout the dredging operation (Appendix 5), with 10 mg/L (the EQG for aquaculture under the Cockburn Sound SEP) conservatively representing a value protective of sensitive marine fauna. The 2 mg/L contour was included in the threshold analysis, as representing the approximate visible plume threshold. The 95th percentile plot is shown in Figure 68 and Figure 71. TSS for the nominated thresholds would be exceeded outside of the relevant footprints for 5% of the time (a total of up to three days over the entire dredging duration). As seen in Figure 71, the 5 and 10 mg/L threshold would be exceeded over an extremely restricted region. This is attributed to the relatively coarse nature of the sediment to be dredged, the very small-scale of the dredging (less than 50 000 m^3) and the relatively clean dredging method used (cutter suction dredge) (Appendix 5).

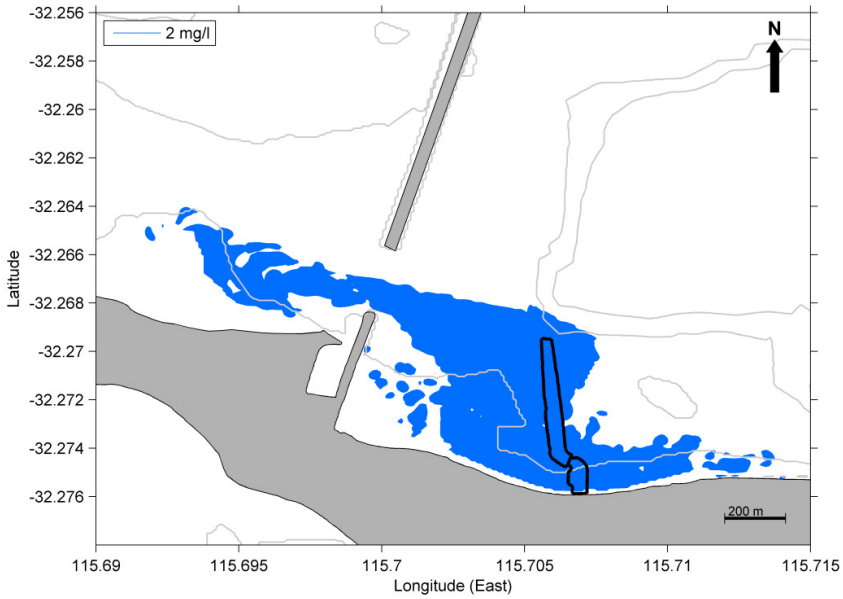


Note: Source: APASA (2011). The TSS plume will not cover the entire area shown at any one moment in time, but represents the total 'footprint' for the entire dredging program. TSS concentrations represent values above background TSS concentrations.

Figure 71 Potential extent of the visible plume, based on the 95th percentile of TSS

Figure 72 shows a comparison between the 99th and 100th percentile TSS thresholds. Relevant to note is that the 100th percentile image has been included to show the worst case extent of TSS during dredging. It is important to note that the 100th percentile scenario would occur for a maximum of 6 hours throughout the entire construction dredging program.





Note: Source: APASA (2011). The TSS plume will not cover the entire area shown at any one moment in time, but represents the total 'footprint' for the entire dredging program. TSS concentrations represent values above background TSS concentrations.

Figure 72 Potential extent of the visible plume, a comparison between the 99th and 100th percentile of TSS

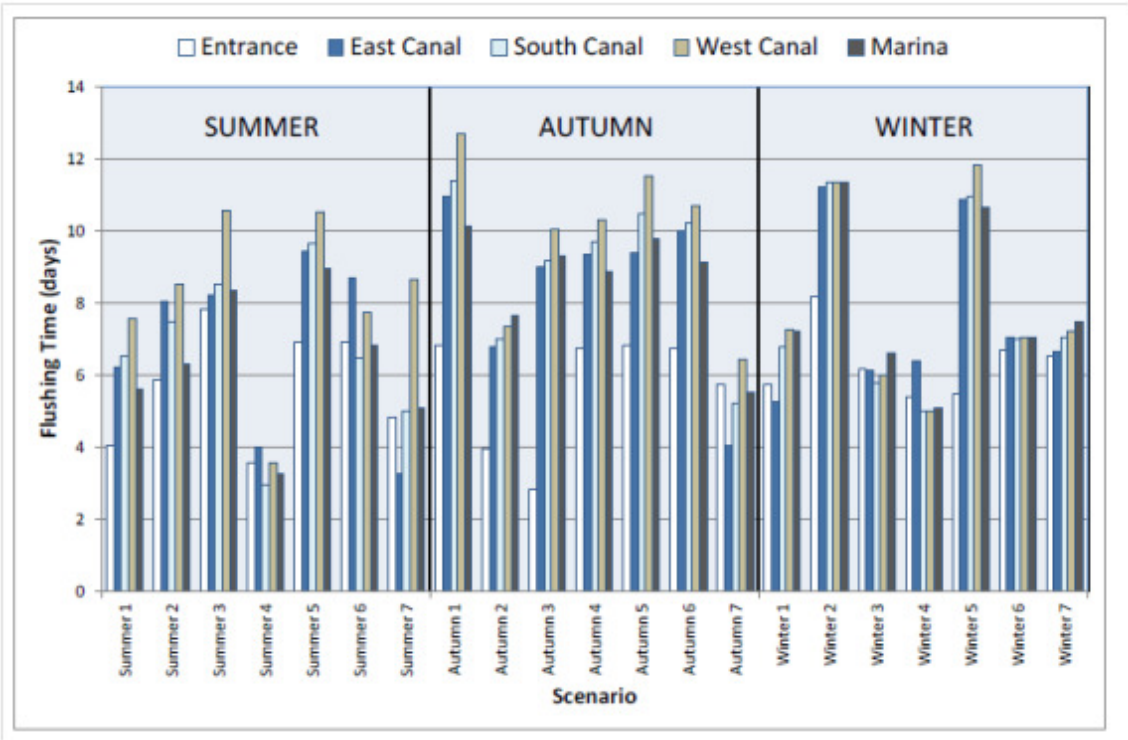
Contaminant release

The potential for contaminant release during dredging and disposal is considered very low, as contaminant concentrations in the sediments met NAGD screening levels (Commonwealth of Australia 2009), EILs and relevant HILs (refer Section 10.2.3).

10.4.2 Flushing related impacts

Flushing times

Flushing times for all the simulations and all of the sites are shown in Figure 73. The median flushing time for all sites and all simulations was predicted to be 6.8 days, with a maximum for the modelled scenarios of 12.7 days. 83% of the flushing time predictions were 10 days or less, and 55% were 7 days or less. Flushing typically proceeded from near the entrance towards the areas furthest away from the entrance, with the longest flushing times predicted to occur at the West Canal (Site 8, refer Figure 63), which is the most remote location from the marina entrance (furthest point of this canal is approximately 820 m from the entrance). Simulations for the autumn period also produced a higher proportion of flushing times exceeding 10 days. The concentration of the bottom waters generally also reached the e-folding level slightly before the surface waters were considered flushed (Appendix 5).



Note: Source: APASA (2011)

Figure 73 Summary of predicted flushing times (e-folding times) at the five analysis sites across all scenarios modelled.

The predictions of flushing rates were carried out for a large number of combinations of winds, tides and atmospheric conditions. Calm conditions were not always associated with poor flushing, as wind is only one of the important mechanisms for exchange of water, with the others being the tides/water levels and density gradient driven flows. A weak wind event can therefore yield different results depending on whether it coincides with spring or neap tides, a previously well mixed or stratified water body, or stable versus highly fluctuating air temperatures. Weak wind speeds may also lead to better flushing than strong winds if the wind direction retards two layer flows.

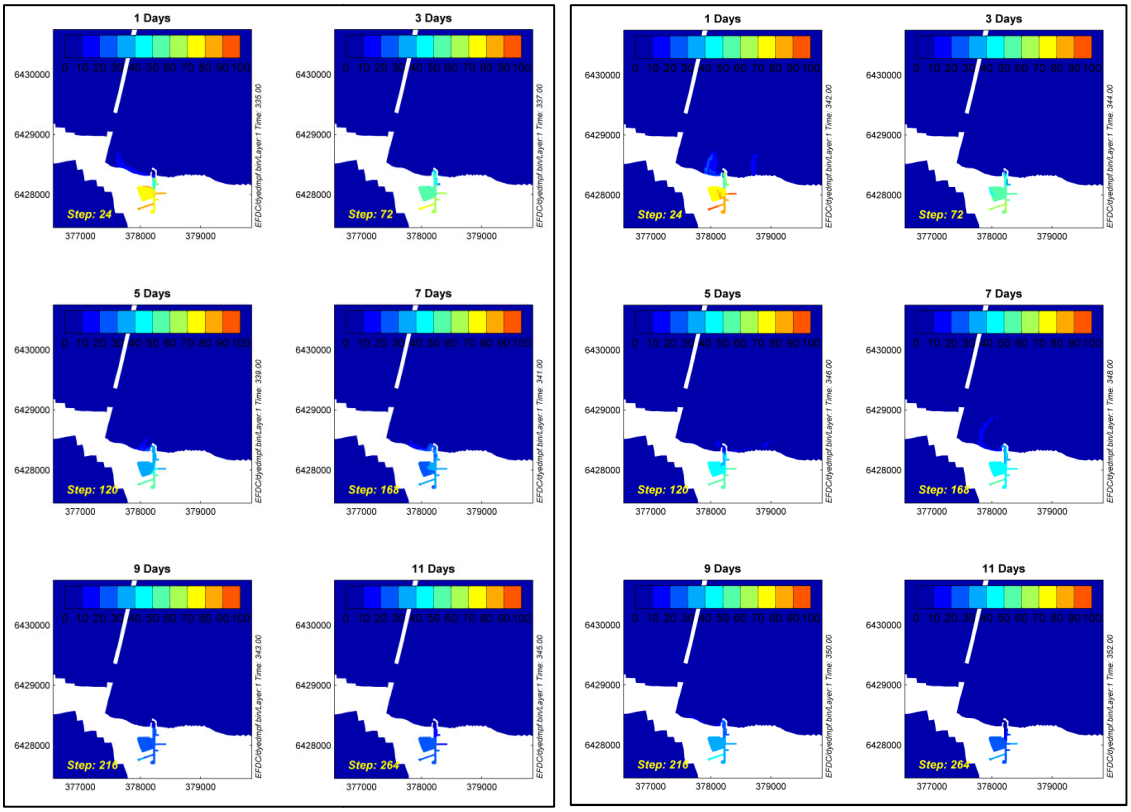
In terms of the wind speed, the worst case for flushing in the modelled scenarios was when the 12 day average wind speed was 4.16 m/s (from early to mid-June, 2003). Reviewing the available Garden Island data set from November 2001 through to March of 2011, this event represented the 1.28th percentile of the record. This means that only 1.28% of recorded 12 day periods had average wind speeds weaker than this modelled scenario. The weakest (0th percentile) from this record was a 12 day average of 3.68 m/s,

occurring during late April and early May of 2003. Wind speeds for around 99% of the time are therefore expected to be greater than the modelled scenario that yielded the longest flushing time, and so the model results (Figure 73) are considered representative of all but rare events.

It should be further noted that the marina varies in depth from 2.7 to 4.0 m AHD, but three of the five points used in estimating residence times and nutrient tracer modelling were in shallow waters at the end of canals. As a result, 60% of the modelled flushing times (Figure 73) are based on the most poorly flushed parts of the marina that represent less than 25% of the volume of marina waters. The assessment of water quality is therefore considered conservative.

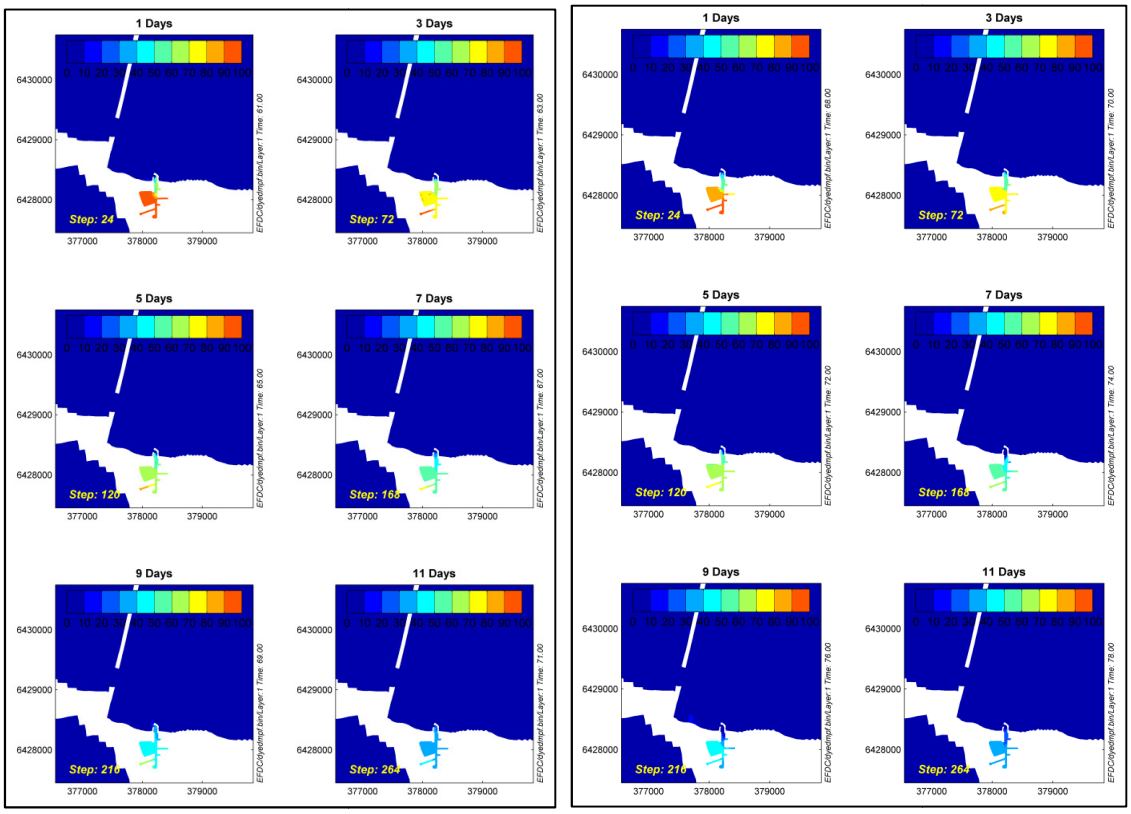
Effects on water quality in Mangles Bay

Effects on water quality in Mangles Bay were minor, and - when discernible - were largely confined to shallow nearshore waters west of the access channel (Figure 74 to Figure 76, see also nutrient tracer modelling results below).



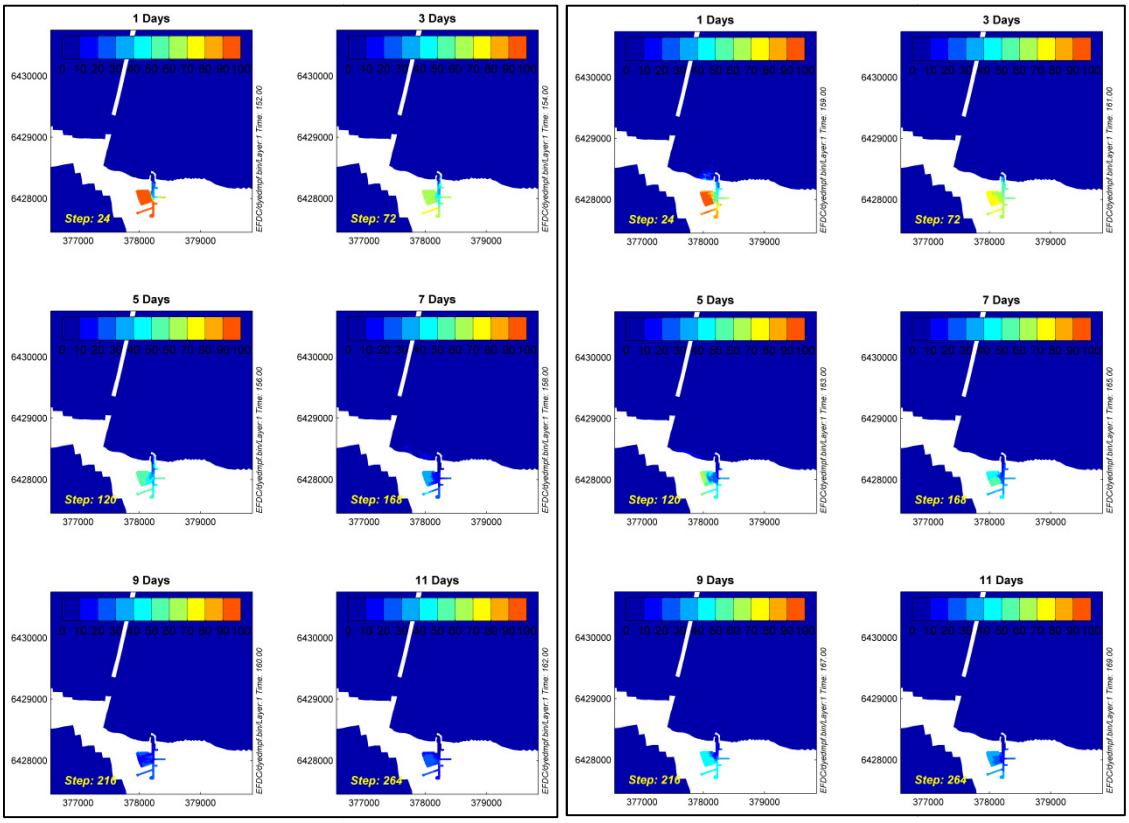
Note: Source: APASA

Figure 74 Illustrative snapshots of dye concentrations entering Mangles Bay for modelling scenario 1 (left) and scenario 5 (right) in summer



Note: Source: APASA

Figure 75 Illustrative snapshots of dye concentrations entering Mangles Bay for modelling scenario 1 (left) and scenario 5 (right) in autumn



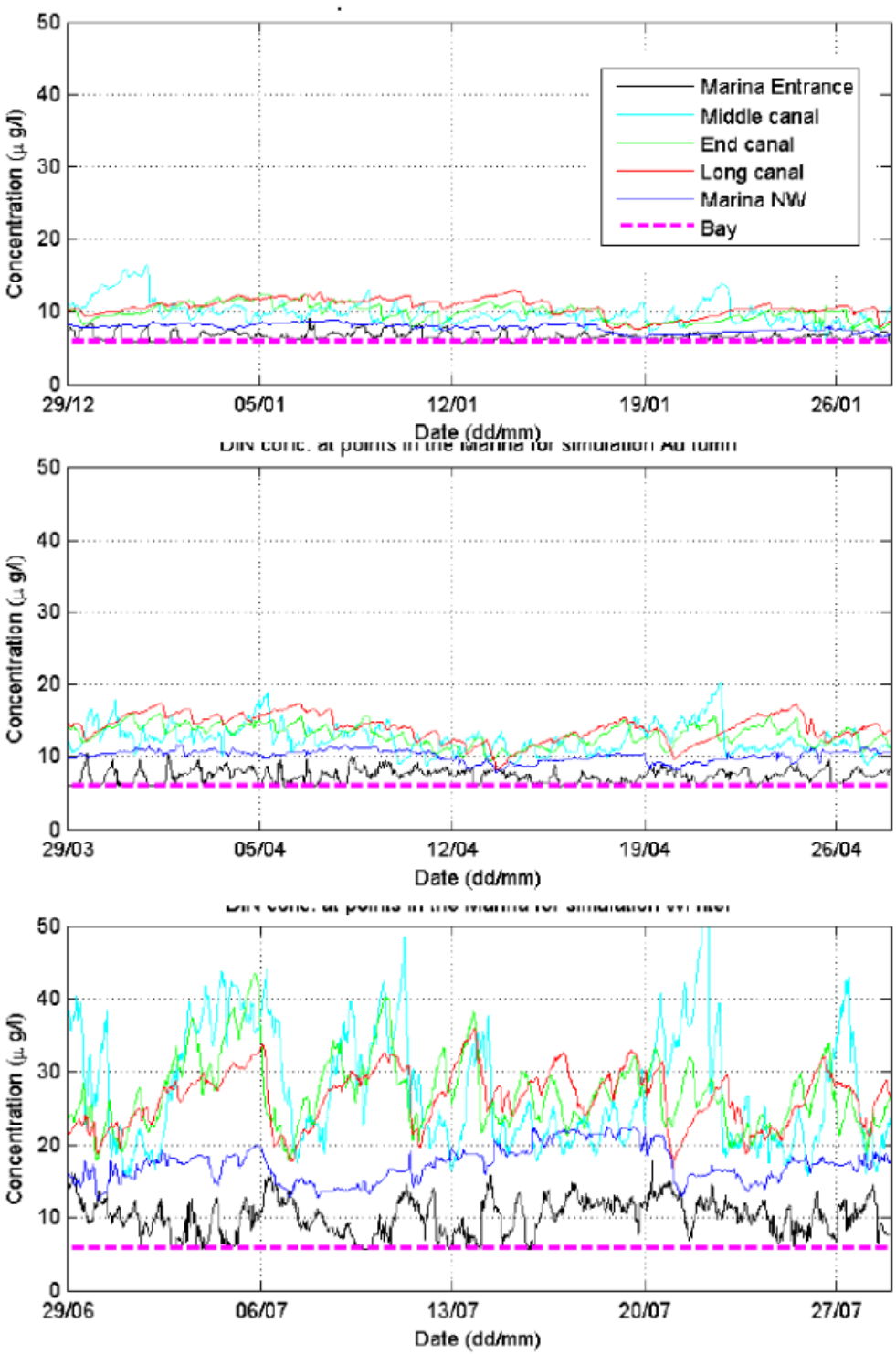
Note: Source: APASA

Figure 76 Illustrative snapshots of dye concentrations entering Mangles Bay for modelling scenario 1 (left) and scenario 5 (right) in winter

Nutrient tracer modelling

Time-series of DIN concentrations at the five output points of the marina (points 5 to 9 on Figure 63) are shown for each of the modelled scenarios over the 30-day analysis period in . There is an overall seasonal variation in the predicted DIN concentrations within the marina, with smaller variations occurring within each season due to the variable flushing rate. As expected, there was a general increase in the predicted DIN concentration at points further away from the entrance, and little discernible effect on water quality at the marine entrance. Importantly, the results also indicated that the flushing should be sufficiently effective to prevent the gradual build-up of the concentrations of nutrients or other contaminants over time. This suggests that the risk of adverse escalations (of nutrients or contaminants) in the marina is relatively low, based on the assumptions made and the input data provided for the modelling. The modelled results do not include inputs due to stormwater discharge, but as discussed in Section 10.5.4, due to stormwater management measures no stormwater runoff is expected under 99% of rainfall events. During large rainfall events it is proposed to discharge stormwater into Mangles Bay through the marina (when it is likely to rapidly exit the marina as a surface freshwater flow), and/or into the realigned Lake Richmond Drain.

During autumn and summer, predicted DIN concentrations in the marina were generally less than twice the background concentration in Mangles Bay. DIN concentrations within the marina were highest in winter (when groundwater DIN loading is highest), with concentrations generally up to four times background concentrations. However the high winter concentrations also coincide with low growth rates for phytoplankton (due to lower temperatures and light availability: Section 10.2.2).



Note: Source: APASA (2011). The background concentration (6 µg/L) is shown by the pink dotted line.

Figure 77 Predicted DIN concentrations at sites within the marina (30 day analysis period) for each season (summer, autumn and winter, arranged vertically from the top)

Increased chlorophyll-a concentrations in marina waters

Predicted increases in chlorophyll-a concentrations from equilibrium (box) modelling are shown in along with a summary of effects on water quality predicted by modelling. Chlorophyll-a concentrations in the marina are predicted to be about twice those of the adjacent waters of Mangles Bay. Data are presented in full in Appendix 5. The relatively modest increase in chlorophyll-a concentrations (e.g. compared to those in water bodies such as the Jervoise Bay Northern Harbour) is attributed to a combination of marina design, the relatively small size and simple configuration of the marina (compared with other marinas in WA), and the small scale of groundwater nutrient inputs.

Table 39 Summary of modelling results for impacts on water quality

Factor	Summer	Autumn	Winter
Average flushing time of marina.	6–8 days	6–8 days	6–8 days
Background chlorophyll-a concentrations Mangles Bay	1.3–2.1 µg/L	1.3–2.1 µg/L	0.6–1.0 µg/L
Estimated average chlorophyll-a concentrations in marina, based on equilibrium (box) modelling.	2.1–3.5 µg/L	2.3–3.7 µg/L	1.5–2.4 µg/L
Contaminant build-up in marina waters.	Not expected. Flushing sufficient to prevent any gradual build-up of the concentrations of dissolved nutrients or other dissolved contaminants over time, and stormwater management measures (refer Section 10.5.4) should ensure little or no inputs of nutrients and contaminants in particulate form.		
Effects on water quality in Mangles Bay.	Marina outflow confined to Mangles Bay. Impacts on water quality due to outflow from marina entrance are occasional, slight (e.g. increases in chlorophyll-a concentrations of 0.1–0.3 µg/L**) and highly localized, extending several 100 metres along shallow nearshore waters towards the Causeway (refer Figure 74 to Figure 76). No significant impact on overall water quality in Mangles Bay.		
Regional effects on water quality in Cockburn Sound.	No significant adverse effect.		
Regional effects on water quality in SIMP.	No significant adverse effect.		

Note: *Using a DIN to chlorophyll conversion ratio of 0.117 in summer and autumn, and 0.0585 in winter.
**Estimated using the predicted chlorophyll-a concentrations in the marina, and the relative impacts on water quality in Mangles Bay shown in Figure 74 to Figure 76.

Consideration of other factors

In addition to flushing times, other important factors determining marina/canal water quality in Western Australia have been found to include:

- trapping of seagrass wrack (e.g. Jurien Boat Harbour and Port Geographe Marina)
- trapping of wind-blown algae and debris (e.g. South Yunderup Canals)
- capture of contaminated groundwater discharge (e.g. Jervoise Bay Northern Harbour, and Hillarys Marina)
- acid sulphate soils (e.g. canals in Mandurah region)
- siltation of entrances
- poor ambient water quality in the environment they were built (e.g. canals on Murray River)
- long-term build up of organic matter (most inland canals).

The Proposal does not involve any of these issues, so the above modelling predictions that are based on flushing times are considered a fair representation of likely water quality.

10.4.3 Impacts due to increased numbers of boats

The Proposal will result in an increased number of boats traversing Mangles Bay and adjacent waters; however this is inevitable with or without the Proposal due to population growth and increased levels of boat ownership in the region (refer Section 16). Water quality impacts due to sediment re-suspension by boating activity will be minimised by provision of well signed access channels with appropriately sign-posted speed limits. The Proposal will also mitigate increased boat traffic impacts as it will help manage the presently uncontrolled movement of boats in Mangles Bay.

The release of hydrocarbons and heavy metals from engine emissions will increase in proportion to boating traffic, but this is expected to be mitigated by management of the presently uncontrolled refuelling activities and sullage disposal in Mangles Bay (via provision of refuelling facilities and sullage pump-out facilities in the marina).

10.5 Potential for and nature of any cumulative impacts

10.5.1 Impacts of turbidity

There will be no cumulative impacts on the marine environment as a result of dredging, as all sediment will be treated and disposed offsite or used onsite for construction where appropriate. Turbidity during breakwater construction and dredging is expected to cause minor, highly localised, and short-term impacts on water quality (and therefore seagrasses) in Mangles Bay. Turbidity generated during construction is not expected to cause any long-term impacts on seagrasses (see also Section 12)

10.5.2 Flushing related impacts

The modelling undertaken for the Proposal indicates chlorophyll levels in the marina will be about twice that of Mangles Bay, but there will be little effect on water quality in Mangles Bay and adjacent waters in Cockburn Sound and the SIMP due to the effects of dilution once the marina waters disperse into Mangles Bay. Modelling further predicts that flushing should be sufficient to prevent any gradual build-up of the concentrations of nutrients or other contaminants over time. Also, with the Proposal, a proportion of groundwater nutrients that presently fuel epiphyte growth on the extensive seagrass meadows of Mangles Bay will instead be taken up by phytoplankton growth in marina waters. Therefore, any slight, localised changes in water quality in Mangles Bay due to outflow of marina waters may be offset by reduced epiphyte growth on seagrass. The seagrasses most likely to be affected by any slight, localised changes in water quality in Mangles Bay are also in extremely shallow waters close to the shore, and therefore much less vulnerable to changes in water quality than seagrass at their depth limit.

The main mechanism for poorer-than-expected water quality will be due to sediment nutrient fluxes being higher than expected. In this case, removal of surficial sediments would be the main management measure, and would comprise part of the operational management plan (Section 10.6.2).

10.5.3 Impacts due to increased numbers of boats

The Proposal is not expected to cause significant cumulative impacts on contaminant-related water quality in Mangles Bay and adjacent waters. Although boat numbers in the area will increase these will be located in the marina, and any contaminants will tend to accumulate in marina sediments rather than Mangles Bay or adjacent waters. The potential for contamination of marina sediments can be gauged by the Swan River Trust's sediment quality data for nine yacht clubs/marinas in the Swan River (Oceanica 2007b; see also *http://www.swanrivertrust.wa.gov.au/science/river/Documents/Sediment%20Mussel%20Report.pdf*), which are arguably more sheltered and less well flushed with marine waters than the proposed Mangles Bay marina. These data indicate that although some elevation of copper and zinc concentrations can be expected in sediments within the marina, concentrations of metals (arsenic, arsenic, cadmium, chromium, copper, mercury, nickel, lead and zinc) should meet relevant EQGs. Swan River data for tributyltin (Oceanica 2007b) do, however, indicate consistent exceedance of the EQG, but it was not clear whether

this was due to historic or recent contamination. As the proposed Mangles Bay marina will start with uncontaminated sediments (i.e. no legacy of historical contamination) and boats moored there should not be using tributyltin as an antifoulant, the potential for contamination is considered low: this is supported by the Mangles Bay sediment data in Table 36 and Table 37. The potential for contamination of sediments with polycyclic aromatic hydrocarbons is also considered low as EQGs are rarely exceeded in local coastal and estuarine waters, even in sheltered estuarine waters adjacent to major urban drains (DoW 2009).

The Proposal also provides opportunities for water quality benefits via the relocation of boats presently moored in Mangles Bay, the conversion to sewerage of properties presently still on septic tanks, and improved capabilities (such as appropriate management of stormwater runoff) to manage boat hardstand activities.

10.5.4 Impacts due to stormwater discharge

Available information indicates stormwater discharging into Mangles Bay contains appreciable quantities of nutrients (mostly in particulate rather than dissolved forms), some metals and (excluding the Lake Richmond Drain) faecal bacteria, but little hydrocarbons, pesticides or herbicides (Section 10.2.1). The Lake Richmond Drain is the largest contributor of stormwater to Mangles Bay due to its large urban catchment, estimated to outweigh the contribution of the minor urban drains by one to two orders of magnitude (Section 10.2.1).

The Proposal involves the urban development of approximately 50 ha of land, and urbanisation will potentially result in an increase in the quantity and decrease in the quality of stormwater runoff from this area. This will be mitigated by the use of Best Management Practices for stormwater in the Proposal area, and the relocation of the Lake Richmond stormwater drain to better flushed waters further east (at Hymus Street, which will reduce stormwater inputs of nutrients and contaminants to Mangles Bay.

In small rainfall events (i.e. less than the 1 in 1 year event), stormwater from roads within the Proposal area will be infiltrated through the use of Best Management Practices such as soakwells, swales and/or underground infiltration cells (refer Section 7.4.3). Rainfall on future residential lots will be managed through the use of soakwells and/or rainwater tanks in smaller rainfall events with the potential for overflow to the road drainage system in larger events (refer Section 7.4.3). Vegetated detention areas and gross pollutant traps will be used to treat stormwater to reduce nutrient and contaminant concentrations, prior to infiltration or discharge. The small rainfall events (less than the 1 in 1 year events) constitute 99% of the volume of rainfall (DoW 2004-2007). Options for stormwater management in larger events may include discharge into Mangles Bay through the marina (as currently occurs at Port Bouvard and Mandurah Ocean Marina), discharge into the realigned Lake Richmond Outlet Drain, or a combination of these options. The design will be outlined in the Low Water Management Strategy that will accompany the Local Structure Plan, as required by *Better Urban Water Management* (WAPC and DPI 2008) (refer Section 7.4.3).

Estimates of contaminant loads to Mangles Bay from stormwater from the Proposal area during large rainfall events (representing 1% of annual rainfall) are compared to other estimates of stormwater contaminant loads to Mangles Bay in Table 40. The added contaminant loads due to the Proposal are minor compared to existing loads, and will be mitigated by the relocation of discharge from Lake Richmond Drain to Hymus Street, where waters are less sheltered and greater dilution of contaminants should occur.

Table 40 Approximate loads of contaminants in stormwater entering Mangles Bay

Contaminant	Lake Richmond Drain*	Minor drains**	Total load without marina	Additional load due to marina***
Total nitrogen	122–8,300 kg	12–830 kg	134-9,130 kg	1.25 kg
Total phosphorus	n/a	n/a	n/a	0.21 kg
Copper	32 kg	3.2 kg	35.2 kg	0.042 kg
Lead	98 kg	9.8 kg	107.8 kg	0.004 kg
Zinc	104 kg	10.4 kg	114.4 kg	0.146 kg

* Refer to Section 10.2.1. Lower end of range for TN is for 2002 and is more representative of lower rainfall years. Metal loads are probably overestimates as they are for higher rainfall years.
** Estimated as an order of magnitude lower than loads from the Lake Richmond Drain, refer to Section 10.2.1
***Based on DoW (2007) data for minor drains in

Table 27, Representative contaminant concentrations used were 0.3 mg/L TN, 0.05 mg/L TP, 0.010 mg/L copper, 0.001 mg/L lead and 0.035 mg/L zinc. Calculations were based on runoff from a land area of 49 ha, for large rainfall events representing 1% of an annual rainfall of 850 mm.

10.6 Management measures and performance standards

10.6.1 Construction

Breakwater construction and dredging of the Proposal area access channel are expected to be the main causes of turbidity during construction, and have the potential to cause localised, minor, short-term impacts on water quality (and therefore seagrasses) in Mangles Bay. Construction activities are not expected to cause any long-term impacts on seagrasses, as the predicted turbidity is minimal. The seagrasses on the shallows of Mangles Bay have also survived much longer construction activities (i.e. construction of the Garden Island Causeway) during periods of far worse water quality (1971–1973). However, all construction activities will be managed under a comprehensive CEMP that includes:

- baseline monitoring of water quality and seagrass health at sites agreed to by the Proponent, DEC and CSMC
- ongoing monitoring of water quality and seagrass health at sites agreed to by the Proponent, DEC and CSMC
- agreed reporting requirements, management triggers for water quality and seagrass health, and required actions if management triggers are exceeded (such as the deployment of silt curtain, temporary cessation of construction activities)
- post-construction monitoring of seagrass health.

It is also proposed to include monitoring of water and sediments in the infiltration ponds used for temporary storage of dredged material, to confirm predictions that overall concentrations of contaminants (especially TBT) meet relevant EQG.

The protocols used to derive the EQGs and EQSs of the Cockburn Sound SEP (Mangles Bay is within the high protection zone) will provide the basis to assess construction impacts on water quality in Cockburn Sound. There are no formal criteria or targets presently defined for the SIMP, but if Cockburn Sound EQC are met in Mangles Bay during construction, marine park values should also be protected.

10.6.2 Operational impacts

With respect to the Cockburn Sound SEP's EQO of Maintenance of Ecosystem Integrity, the shallow waters of Mangles Bay presently:

- 'exceed' the nutrient-related water quality EQG for high ecological protection and moderate ecological protection, as do many other sites in southern end of Cockburn Sound (refer Section 10.2.2, noting that comparison with these EQG is for information only, as they are not meant to apply to individual sites)
- exceed the site-based phytoplankton biomass EQG and EQS for high ecological protection and the EQG for moderate protection, but not the EQS for moderate protection (refer Section 10.2.2).
- meet nutrient-related EQS for seagrass health for high ecological protection at most sites, but not all, and moderate ecological protection at all sites monitored adjacent to the Proposal Section 12)
- meet EQGs for contaminants in sediments at sites adjacent to the Proposal (Section 10.2.4).

With respect to the EQO of Maintenance of Primary Contact Recreation Values (such that primary contact recreation [such as swimming] is safe), the waters of Mangles Bay adjacent to the Proposal area also meet relevant EQG for faecal bacteria (refer Figure 58).

It is proposed that the ongoing (operational) effects of the Proposal on the marine waters of Cockburn Sound be assessed in terms of the above EQC, with the objective of ensuring that the existing level of compliance is maintained. It is anticipated that the marine waters between the breakwaters (an area about 50 m by 180 m; refer Figure 7) will be zoned for moderate ecological protection, and relevant EVs and EQOs will apply: spatial patterns of water quality in the marina indicate water quality in this area should be little different to Mangles Bay (e.g.) and therefore that it should meet the site-based EQG and EQS for phytoplankton biomass, excluding atypical years such as 2010/2011 (when water quality in Mangles Bay did not meet the EQG). In addition, relevant EQC for the EQO of Maintenance of Aesthetic Values should be met in Mangles Bay.

The majority of marina waters (i.e. excluding the small area between the breakwaters) should comply with WAPC Policy No. DC1.8 general aesthetic guidelines, which require artificial waterways to be:

- free from substances which will settle to form putrescent or otherwise objectionable sludge deposits
- free from floating debris, oil, grease, scum, foam and other floating materials in amounts sufficient to be unsightly or otherwise objectionable
- free from materials which will produce colour, odour, turbidity, or other conditions to such a degree as to be unsightly or otherwise objectionable.

Marina activities will need to be managed under an Operational Management Plan that includes:

- a fuel spill management plan
- maintenance and management plan for marina facilities (including maintenance dredging and – if required - removal of subtidal wrack, or nutrient-rich surficial sediments))
- codes of conduct for, and surveillance of, users of the marina (including sullage management)
- ongoing monitoring of water quality and sediment quality within the marina, and water quality, sediment quality and seagrass health at agreed sites in Mangles Bay.

As with construction-related impacts, if relevant EQC are met in Mangles Bay, the values of the adjacent waters of SIMP should also be protected.

10.7 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

Construction of the Proposal will generate some turbidity, mainly during dredging of the marina access channel; however modelling predictions indicate it will cause only minor, highly localised, and short-term impacts on water quality in Mangles Bay. This is attributed to the short duration of the dredging program, the low proportion of fine particles in the material to be dredged, and the relatively clean dredging method (a small cutter suction dredge). Dredging will also be timed to minimise potential impacts on marine biota (refer Section 12 and 13). No adverse effects expected due to contaminant release during dredging and disposal, as contaminant levels in the sediments to be dredged meet all relevant ecological and human health guidelines.

Marinas are, by necessity, calm, sheltered environments, and therefore are less well flushed than adjacent waters. Any marina will have lesser water quality than its adjacent waters: Perth's existing ocean marinas typically have chlorophyll levels 1.5 to 4 times higher than adjacent waters (Bowman Bishaw Gorham 2001). The Proposal's marina has been designed to maximise the natural flushing of inner marina waters by wind and tide, and modelling indicates chlorophyll levels in the marina will be about twice that of Mangles Bay, with little effect on water quality in Mangles Bay and adjacent waters (Cockburn Sound and the SIMP). This relatively modest increase in chlorophyll-a concentrations is attributed to a combination of marina design, the relatively small size and simple configuration of the marina (compared with other marinas in WA), and the small scale of groundwater nutrient inputs. Nor does the Proposal have any of the associated problems of some other marinas in WA, such as extensive areas of seagrass wrack (such as at Jurien Boat Harbour and Port Geographe Marina), trapping of wind-blown algae and debris (such as at South Yunderup Canals) or acid sulphate soils (such as in canals in the Mandurah region). Modelling further predicts that flushing should be sufficient to prevent any gradual build-up of the concentrations of nutrients or other contaminants over time.

The Proposal may also result in impacts on marine water quality with increased recreational boat activity resulting in sediment re-suspension, inputs of metals and hydrocarbons from engine emissions, antifoulants, fuel spills and sullage disposal. The increase in boat activity will be minor in comparison to increases that will occur anyway due to increases in population and the level of boat ownership in the region (refer Section 16), but can be managed by:

- provision of better management and facilities (recreational boating activity is largely unregulated at present)
- use of 'best practice' measures and strict regulations for the Proposal, to ensure minimal inputs of contaminants to the marine environment
- provision of well marked access channels with appropriately sign-posted speed limits, to reduce sediment re-suspension by boating activity. The Proposal will also mitigate impacts due to increased boat traffic as it will help manage the presently uncontrolled movement of boats in Mangles Bay
- management of the presently uncontrolled refuelling activities and sullage disposal in Mangles Bay via provision of refuelling facilities and sullage pump out facilities in the marina
- opportunities for water quality benefits via the relocation of some boats presently moored in Mangles Bay, the conversion to sewerage of properties presently still on septic tanks, improved capabilities (such as appropriate management of stormwater runoff) to manage boat hardstand activities, and better management of stormwater drains entering Mangles Bay, including the Proposal's relocation of the Lake Richmond stormwater drain further east.

With the above mitigation measures, it is considered that the Proposal meets EPA objectives and SIMP objectives for marine water quality and sediment quality. It is acknowledged the shallow waters of Mangles Bay presently do not meet phytoplankton biomass EQG and EQS for high ecological protection, and only met the moderate protection EQG in 2009/10 but not in 2010/11: the latter exceedance is, however, considered to be due to an atypically hot summer. EQC for seagrass health for high ecological protection were met at three of the four sites monitored in the shallow waters of Mangles Bay, and

sediment quality EQC were met at all sites monitored. The Department of Health's data also indicate recreational EQC (faecal bacteria) are met. It is considered that the Proposal will not result in any significant lessening of water quality in Mangles Bay, and that EQC for those environmental indicators that are presently met will continue to be met. The marine waters between the Proposal's breakwaters are expected to be zoned for moderate ecological protection, and should meet the EQG and EQS for phytoplankton biomass, excluding atypical years such as 2010/2011 (when water quality in Mangles Bay did not meet the EQG). The majority of marina waters (i.e. excluding the small area between the breakwaters) should also meet WAPC Policy No. DC1.8 guidelines for artificial waterways.

11. Coastal processes impact assessment

11.1 Relevant environmental objectives, policies, guidelines, standards and procedures

11.1.1 EPA objectives

The EPA objective for the marine environment is:

To maintain the integrity, ecological functions and environmental values of the seabed and coast.

11.1.2 Legislation, policy and guidance

Planning and Development Act 2005

The *Planning and Development Act 2005* (PD Act) provides for a system of land use planning and development in the State and for related purposes.

The purposes of the PD Act are:

- consolidate the provisions of the Acts repealed by the *Planning and Development (Consequential and Transitional Provisions) Act 2005* (the *Metropolitan Region Town Planning Scheme Act* (1959) , the *Town Planning and Development Act* (1928) and the *Western Australian Planning Commission Act* (1985) in a rewritten form
- provide for an efficient and effective land use planning system in the State
- promote the sustainable use and development of land in the State.

Under section 5AA of the repealed *Town Planning and Development Act (1928*), the Commission is authorised to prepare State Planning Policies with the approval or direction of the Minister. Section 25 of the PD Act provides that any statement of planning policy in force under the *Town Planning and Development Act (1928)* continues in force as a State Planning Policy under the new act (PD Act). The preparation of State Planning Policies is to have regard for the following:

- demographic, social and economic factors and influences
- conservation of natural or cultural resources for social, economic, environmental, ecological and scientific purposes
- characteristics of land
- characteristics and disposition of land use
- amenity, design and environment
- communications
- developmental requirements of public authorities.

Government and industry guidelines

Western Australian Planning Commission (WAPC) guidelines require development of coastal facilities to take into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical criteria to ensure sustainable use of coastal areas for maritime industry, commercial and other activities. The two overarching WAPC policies are outlined below.

Statement of Planning Policy No. 2.6 State Coastal Planning Policy

Statement of Planning Policy No. 2.6: State Coastal Planning Policy (SPP2.6) was developed under section 5AA of the *Town Planning and Development Act* (1928) (WAPC 2006). The policy applies to the coast throughout Western Australia with the objectives to:

- protect, conserve and enhance coastal values, particularly in areas of landscape, nature conservation, indigenous and cultural significance
- provide for public foreshore areas and access to these on the coast
- ensure the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities
- ensure that the location of coastal facilities and development takes into account coastal processes including erosion, accretion, storm surge, tides, wave conditions, sea level change and biophysical criteria.

SPP2.6 outlines the requirements in terms of the application of coastal foreshore reserves and development setbacks for physical processes. Coastal setbacks refer to the distance required between development and specific coast features to provide for the protection of both physical and ecological factors.

The setback requirements for developments that benefit from the protection of existing formal coastal protection systems will be determined on a case by case basis, with any coastal processes setback distance taking into account the nature of the structure(s) in question.

Coastal development in Mangles Bay may take existing setbacks and adaptive management strategies into account when determining an acceptable coastal protection strategy for the proposed area. The coastal environment in the Proposal area is already cleared and modified with seawalls and jetty structures.

The consideration of SPP2.6 in the Proposal is discussed further in Section 11.5.2.

Sea Level Change in Western Australia – Application to Coastal Planning

In recognition of nationally accepted and adopted increases in sea level rise projections, the WAPC considered it necessary to amend the sea level rise value in SPP2.6. These amendments are discussed in the DoT publication *Sea Level Change in Western Australia – Application to Coastal Planning* (DoT 2010), for which the key outcomes are:

- a vertical sea level rise of 0.9 m is adopted when considering the setback distance to allow for the impact of coastal processes over a 100 year planning timeframe (2010 to 2110)
- for planning timeframes beyond 100 years, a vertical sea level rise of 0.01 m/year is added to 0.9 for every year beyond 2110.Findings of surveys and investigations

In order to identify the existing coastal processes surrounding Mangles Bay and the potential for impacts to these processes by the Proposal, the Proponent commissioned a coastal processes assessment. The coastal processes assessment was conducted by JFA (2011) and incorporated the following approach:

- preliminary desktop review of the regional geomorphology, metocean and synoptic setting and historical shoreline movement
- wave modelling to define the annual nearshore wave conditions
- investigation of sediment transport processes utilising annual wave modelling results
- analysis of historical shoreline movements
- determination of post construction equilibrium beach shapes and identification of areas of erosion and accretion utilising modelled nearshore wave conditions.

The coastal processes assessment recommended strategies to appropriately manage the beaches within the Proposal area in order to minimise impacts and maintain stability. Unless otherwise specified, the

following description of the coastal processes of the Proposal area has been adapted from the Mangles Bay Marina Based Tourism Precinct Project Coastal Processes Assessment (JFA 2011) (provided in Appendix 5).

11.1.3 Regional coastal setting

Cockburn Sound comprises a large basin area confined by shallow banks to the north and south (Figure 78). The broad and relatively deep central basin, which gently slopes to a maximum depth of 22 m, is flanked by the relatively steep slopes of the surrounding banks, shoals and shoreline to the north, south and Garden Island to the West, and a lower gradient bank to the East (Geoscience Australia 2005a). The shallow sheltered waters of Cockburn Sound (and Mangles Bay) support extensive seagrass meadows and a wide range of marine fauna (Strategen 2010).

Stratigraphic studies have identified that Cockburn Sound consists primarily of marine carbonate muddy sediment over the clay soil deposited prior to the Holocene sea level rise (Geoscience Australia 2005a). Sampling conducted in 2004 identified that the sediments of Cockburn Sound are primarily biogenic carbonates (Table 41).

Table 41 Summary of Cockburn Sound sediment (adapted from Geoscience Australia 2005a)

Area within Sound	Approximate depth	Sediment description
Central basin	15 – 20 m	Sandy mud and mud
Marginal banks	2 – 10 m	Carbonate sand
Eastern nearshore zone	-	Mixed carbonate and quartz sand

Cockburn Sound is bound to the west by Garden Island and to the north by Parmelia Bank (Figure 78). These formations result in the sound being relatively sheltered from swell energy. Limited swell does penetrate through from the northern entrance to the Sound. The local seas are dependent on wind conditions and basin dimensions. In the southern portion of Cockburn Sound, the locally generated seas have been found to come from the south or south west in summer, and from the west to northwest in winter.

The coast, where the Proposal is located, experiences diurnal microtidal conditions, with a maximum spring tidal range of 0.6 m. At Fremantle, approximately 25 km north of the Proposal area, the average high and low water levels recorded are 0.97 m and 0.5 m respectively (JFA 2011). Studies of extreme water levels at Fremantle have estimated the 1 in100 year peak tide level at 2 m, and a 1 in 10 year high water level of approximately 1.8 m (JFA 2011). Due to the proximity to the Proposal area, these values have been used to develop the models for the coastal processes assessment.

Source: Imagery supplied by Landgate (2010)
Coordinate System: MGA94 Zone 50
Date: 8/2/2012
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F026.dgn

Cockburn Sound

Figure No: **78**

11.1.4 Geomorphology of the Proposal area

Mangles Bay, located in the southern end of Cockburn Sound, contains a series of narrow beaches dropping to large subtidal platforms populated by seagrass. The Mangles Bay foreshore currently comprises of sandy beach backed by low dunes and is presently backed by storage facilities for the local yacht club. It is reported that the beaches in this sector are not popular swimming beaches and are mainly used for transiting along by walking and for the launching of boats (Strategen 2011).

The beaches at Mangles Bay have been identified as low energy beaches. The defining characteristics of low energy beaches which can be seen at Mangles Bay include:

- minimal non-storm significant wave heights
- low significant wave heights during strong onshore winds
- narrow beachface widths in microtidal environments
- morphological features defined by higher energy events.

A classification system has been developed for low energy beaches at Cockburn Sound, which are classified in four different categories; Exponential, Segmented, Concave-Curvilinear and Convex-Curvilinear (Travers 2007). The beaches at Mangles Bay display characteristics of the exponential classification, including:

- concave upper beach
- long, flat, sub tidal terrace
- fine grained sediment.

Low energy and exponential beaches occur at sites sheltered from the effects of ocean waves. At Mangles Bay the beaches are sheltered primarily by the man-made Garden Island Causeway.

In the case of low energy beach environments, morphological change (changes to the physical characteristics of the beach profile) are primarily driven by high energy, low frequency storm events. At Mangles Bay sediment transport is restricted to movement between the upper and lower foreshore. This is caused by changes in the energy of locally generated waves due to variations in wind speeds. Sediment transport in the Proposal area is discussed further in Section 11.1.6.

11.1.5 Wave climate of Proposal area

The wave characteristics of low energy environments are typically a mixture of local and non local wave regimes. Locally generated waves are usually found within areas where the wave energy is limited by the size of the wave generation area (fetch limited), such as enclosed basins. Non-locally generated waves are characteristic of sheltered environments in the lee of islands, behind submerged barriers or near entrances to larger external basins. Wave modelling at Mangles Bay and Cockburn Sound indicates that a mix of both regimes exist within the Proposal area.

Offshore waves

In order to develop an understanding of the offshore wave climate surrounding the Proposal area, wave modelling was conducted utilising data from Department of Transport (DoT) monitoring buoys at Rottnest, Owen Anchorage and Cottesloe.

The modelling identified three predominant swell wave conditions with incident wave directions of 225 degrees (south southwest), 255 degrees (south west) and 285 degrees (west northwest); swell from the south south-west and south west directions; and storm event waves from the northwest. The entrance to Cockburn Sound between Garden Island and Cape Peron is constricted by the Garden Island Causeway resulting in two smaller openings, north and south of the Causeway. Swell waves are able to penetrate into Cockburn Sound through both entrances. The approaches of the predominant offshore waves is summarised in Table 42.

Table 42 Predominant wave patterns at the Proposal area

Source – direction	Predominance	Entrance to Cockburn Sound	Wave approach to Proposal area
Offshore swell – South southwest (225 degrees)	5%	Southern causeway	Southerly
		Northern causeway	Southerly
Offshore swell – Southwest (255 degrees)	75%	Southern causeway	Northerly and north easterly
		Northern causeway	Northerly and north easterly
Storm event – West northwest (285 degrees	20%	Southern causeway	Southerly
		Northern causeway	Southerly

Incident south south westerly waves

South south westerly incident swell waves (225 degrees) make up approximately 5% of the swell waves approaching Cockburn Sound. As these swell waves reach Cape Peron a proportion of the waves diffract over the headland (south of the Causeway), gradually changing direction and decreasing in wave height until they approach the Proposal area in a southerly direction (Figure 79). A second set of waves diffract over the northern tip of the Garden Island Causeway consequently resulting in southerly waves with lower wave heights approaching the site.

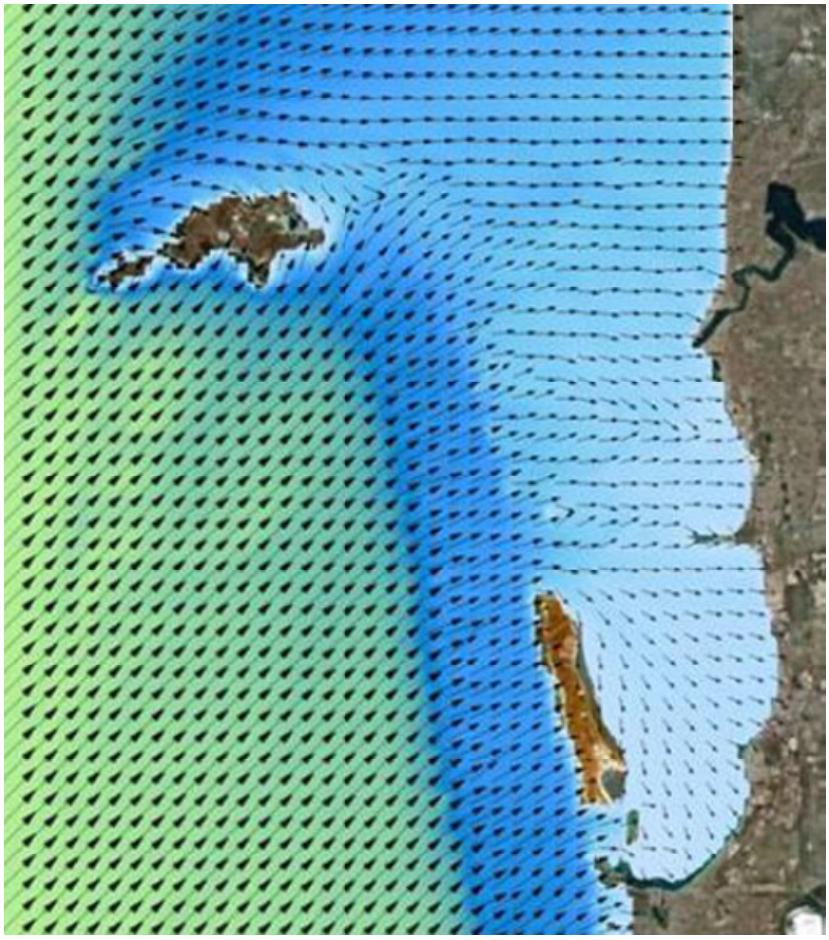


Figure 79 Incident south southwest swell waves

Incident south westerly waves

Modelling has identified that the dominant offshore swell wave condition surrounding Cockburn Sound has an incident wave direction of 255 degrees (south westerly). As these offshore swell waves approach Cockburn Sound and refract along the shallow regions of the Rottnest Shelf and surrounding reefs, they gradually change to a westerly direction as they approach Cockburn Sound (Figure 80).

The presence of the Garden Island Causeway greatly restricts swell wave penetration into Cockburn Sound. However, swell waves are able to penetrate into Cockburn Sound from two entrances referred to previously (the southern and northern ends of the Causeway). Through the southern entrance, waves diffract around the Cape Peron headland resulting in lower wave heights and north to north easterly wave directions. Through the north entrance, waves diffract around the northern tip of the Causeway, again resulting in northerly to north easterly waves.

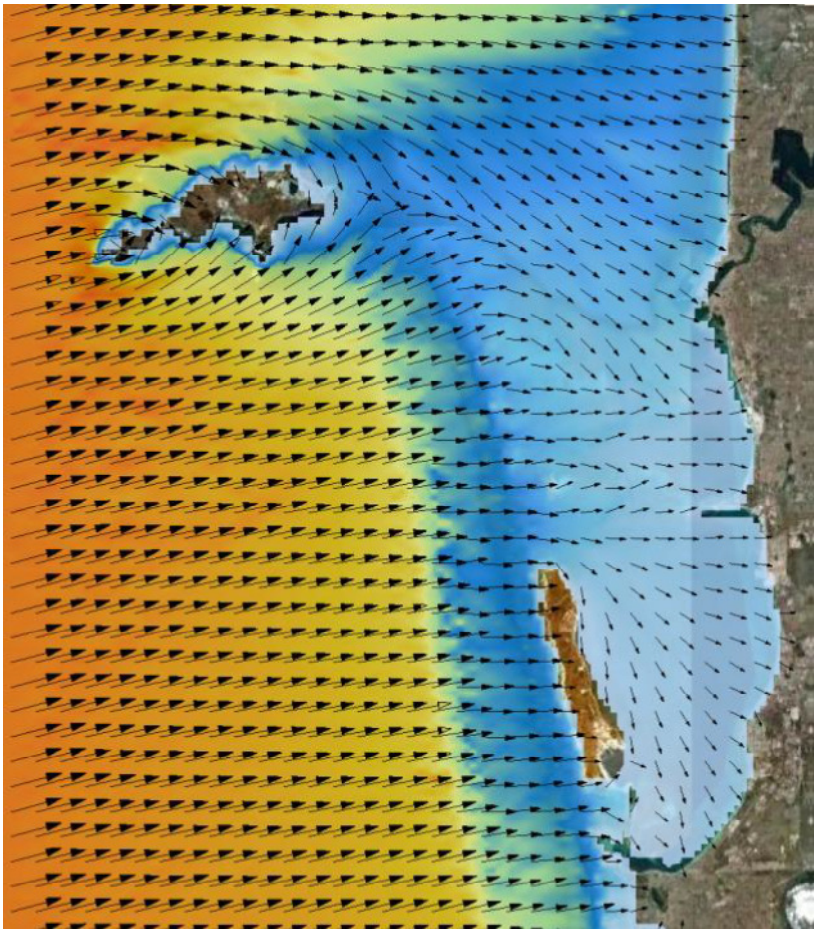


Figure 80 Incident SW swell waves

Incident west north westerly waves (Storm event waves)

As storm generated incident waves approach Cockburn Sound from a west north westerly direction they decrease in wave height as they travel nearshore, diffract around the Garden Island Causeway and travel south into Cockburn Sound (Figure 81). Waves which have refracted into the Garden Island entrance diffract around Cape Peron, and continue to refract until they are almost perpendicular to the shoreline at Mangles Bay.

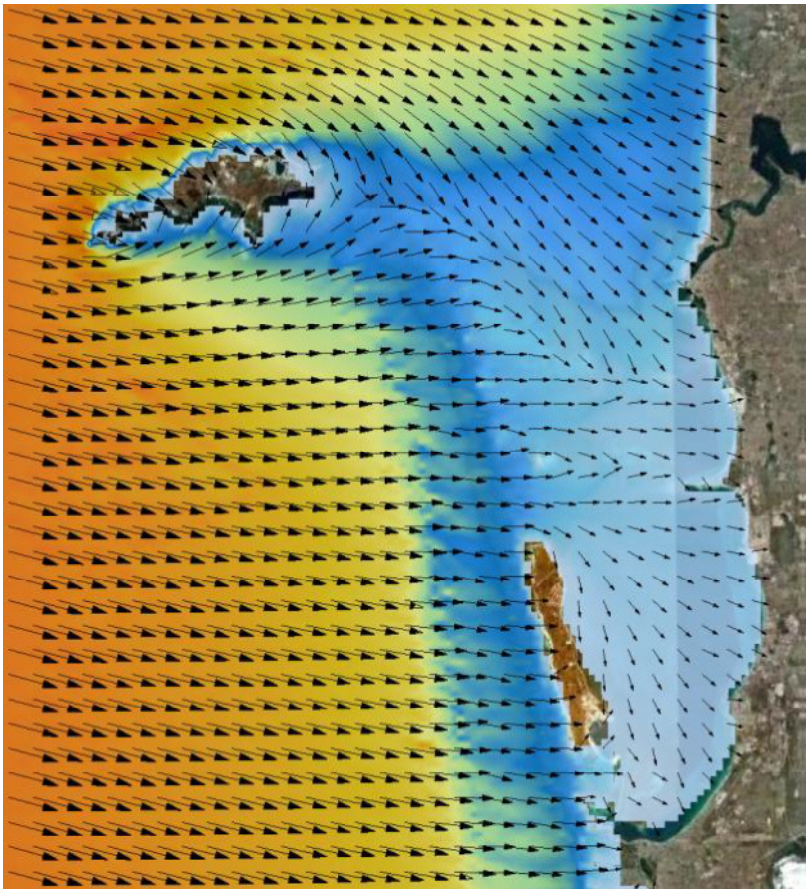


Figure 81 Incident west northwest swell waves

Locally generated waves

In addition to offshore swell and storm waves, the seas at Mangles Bay also have a locally generated component. Located in the southern end of Cockburn Sound, the locally generated waves come from the long fetches to the north northeast and are driven by strong northerly winds.

11.1.6 Sediment transport and morphological change

Sediment in Cockburn Sound is transported southwards along the eastern edge, driven by oblique waves arriving at the shoreline (DoT 2009). Mangles Bay is located in the 'Rockingham sedimentary sub-cell' of Cockburn Sound, bounded by Cape Peron to the southwest and Woodman Point to the north.

Coastal structures

A number of shoreline structures have been constructed in the vicinity of the Proposal area since 1971, the most significant of which is the Garden Island Causeway. Prior to the construction of the Garden Island Causeway, sediment was transported east into Mangles Bay. Since the causeway was constructed (1971 – 1973) sediment has built up on the west side of the groyne and in the Cape Peron Boat Harbour sand trap. Since the construction of the causeway a number of coastal protection measures have been installed along Mangles Bay including:

- original sand trap groyne west of Causeway (1973)
- 90° extension to sand trap groyne (1986)
- spur added to sand trap groyne (1990)
- DEC sea wall (late 1980)
- Hymus St Groyne (post causeway)
- Fishing Club seawall and ramp (post causeway)
- Palm Beach groynes (post causeway).

The construction of the causeway interrupted sand supply from the west, resulting in the beaches of Mangles Bay becoming primarily erosive (losing sediment). However analysis of historical movement patterns indicates that most of the beaches had relatively stabilised by 1988.

Sediment transport trends

To assess the sediment transport at Mangles Bay, the beaches can be divided into four distinct segments, called compartments, based on differences in beach orientation (Figure 82). The variation in orientation between these segments is a function of swell wave patterns and the influence of the physical structures listed above. The historical trends in morphology of the four Mangles Bay compartments were indentified through a comparison between the 1988 and 2010 vegetation lines (Figure 83 to Figure 85).

Figure 82 Mangles Bay beach compartments

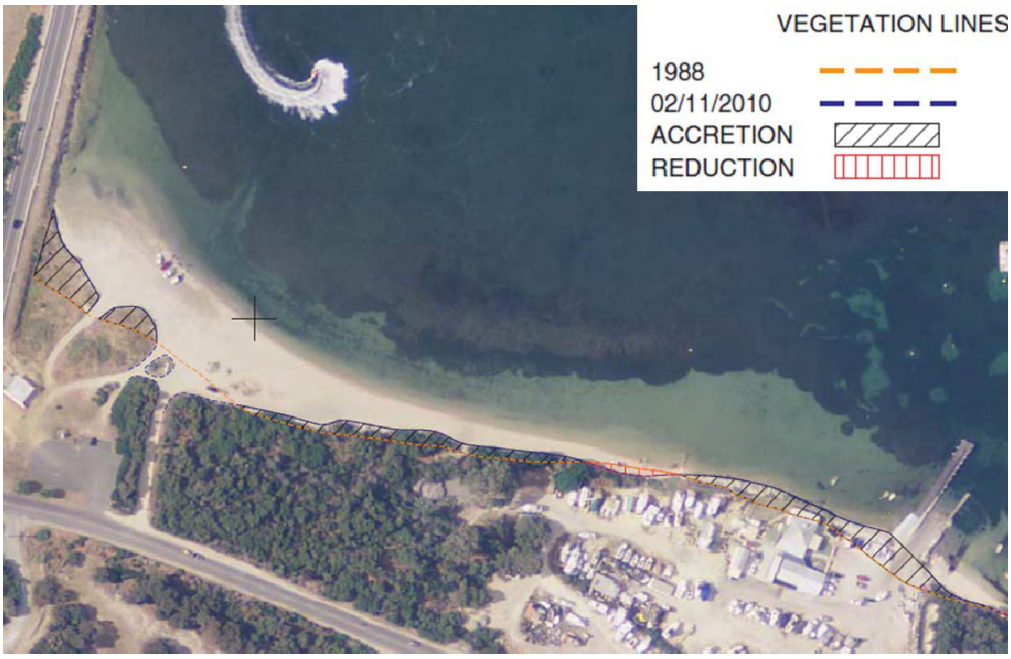


Figure 83 Vegetation line changes at Compartment 1

Figure 84 Vegetation line changes at Compartments 2 and 3

Figure 85 Vegetation line changes at Compartment 4

In addition to an assessment of historical trends, sediment transport calculations were conducted on each beach compartment, based on the height and period of the incident wave, the beach grain size, the angle of wave propagation and the slope of the seabed. The results of these calculations indicated that the annual swell wave energy is the primary determining factor of sediment transport within Mangles Bay.

Historical shoreline movement and present day morphology differs between each segment as sediment transport is influenced by the structures (Table 43).

Table 43 Sediment transport and beach morphology at Mangles Bay (adapted from JFA 2011)

Beach Section	Historical trend (1988 – 2010)	Sediment transport trend
Compartment 1	Considerable accretion immediately adjacent to the causeway and existing boat ramp.	Potential sediment transport is towards the east. Beach orientation is stable.
Compartment 2	Consistent accretion at a relatively small accretion rate. Erosion west of Hymus St groyne due to diffraction of dominant swells around the headland. Ongoing sand renourishment is being implemented.	Potential sediment transport is towards the east. Beach orientation is stable. Expected accretion between each end.
Compartment 3		Potential sediment transport is towards the west from the groyne at Hymus Street. Transitional orientation.
Compartment 4	Orientations were rotated following installation of groynes, aligning with the dominant swell direction. Substantial accretion.	Potential sediment transport is towards the west. Beach orientation is stable.

The existing beach orientations at Compartments 1, 2 and 4 are considered to be relatively stable (JFA 2011). The existing orientation of the beach in Compartment 3 has been stabilised with the seawall at the end of the Hymus Street and the nearby groyne which acts as a headland. This beach is in transition between the alignments at Compartment 2 and 4, influenced by sand renourishment activities and the presence of the Hymus Street Groyne (JFA 2011).

In summary, the existing beaches at Mangles Bay have been characterised as low energy beaches with little sediment supply. Sediment exchange is limited to the region between the upper swash and subtidal terrace (as indicated by the edge of the seagrass). There is very little or no longshore sediment transport within the Proposal area region and beach alignments have been identified as stable. Additionally, the coastline spanning the Proposal area is currently divided into distinct sub compartments by existing coastal structures.

11.1.7 Climate change

Global sea level rise

Studies have established that the global sea level has risen over the past two centuries, with an increasing rate of rise seen in recent times (DoT 2010). Sea level rise is in part comprised of short-term fluctuations caused by seasonal variations, astronomical tides, storm surges and El Nino-Southern Oscillation (ENSO) events. Table 44 outlines the influence these processes have on sea level variability along the WA coastline.

Table 44 Major processes influencing sea level variability along the southwest WA coastline (Pattaratchi & Eliot 2005)

Time scale	Dominant Processes	Maximum range
12-24 hours	Astronomical tide	0.8 m
1-10 days	Storm surge	0.8 m
Seasonal	Leeuwin Current	0.3 m
Inter-annual	ENSO	0.3 m

The other contribution to sea level rise is driven by climate change, the alteration to global climate patterns attributed to the increase in greenhouse gas emissions into the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) provides projections for sea level change based on future emission scenarios. Their projections for sea level rise are made up of thermal expansion and melt waters from glaciers, ice caps, the Greenland Ice Sheet and the Antarctic Ice Sheet (DoT 2010). The long-term estimates for global average sea level rise are between 1.5 – 3.5 m by 2200, and between 2.5 – 5.1 m by 2300 (DoT 2010).

Regional sea level rise

As sea level change is not likely to be uniform across the globe, CSIRO (2007) used the results of the IPCC modelling for Australia to investigate regional diversions to global projections. This investigation identified that the average sea level rise estimated for Australia is close to the global averages. Based on a review of these studies, DoT (2010) made recommendations which were subsequently incorporated into *State Planning Policy 2.6 State Coastal Planning Policy Schedule 1 Sea Level Rise* (refer to Section 11.1.2) (WAPC 2006).

A rise in sea levels has implications for coastal development and considerations must be made with regards to setback distances and the implementation of coastal defence structures. These steps are discussed further in Sections 11.5.1 and 11.5.2.

11.2 Evaluation of options or alternatives to avoid or minimise impact

There are a number of coastal defence options available, with both hard and soft engineering measures to provide a range in protection and beach amenity. The five options considered for beach management for the Proposal include:

1. Groynes.
2. Seawalls.
3. Sills.
4. Detached Breakwaters.
5. Beach Nourishment.

Of these options outlined above, the use of groynes, seawalls and beach nourishment measures have been selected as appropriate management measures for the Proposal.

11.3 Assessment of likely direct and indirect impacts

The following aspects of the Proposal may potentially impact on coastal processes:

- construction of the marina entrance breakwater and channel which may interrupt longshore sediment transport
- construction of the breakwaters may result in the accumulation of seagrass wrack against the structure.

In addition to consideration of the potential impacts of the Proposal on coastal processes, the effects of sea level rise and processes on coastal infrastructure need to be considered in the design of coastal structures.

11.3.1 Longshore sediment transport

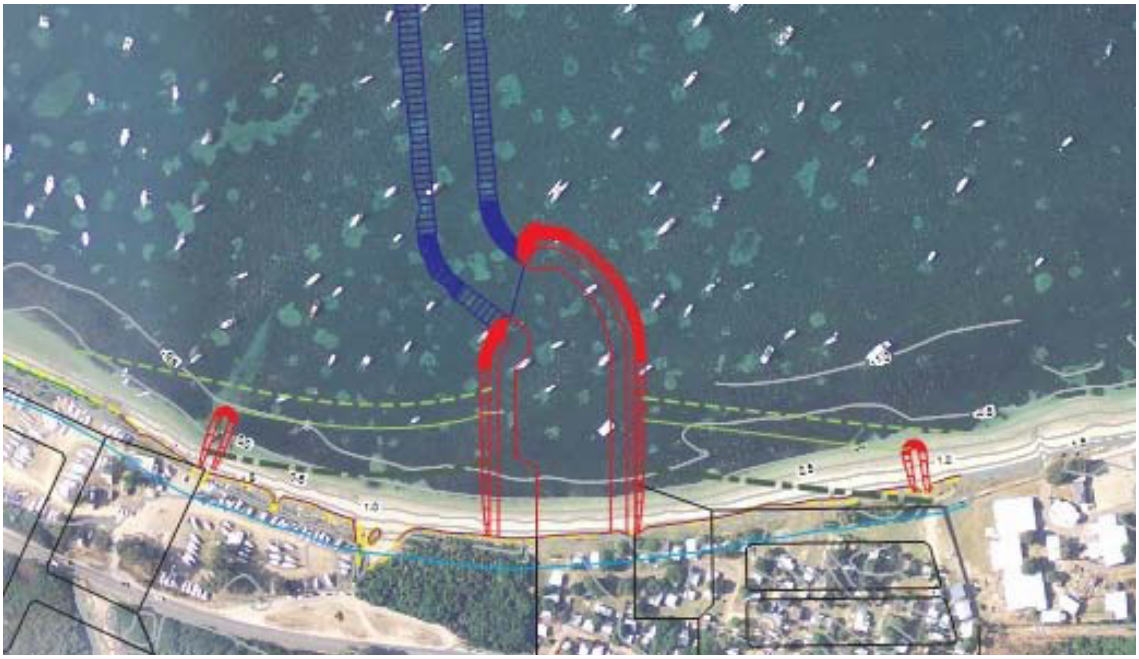
The proposed development lies in between compartments 2 and 3 of the Mangles Bay beaches (Figure 82). Construction of structures along the shoreline has the potential to change incident wave height, directions and sediment transport regimes. Changes to incident wave characteristics will result in a reorientation of the beach face until it reaches a new equilibrium. JFA (2011) modelled the potential changes to beach orientation at Mangles Bay as a result of the installation of the Proposal's breakwaters.

The construction of the marina entrance breakwaters will change the incident ambient wave pattern west of the proposed development. Waves arriving from the dominant northerly wave direction will diffract around the western breakwater head, creating a gradient in wave height and consequently wave setup along the coast. This will generate a gradual transfer of sediment from the exposed area towards the area sheltered by the structure.

This sediment transfer will result in a reorientation of the beach to the west of the proposed breakwater, with an accumulation of sediment along the western side of the structure. Sediment transport within compartment 3 (to the east of the proposed marina entrance structure) is in a westerly direction from the existing groyne at Hymus Street. Following the construction of the proposed breakwater, this sediment trend will result in build up against the eastern edge of the breakwater.

Deposition and beach realignments along both sides of the marina entrance would continue until a new equilibrium is reached, with significant losses to the subtidal area and seagrass meadows. The reorientation of the beaches either side of the proposed marina breakwater entrance will be mitigated through the incorporation of beach defence structures (discussed further in Section 11.5.1)

The potential beach realignment as a result of the Proposal is shown in Figure 86.



02/11/2010 VEGETATION LINE
20m SETBACK
BOTTOM OF BANK (FROM 2009 McMULLEN NOLAN FEATURE SVY)
45m SET BACK FROM TOE OF BEACH
SHORELINE
TOE OF BEACH

Figure 86 Long-term shoreline orientations driven by the Proposal

11.3.2 Accumulation of seagrass wrack

Beach stability and reclamation impacts

The proposed area development concept as shown in Figure 5 requires the development of beaches fronting the development limited in area as defined in the ESD. Coastal processes studies have indicated that beaches developed in the Proposal area will be stable, oriented to the diffracted background energy and have morphological responses similar to the existing beaches. The beach alignments shown will only develop in the presence of available sediment.

Impacts on seagrass will be limited to the same active profile widths as evident on the existing beaches and as indicated by the shoreward edge of the seagrass meadow.

Impact on wrack accumulation

The dynamics of seagrass wrack accumulation on the beaches of Port Geographe, South West Australia, located approximately 150 km south of Mangles Bay were studies by Oldham *et al.* (2010) and provides useful information for the assessment of the potential for seagrass accumulation at Mangles Bay.

The key findings related to factors influencing seagrass wrack accumulation on the beaches of Port Geographe are outlined in the following paragraphs. The corresponding effects of these factors on seagrass wrack accumulation at Mangles Bay is also outlined.

Wrack Production

In the study of seagrass wrack dynamics at Port Geographe, Oldham *et al.*, (2010) found that seagrass wrack is mostly produced in offshore seagrass meadows in the Summer – Spring season due to the shedding of mature leaves. Additionally, in the Autumn – Winter season, some leaves and whole clumps of meadow can be ripped out of the sediment during storm events.

Geographe Bay has nearly 8725 ha of seagrass, mostly *Posidonia sinuosa* (~80%) but some *Amphibolis*. About 32 500 tonnes of wrack is produced each year, and ~7500 tonnes (about 25%) ends up on the beach. Each hectare of *Posidonia* meadows in Geographe Bay produce about 2-3 tonnes of wrack each year.

By comparison, Mangles Bay has 100 ha of seagrass, mostly Posidonia sinuosa. There are no other seagrass meadows that might contribute wrack to Mangles Bay and half of the meadows in Mangles Bay are to the west of the breakwaters, and so northwest storms would push any wrack from this area away from the breakwaters.

Nearshore wrack transport from offshore meadows

Oldham found that the first major storms of the autumn – winter period transport a proportion of the offshore wrack into the surf zone and onto the beaches of Geographe Bay. The Oldham *et al.* study was conducted over the 2008 – 2009 period whereby, at the end of May more than 98% of the wrack that had been produced since the previous winter was located in the offshore habitats however, only 1.3% was on the beaches of Port Geographe (Oldham *et al.* 2002).

Geographe Bay is also a more dynamic environment to Mangles Bay. Wave energy potentially impacting Mangles Bay during storms is significantly limited by the Bay's orientation, Garden Island and the causeway. In comparison, Geographe Bay is sheltered but is not protected by high energy events which both produce seagrass wrack and transport it into nearshore environments.

Given these factors and that the extent of the seagrass meadows influencing wrack accumulation at the proposal site is significantly less than at Port Geographe, seagrass wrack accumulation on the beaches of Mangles Bay is expected to be small in volume as is indicated by current observations.

Factors reducing onshore wrack accumulation

In addition to the small quantities of seagrass wrack accumulations on the beaches of the proposal area, other factors affecting any accumulation of wrack in any one location are outlined below.

Offshore wrack transport

Due to the low energy environment and the narrow mean energy direction range, beaches developed in accordance with the proposed layout are considered to be highly stable in orientation and governed largely by low frequency cross shore sediment processes.

Wrack is deposited onto beaches largely during storm events, when water levels are high. If it remains on the beach long enough, it gradually becomes compacted, incorporating sand, making it denser and more difficult to be washed off the beach. At the same time, however, the wrack particles dry and become more buoyant. At the next high water event that covers the wrack, or during the next winter storm(s), wrack accumulations are eroded and wrack particles are returned to the water and many remain buoyant enabling them to be transported away from the beach.

In this way, beach cast wrack can subsequently be transported back offshore, into the surf zone, where longshore transport can move it until it is obstructed by coastal structures where it accumulates, for example the Port Geographe breakwater. Mangles Bay, has relatively little net longshore transport, in the order of less than 1000 to 2000m^3/y, resulting in a potential for only very small amounts of wrack to accumulate against the coastal structures.

Seagrass may potentially move into the dredge channel and harbour, but as seagrass wrack production volumes are considered to be relatively small, this is not considered to be a significant problem for the development.

Mitigation in Design

Segmentation of the beaches into a number of compartments by training structures and control groynes to protect the development waterfront limits accumulation of wrack at any one location by reducing the catchment. This largely eliminates management problems of odour due to wrack breakdown in large masses and facilitates natural removal of wrack.

The breakwaters themselves are also aligned so that any wrack coming from ‘eastern’ Mangles Bay meadows is unlikely to enter the marina.

11.4 Potential for and nature of any cumulative impacts

As outlined in Section 11.1.6, a number of structures have been installed along the coast of Cape Peron and the beaches of Mangles Bay, including the beach management groynes and the Garden Island Causeway. The presence of these structures has already played a role in establishing the current beach profiles and sediment transport conditions. The Proposal is likely to have some cumulative effect on the overall sediment transport of Mangles Bay and the morphology of its beaches, resulting in an altered profile which is not only different from the current stable state, but also modified from the original natural beach profile.

Future infrastructure developments along this coast will also add to this history of a changing shoreline and alteration in longshore sediment transport. The proposed Port Rockingham Marina will be located adjacent to the intersection of Wanliss St and Rockingham Beach Road, to the northeast of the Proposal Area. This development will further interrupt longshore sediment transport along the southern end of Cockburn Sound.

On the basis of the relatively limited longshore transport within Mangles Bay, it is assessed that the structures associated with the Proposal will impact on the current dynamics, however, the changes will not be significant or dramatic and the system will achieve a new equilibrium.

11.5 Management measures and performance standards

In order to meet the environmental objectives for coastal processes, measures will be implemented to protect the shore from erosion while ensuring that existing and planned recreation areas are not compromised. This will require the maintenance of beaches fronting the development to improve and protect social amenity and public access to mitigate the loss of a small amount of beach.

This level of maintenance requires that sufficient buffers are provided to allow for natural variability or that the structures are built to maintain access as the beach level changes in response to varying conditions. Natural variability in the Proposal area has diminished due to additional protection afforded by the Garden Island Causeway and existing beach defence structures. However, storm erosion has been considered, including the maintenance for any losses from the beach compartments as part of the management measures required for the Proposal.

The Proposal includes development which would bisect the already compartmentalised coastal sector with a marina entrance channel, protected by coastal structures against the penetration of infrequent high energy storm events (Section 3.4). In addition to the management and beach protection infrastructure required for the coastal infrastructure, coastal protection will also be required for the land-based aspects of the Proposal such as the Yacht club and accommodation.

The utilisation of coastal defence structures and application of appropriate setbacks is discussed below.

11.5.1 Coastal defence

Groynes

Groynes are shore structures designed to reduce longshore sediment transport and to retain beach material. The shoreline between the groyne and adjacent structure (potentially another groyne) realigns towards the dominant wave direction and as a consequence, longshore sediment transport is reduced. Groynes slow longshore drift rates, causing accumulation in groyne bays, with the enhanced beach profile providing greater protection to the shoreline.

The installation of two groynes has been incorporated into the Proposal, as an important management measure, located on either side of the proposed marina breakwater entrance. A short groyne is proposed to the west of the marina entrance at the location of the existing boat ramp. The second groyne will be located to the east of the marina entrance approximately 250 m from the existing Hymus Street Groyne. The primary function of these structures is to compartmentalise the beach and interrupt the potential beach realignment and sediment accumulation against the edge of the breakwater entrance (as outlined in Section 11.3.1).

In addition, segmentation of the beaches into a number of compartments limits accumulation of seagrass wrack at any one location by reducing the catchment of potential transport. This minimises problems of odour due to wrack breakdown in large masses and facilitates natural removal of wrack.

The resulting beach orientation as driven by these groyne placements is illustrated in Figure 86.

Buried Sea walls

Seawalls are generally built along the coastline to advance a coastal frontage into the sea, to protect the land from erosion and flooding or to provide an amenity function. A buried seawall will be installed adjacent to development along the beaches within the Proposal area. Although the location of the buried seawall has not been finalised, the following characteristics will be incorporated into the design:

- sea walls will only be exposed to waves during extreme weather events
- consideration of appropriate crest height of storm waves
- consideration of the variability of the natural system as well as any additional clearances (e.g. to road reserves, property etc).

The sea wall will act as a demarcation between the coastal zone and the adjacent development reserves, as is required by SPP 2.6 (WAPC 2003). The structure will act to mitigate the erosive effects of a severe storm on infrastructure and developed land.

Internationally, the recommended best practice has been developed with the aim to raise coastal systems with rising sea levels i.e. as sea level rise increases. The buried seawall will also serve as a foundation element to allow the height of the coastal system to be raised while affording protection against shoreline retreat.

Beach nourishment

As outlined in Section 3.4, the construction of breakwaters and other shoreline structures can interrupt longshore transport and cause realignment of the beach fronts.

Developed beaches fronting the Proposal area may require maintenance to improve and protect social amenity and public access to offset the loss of a small amount of beach. Given the low energy environment, infrequent storm events and compartmentalisation of the beaches of the Mangles Bay area, maintenance requirements are expected to be very small. The reoriented beaches designed with a buffer for short and medium-term variability should require no more maintenance than the current shoreline segment already managed by the City of Rockingham.

The City of Rockingham currently excavates approximately 10,000 m^3 of sand yearly from the sand trap west of the Garden Island Causeway (JFA 2011). A portion of this sediment may potentially be deposited along the beaches at Mangles Bay as part of an integrated adaptive management strategy for this coastal segment.

Beach nourishment, if undertaken regularly and coupled with regular monitoring of sand levels, will afford protection against long-term shoreline erosion, ensuring that the beaches retain their width over time. Episodic maintenance can be expected to be small in quantity and in excess of 10 year intervals and generally only in response to adaptation to projected rising sea levels over the next 100 years.

11.5.2 Coastal Setback Management

Existing coastal setback requirements for Mangles Bay

The existing coastal setback requirements for the beaches at Mangles Bay were defined in the Southern Perth Metropolitan Coast Coastal Setback Study (MRA 2005). Four components have been considered in identifying the setback requirements at Mangles Bay as summarised in Table 45. These four components were addressed to calculate setback requirements for the Proposal (JFA 2011).

Table 45 Summary of previous setback requirements for Mangles Bay

Setback component	Setback calculations (MRA 2005)
(S1) Distance for absorbing Acute Erosion.	Storm erosion potential in the vicinity of the Proposal area at 7 m.
(S2) Distance to allow for Historic Trend.	Historic erosion trend of 65 m.
(S3) Distance to allow for Sea Level Change.	Allowance for sea level in the vicinity of the site with a 100 year planning horizon of 38m using the Bruun Rule. Under the revision of the sea level rise allowance to 0.9m in recent coastal planning guidance for sea level rise and its application to coastal planning (DoT 2010) this would be calculated to give an S3 allowance of 90m.
Regional Setback allowances – 100y.	MRA (2005) calculated a total setback in the vicinity of the site with a 100 year planning horizon of 110m. Under current guidance for S3 to allow for sea level rise, this would be 162m. A setback of this proportion does not currently exist within this coastal sector.

Setback calculations for the Proposal

The recommended coastal setback allowance calculation, as outlined in SPP 2.6 (WAPC 2003) is comprised of three distinct components, each of which have been addressed for the Proposal (JFA 2011). The calculated setback requirement for the Proposal also considered the management structures and beach nourishment activities which have been incorporated into the Proposal design. Table 46 summarises the setback requirements of the Proposal as per SPP 2.6 requirements.

Table 46 Setback requirements of the Proposal

Setback component	Calculated setback distance	Distance considering management measures
(S1) Distance for absorbing Acute Erosion	<10 m	0 m
(S2) Distance to allow for Historic Trend	20 m	20 m
(S3) Distance to allow for sea level change	90 m	0 m
Final setback distance	20 m	

(S1) Distance for absorbing Acute Erosion

The (S1) component of SPP 2.6 (WAPC 2003), was calculated as <10 m, which is in agreement with MRA (2005) calculations. However, the implementation of coastal defence structures (buried seawall), coupled with active beach management (beach nourishment) is considered to mitigate the effects of infrequent storm erosion thus eliminating the requirement for the (S1) setback buffer as this will be incorporated into the minimum allowance of (S2) below. It is also noted that nourishment sources within the Proposal area are available for future management.

(S2) Distance to allow for Historic Trend

Shoreline movement trends were estimated from shoreline movement plans produced by DPI (DoT 2009). In all compartments, the rate of shoreline movement was assessed as having either 0 m net erosion trend since 1988 or to be accretionary unless disturbed by anthropogenic factors. This is generally attributed to the stabilising influence of coastal structures within the Proposal area coastal segment. Therefore, the shoreline along the Proposal area has been identified as stable and a 0 m net historic trend assumed.

In addition, the construction of a buried seawall will protect against long-term beach erosion. In this regard, to allow for natural variability and ease of management, the minimum (S2) component of the setback allowance at Mangles Bay of 20 m is considered appropriate.

(S3) Distance to allow for sea level change

As per SPP 2.6 (WAPC 2003) guidelines, the (S3) component of the setback allowance at Mangles Bay has been calculated as 90 m. However, active beach management in conjunction with coastal defence structures (buried seawall) will be used as an adaptation strategy to maintain the position of the shoreline, to mitigate against the effects of sea level rise. Changes to the beach height and crest levels to manage impacts can be implemented in the future, if required. In this regard, the requirement for the (S3) setback buffer is eliminated.

11.6 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

It is expected that the implementation of the coastal management activities (Section 11.5) will have the following outcomes relating to coastal processes:

- reorientation of beach profiles at Mangles Bay, with sediment deposition on either side of the marina breakwater
- minor seagrass accumulation in the dredge channel and harbour
- minimal impact to development and foreshore area by sea level rise and storm events.

12. Benthic primary producer habitat impact assessment

12.1 Relevant environmental objectives, policies, guidelines, standards and procedures

12.1.1 EPA Objective

The EPA environmental objective for Benthic Primary Producer Habitat (BPPH) is:

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.

12.1.2 Legislation, policy and guidance

EPA Environmental Assessment Guidelines No. 3

EPA Environmental Assessment Guideline No. 3 '*Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment'* (EAG No. 3; EPA 2009b) recognises the fundamental ecological importance of BPPH and the potential consequences of their loss for marine ecological integrity. BPPHs are defined as seabed communities within which algae, seagrass, mangroves, corals or mixtures of these groups are prominent components; and also include areas of the seabed that can support these communities.

Environmental Protection Principles

EAG No. 3 expects the following hierarchy of principles to be addressed by all proponents when assessing proposals that could cause damage/loss of BPPH (EPA 2009b):

1. All proponents should demonstrate consideration of options to avoid damage/loss of BPPH (Section 12.3.1).
2. Where avoidance of BPPH is not possible, then design should aim to minimise damage/loss of BPPH and proponents will be required to justify the need for damage/loss of BPPH (Section 12.3.2).
3. Proponents will need to demonstrate 'best practice' design, construction methods and environmental management aimed at minimising further damage/loss of BPPH through indirect impacts. This item is addressed through the impact assessment and management options of this PER (Sections 12.4 and 12.6).

The Proponent has addressed each of these principles through the consideration of options or alternatives for the Proposal (Section 12.3). The management of construction methods in order to minimise effects on BPPH (including direct losses as well indirect losses such as shading effects) will be outlined in the CEMP. Potential impacts and management, including the offset of seagrass losses through rehabilitation within Cockburn Sound are described in Section 12.6. These principles are also outlined below in EPA Environmental Assessment Draft Guideline No. 7 '*Marine Dredging Proposals'* (EAG No. 7; EPA 2011).

Local Assessment Units

The EPA has provided a risk-based spatial assessment framework for evaluating cumulative irreversible loss of and/or serious damage to BPPHs (EPA 2009b). The EPA has termed the areas within which to calculate cumulative losses 'Local Assessment Units' (LAU). The proponent is required to determine the boundary of the LAU.

There are six categories of marine ecosystem protection (category A through to F) defined in EAG No. 3 and used to define the cumulative percentage loss threshold for BPPH within any defined LAU. In order to apply an appropriate protection category, the following calculations of the spatial extent of BPPH are required (EPA 2009b):

- prior to all human induced disturbance (i.e. prior to European habitation)
- estimate of existing losses at the time of the proposal
- the additional loss or damage as a result of the proposal (i.e. cumulative losses of BPPH).

Cockburn Sound is defined by the EPA as a LAU with an area of 105.7 km^2 (10 570 ha); and includes the region bounded by the east coast of Garden Island, a line drawn from the north end of Garden Island across to Woodman Point, along the eastern shore of Cockburn Sound and the causeway linking Rockingham to Garden Island. The proposed loss and previous habitat loss are totalled to determine a cumulative impact that is assessed by the EPA in light of the ecosystem's level of protection. The Guidelines classify Cockburn Sound as a Category F: areas where cumulative loss guidelines have been significantly exceeded (refer Section 12.2.1). Due to the application of this category, proposals in Cockburn Sound (including Mangles Bay) must therefore not cause any net damage/loss of seagrass.

EPA Environmental Assessment Guidelines No. 7

EPA Environmental Assessment Guideline No. 7 '*Environmental Assessment Guideline for Marine Dredging Proposals'* (EAG7, EPA 2011) sets out guidance for predicting impacts to benthic communities and habitats due to significant dredging activities, to ensure these are presented in a clear and consistent manner. In particular, it advocates a spatially-based zonation scheme for the predicted extent, severity and duration of impacts, as follows:

- Zone of High Impact (ZoHI) - the area where impacts on benthic communities are predicted to be irreversible (defined as lacking a capacity to return or recover to a pre-dredging state within a timeframe of five years or less)
- Zone of Moderate Impact (ZoMI) - the area where predicted impacts on benthic communities are expected to be sub-lethal, and/or the impacts recoverable within a period of five years following completion of the dredging activities
- Zone of Influence (ZoI) - the area where changes in environmental quality associated with dredge plumes are predicted, but these changes are not expected to result in a detectible impact on benthic communities.

Predicted impacts as per EAG7 (EPA 2011) requirements are provided in Section 10.4.

Western Australian Government's Environmental Offsets Policy

The Western Australian Government's Environmental Offsets Policy provides the overarching framework that underpins environmental offset assessment and decision-making in Western Australia. The use of environmental offsets is underpinned by six principles:

1. Environmental offsets will only be considered after avoidance and mitigation options have been pursued.
2. Environmental offsets are not appropriate for all projects.
3. Environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being impacted.
4. Environmental offsets will be based on sound environmental information and knowledge.
5. Environmental offsets will be applied within a framework of adaptive management.
6. Environmental offsets will be focussed on longer term strategic outcomes.

The policy also specifies the need for detailed guidelines on the respective roles and responsibilities of relevant parties; legislative requirements; and assessment and decision making processes, auditing, monitoring and review to be prepared in consultation with key stakeholders. Further, it describes the Offsets Register intended to provide a public record of all offset agreements in WA in a centralised form, and that includes the following information:

- spatial location of the offset;
- type of offset and values being offset;
- compensatory values of the offset;
- timelines for implementation; and
- agency that is responsible for monitoring the environmental offset.

EPA Position Statement No. 9

EPA Position Statement No. 9 '*Environmental Offsets*' (EPA 2006c) sets out the EPA's overarching policy for the use of environmental offsets in the context of EIA in Western Australia. The EPA's policy position is that environmental offsets should be used with an aspirational goal of achieving a 'net environmental benefit'. The policy includes guiding principles and a decision framework for the use of environmental offsets. The guiding principles of the policy are as follows:

- Environmental offsets should only be considered after all other reasonable attempts to mitigate adverse impacts have been exhausted
- An environmental offset package should address both direct offsets and contributing offsets
- Environmental offsets should ideally be 'like for like or better'
- Positive environmental offset ratios should apply where risk of failure is apparent
- Environmental offsets must entail a robust and consistent assessment process
- Environmental offsets must meet all statutory requirements
- Environmental offsets must be clearly defined, transparent and enforceable
- Environmental offsets must ensure a long lasting benefit

These principles have been used in the development of the Proposal's seagrass transplantation offset (Section 12.7).

EPA Guidance Statement No. 19

EPA Guidance Statement No. 19 '*Environmental Offsets – Biodiversity*' (EPA 2008b) sets out the EPA's advice on when offsets are considered to be appropriate as part of the EIA process for a proposal, and how proponents should address and present environmental offsets in those instances. The advice complements EPA Position Statement No. 9, which provides the EPA's overarching policy and position on environmental offsets. EPA Guidance Statement No. 19 provides further clarification in relation to the policy's interpretation and implementation on the following aspects:

- the EPA's expectation for the appropriate use of environmental offsets;
- application of offset principles in relation to significant adverse impacts to biodiversity assets – in particular the 'like for like or better' principle;
- situations where the application of offset principles are extremely difficult or challenging to implement;
- timing of offset considerations during the EIA process; and
- transparency and auditing effectiveness of offsets packages.

With respect to the third bullet point above, at the time at the time Guidance Statement No. 19 was written the success of seagrass restoration techniques was still considered unproven, and so it states that "*...offsets (particularly direct offsets) in the marine environment pose significant technical and tenure-related difficulties"*. It therefore advises that "*Proponents should be mindful of the difficulties in developing and implementing marine-based offsets before proceeding with these*". As seagrass transplantation now has a proven track record in Cockburn Sound (Section 12.7), it has been used as an offset in the Proposal.

The *State Environmental (Cockburn Sound) Policy 2005* (Cockburn Sound SEP) establishes the framework within which Cockburn Sound and the adjacent land (the Cockburn Sound catchment) are to be managed so as to protect environmental quality in the Sound. The Cockburn Sound SEP establishes a risk-based approach to environmental management, which is underpinned by EVs and spatially defined EQOs (Government of Western Australia 2005b) to ensure the EVs are protected (Table 47).

Table 47 Environmental values and environmental quality objectives for Cockburn Sound

Environmental values (EVs)	Environmental Quality Objectives (EQOs)
Ecosystem health	Maintenance of ecosystem integrity in terms of structure (e.g. biodiversity, biomass and abundance of biota) and function (e.g. food chains and nutrient cycles).
Seafood safe for eating	Maintenance of aquatic life for human consumption, such that seafood is safe for human consumption when collected or grown.
Aquaculture	Maintenance of aquaculture, such that water is of a suitable quality for aquaculture purposes.
Recreation and aesthetics	Maintenance of primary contact recreation values, such that primary contact recreation (e.g. swimming) is safe. Maintenance of secondary contact recreation values, such that secondary contact recreation (e.g. boating) is safe. Maintenance of aesthetic values, such that the aesthetic values are protected.
Industrial water supply	Maintenance of industrial water supply values, such that water is of suitable quality for industrial water supply purposes.

EQC have been specifically developed for Cockburn Sound to provide the quantitative benchmarks for measuring success in achieving the EQOs set in the SEP (Government of Western Australia 2005b). There are two types of EQC:

1. Environmental Quality Guidelines (EQGs): threshold numerical values which, if met, indicate a high degree of certainty that the associated EQO has been achieved. If the guideline value is not met then a more detailed assessment process against an environmental quality standard is triggered.
2. Environmental Quality Standards (EQSs): threshold numerical values that indicate a level beyond which there is a significant risk that the associated EQO has not been achieved and a management response is triggered (Government of Western Australia 2005b).

The ecological EV of ecosystem health has different EQC for zones of high, moderate and low ecological protection, whereas the social EVs (safe seafood, aquaculture, recreation and aesthetics, and industrial water supply) have the same EQC applied throughout Cockburn Sound.

There are specific EQSs for seagrass health established under the Cockburn Sound SEP (EPA 2005a), based on annual measurements of seagrass shoot density in summer. As with phytoplankton biomass EQC (refer Section 10.2.2), comparisons are made to percentiles derived from reference site data that are updated each year. There is an EQS that must be met in each current year, and an EQS that must be for two concurrent years.

For the high ecological protection area the EQSs are:

1. Ambient values for seagrass shoot density during January and in two consecutive years ("2-year EQS") are:
   - greater than the 20th percentile of seagrass shoot density at an appropriate reference site

     or
   - greater than the value for that indicator as specified in Table 48.
2. Ambient values for seagrass shoot density in any one year ("1-year EQS) are:
   - greater than the 5th percentile of seagrass shoot density at an appropriate reference site

     or
   - greater than the value for that indicator as specified in Table 48.
3. The upper and lower depth limit of seagrass meadows must not show a statistically significant retreat relative to baseline distribution.

Table 48 Numerical environmental quality criteria for seagrass in Cockburn Sound for 2011

Environmental Quality Indicators (seagrass)	EQS's (High protection)
2-year EQS shoot density (shoots m-2)	
1.5 – 2.0 m depth	775
2.0 - 3.0 m depth	625
3.0-4.0 m depth	425
5.0 – 6.0 m depth	425
7.0 - 8.0 m depth	150
1-year EQS (shoots m-2)	
1.5 – 2.0 m depth	438
2.0 - 3.0 m depth	390
3.0-4.0 m depth	108
5.0 – 6.0 m depth	150
7.0 - 8.0 m depth	75

Source: Data provided courtesy of the CSMC

The ongoing (operational) effects of the Proposal on the marine waters of Cockburn Sound will be assessed in terms of these EQSs. A baseline seagrass health survey was conducted at four sites in Mangles Bay in March 2011 (refer Section 12.2.2) to ascertain the status of seagrass health prior to the proposed development. Temporary effects due to construction (e.g. turbidity and any nutrient-related effects during dredging) will be managed and monitored separately (although still based on measures of seagrass shoot density), as they are likely to take place outside the summer monitoring season targeted by the Cockburn Sound SEP (refer to the CEMP, Appendix 1).

12.1.3 Shoalwater Islands Marine Park Management Plan

The SIMP borders Mangles Bay at the Garden Island Causeway (Figure 87). The SIMP covers an area of approximately 6545 ha and contains the waters of Shoalwater Bay, Warnbro Sound and a part of Cockburn Sound off Cape Peron. The SIMP is vested to the MPRA, and managed by the DEC, apart from recreational fishing which is managed by the DoF in close cooperation with DEC. The Shoalwater Islands (i.e. the terrestrial portion) are managed under the 1992 Shoalwater Islands Management Plan.

The *Shoalwater Islands Marine Park Management Plan 2007–2017* (the management plan) was formally approved by the Minister for the Environment in August 2007 (DEC 2007). The management plan sets out, among other things, a zoning scheme and a 'best practice' model for managing the identified ecological and social values of the SIMP. The zoning scheme proposes that the areas to the north of

Cape Peron (to the west of the Causeway) be within a General Use Zone. Shoalwater Bay (on the southern side of Cape Peron) is a recommended Special Purpose Zone for wildlife conservation, and further south are two sanctuary zones (at Second Rock, and Becher Point), and a Special Purpose Zone for Special Purpose Zone for scientific reference at Murray Reef.

Each ecological and social value for the SIMP has identified management objectives, strategies, performance measures and targets to achieve. For example, the management objective for seagrass communities in the SIMP is summarised as:

> *Seagrass is an important primary producer and the extensive and diverse perennial seagrass meadows are important habitats for invertebrates and finfish.*

Performance measures for seagrass include diversity and biomass. Short-term targets are to be developed as required, while long-term targets include no net loss of seagrass species diversity as a result of human activity in the SIMP; and no loss of perennial seagrass biomass as a result of human activities in the SIMP (DEC 2007). The Proposal area lies outside the boundary of the SIMP, however these objectives, strategies, performance measures and targets have been considered in order to mitigate any potential for indirect or flow-on effects from the construction and operation phases of the Proposal.

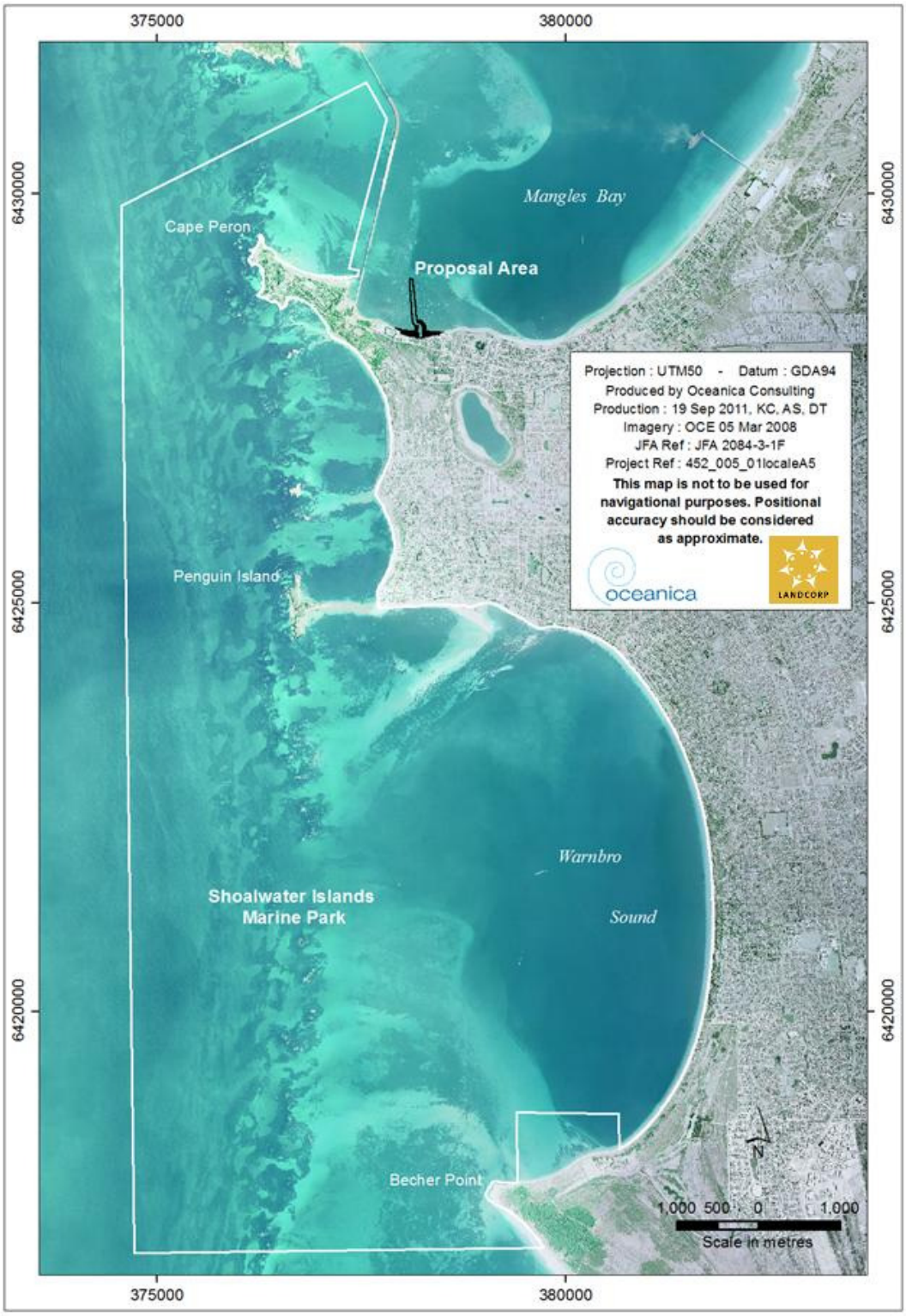


Figure 87 Shoalwater Islands Marine Park boundary

12.2 Findings of surveys and investigations

12.2.1 Historical seagrass loss

Cockburn Sound has a history of poor water quality and large-scale loss of seagrass meadows dating from the 1960s and 1970s. Although environmental conditions have improved markedly since the 1970s, a legacy of this past is that water quality and seagrass meadows remain key environmental concerns. In Cockburn Sound, seagrass meadows originally occupied approximately 4000 ha (predominantly *Posidonia* sp.) and covered much of the seabed where water depths were less than 8-10 m (DEP 1996). Between 1942 and 1957, seagrass cover and distribution remained relatively unchanged, however between 1957 and 1968 there was a gradual retreat of meadows from the deeper margin of the eastern bank and thinning along portions of the adjacent shoreline. By 1972, most of the seagrass meadows on the eastern margin had disappeared and by the late 1970s only about 900 ha remained, with an estimated 750 ha remaining in 1993 (DEP 1996). The need for the protection of the remaining seagrass meadows and potential seagrass habitat is identified in the EPA's Strategic Environmental Advice on the Marine Environment of Cockburn Sound (Bulletin 907, EPA 1998), and at the time the advice was written the success of seagrass restoration techniques was also unproven.

The shallow flats of Mangles Bay contain approximately 100 ha of seagrass, comprising the main area of seagrass meadow that remains on the eastern shore of Cockburn Sound between the Causeway and Woodman Point. Loss of seagrass is one of the two primary marine environmental issues relevant to the Proposal identified in the EPA's Bulletin 1237 in its strategic advice to the Minister for the Environment, under section 16(e) of the EP Act (EPA 2006b).

In Mangles Bay there has been an estimated 3 ha of seagrass loss due to mooring scars, as detailed in Section 12.2.3.

12.2.2 Seagrass health monitoring

Maintaining existing seagrass meadows within Cockburn Sound is one of the EPA's key environmental objectives, with seagrass shoot density also used as an indicator of seagrass health under the Cockburn Sound SEP (EPA 2005a). In assessing seagrass health, monitoring of sites in Cockburn Sound is compared against a reference site in Warnbro Sound, which is assumed to be unaffected by the same pollution pressures as Cockburn Sound (Auditor General 2010).

The Proponent undertook a baseline survey of seagrass health at two sites (one either side of the Garden Island Causeway) during January 2010 (Figure 88). In addition four long-term seagrass health monitoring sites were established in March 2010. These sites were located approximately 100 m and 200 m distance either side of the proposed marina channel in water depths of approximately 2 m, to allow future comparison with Cockburn Sound EQC (Figure 88). The results of these two studies are described below.

Preliminary assessment of seagrass health 2010

Seagrass monitoring was undertaken during January 2010 in *Posidonia sinuosa* meadows at one site west of the causeway (Site MBW, water depth 2.6 m) and one site to the east of the causeway in Mangles Bay (Site MBE, water depth 1.4 m) (refer Figure 88). Shoot density counts were documented based on standard operating procedures established for the Cockburn Sound SEP (EPA 2005b) (refer Appendix 5).

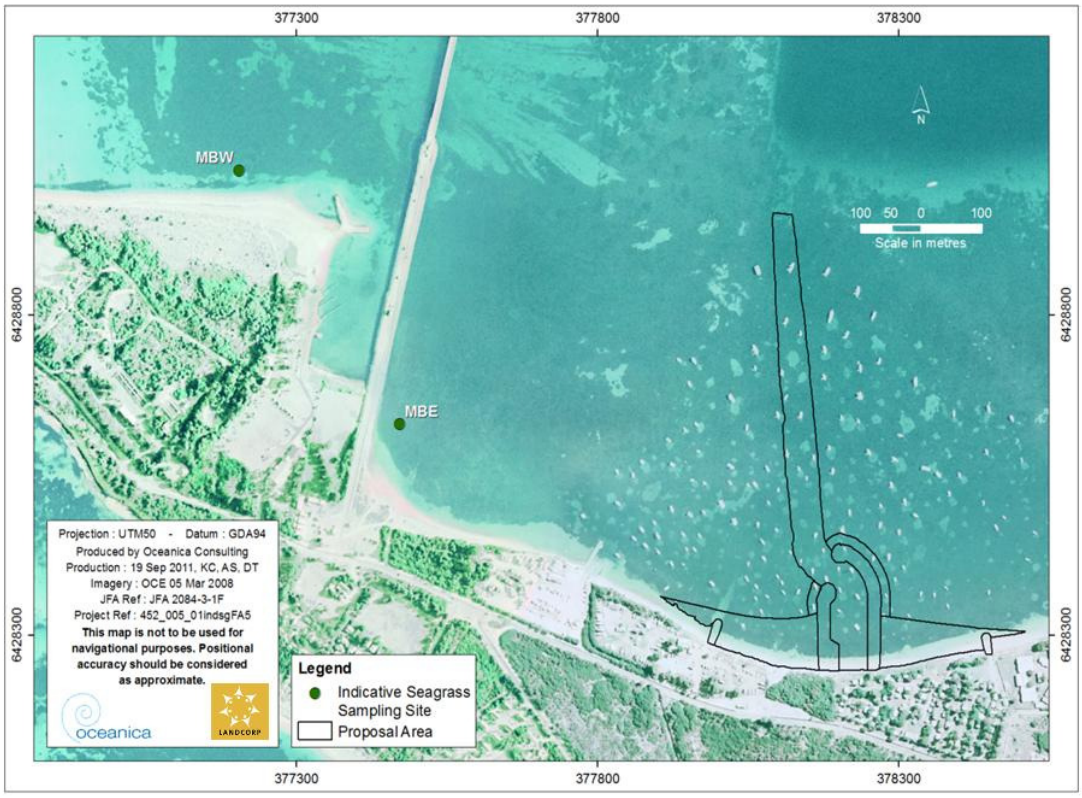


Figure 88 Seagrass health monitoring sites in Mangles Bay, summer 2010

The average shoot density for *Posidonia sinuosa* at the site west of the causeway (656 ± 76) was greater than the site east of the causeway in Mangles Bay (399 ± 40). The median shoot density count for *P. sinuosa* at site MBW was 544/m^2 and at MBE was 376/m^2 (Table 49). The median for the reference site (MBW) met the 1 year shoot density EQS for high ecological protection, but the potential impact site (MBE) did not (Table 49).

Table 49 Seagrass shoot density counts (1 m^2) at Mangles Bay, January 2010

	Site MBW (water depth 2.6 m) 2	Site MBE (water depth 1.4 m)3
Mean ± S.E.	656 ± 76	399 ± 40
Median	544	376
High protection area EQS for 1 year1	**375**	**458**

[1] Cockburn Sound Environmental Quality Standard (EQS) for a high ecological protection area derived from data obtained between 2003 and 2010 for Warnbro Sound.

[2] EQS based on Warnbro Sound data for 2.0 to 3.0 m water depth. Data supplied courtesy of the CSMC.

[3] EQS based on Warnbro Sound data for 1.5 to 2.0 m water depth. Data supplied courtesy of the CSMC.

Seagrass health 2011

Seagrass monitoring was undertaken in March 2011 using standard operating procedures established for the Cockburn Sound SEP (EPA 2005b). The seagrass shoot density counts were undertaken in *Posidonia sinuosa* meadows at four sites in water depths of 2.5–3.0 m, apart from one site at a depth of 1.5 m (Figure 89). The 2011 sites adjacent to the Proposal area were specifically located in deeper water than the 2010 survey (where shoot densities easily met the 1 year EQS for a high ecological protection area), as these were expected to be more sensitive to lesser water quality. Although attempts were made to locate all sites along the 2.5–3.0 m depth contour, the rapid shallowing of waters towards the Causeway meant that this was not possible for the westernmost site (refer Oceanica 2012, Appendix 5).

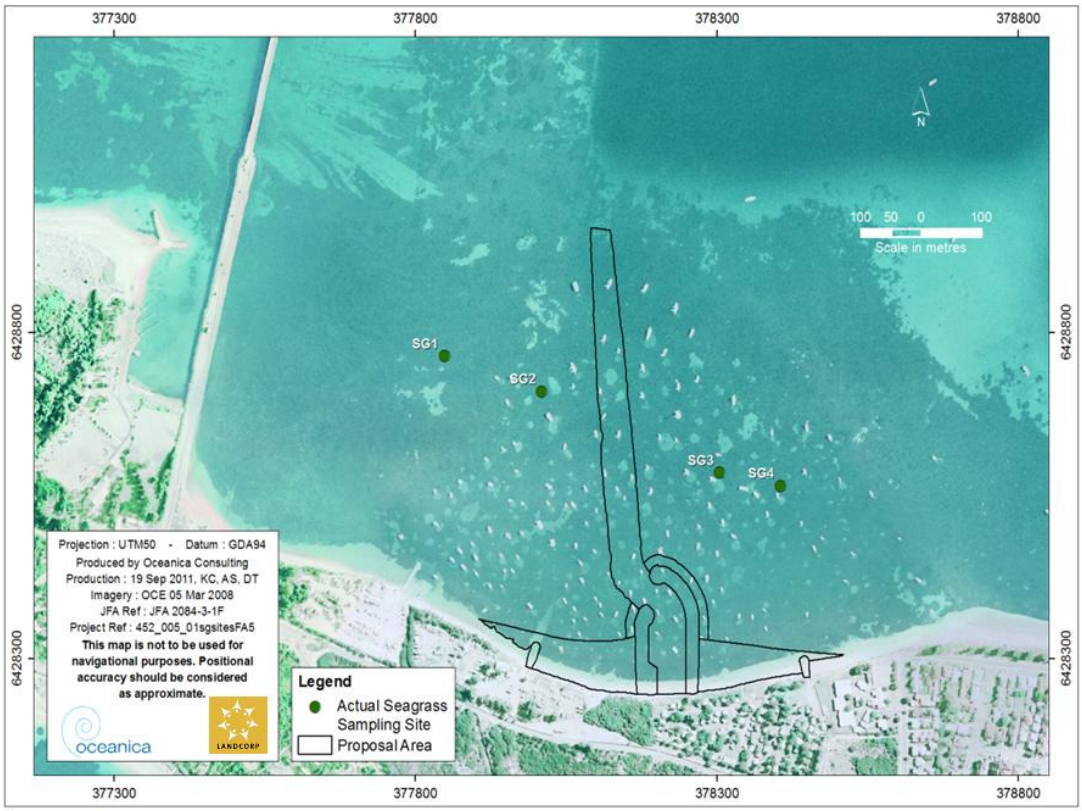


Figure 89 Seagrass health monitoring sites in Mangles Bay, March 2011

The average shoot density for *Posidonia sinuosa* was lowest at site SG4 (447 ± 57) and highest at site SG1 (707 ± 73) (Table 50). The median shoot density count for *P. sinuosa* at all sites met the 1 year shoot density EQS for moderate ecological protection area (Table 50). Sites SG1, SG2 and SG3 met the 1 year EQS for a high ecological protection area, while site SG4 was below the 1 year EQS for a high ecological protection area (Table 50).

Table 50 Seagrass shoot density counts (1 m^2) at Mangles Bay, March 2011

Site	SG1 (1.5 m)	SG2 (2.5 m)	SG3 (3.0 m)	SG4 (3.0 m)
Mean ± S.E.	707 ± 73	822 ± 100	531 ± 64	447 ± 57
Median	713	913	438	363
High protection area EQS for 1 year	**438**[1]	**390**[2]	**390**[2]	**390**[2]

[1] Cockburn Sound EQS derived from data obtained between 2003 and 2011 for Warnbro Sound (1.5 to 2.0 m water depth).

[2] Cockburn Sound EQS derived from data obtained between 2003 and 2011 for Warnbro Sound (2.0 to 3.0 m water depth).

CSMC Report Cards and WA Auditor General' s Report

The CSMC has a routine seagrass monitoring site in Mangles Bay, located in a water depth of 3.2 m, that has occasionally failed to meet the high protection EQS in the past. A review of the Environmental Management of Cockburn Sound in the *Western Australian Auditor General's Report Environmental Management of Cockburn Sound* (Auditor General 2010) showed that seagrass shoot density at Mangles Bay met the EQS between 2005 and 2007, but did not meet the EQS between 2008 and 2010. Shoot density improved in 2011 (in contrast to water quality in 2011), and although the 1 year EQS was met the 2 year EQS was still exceeded (information supplied courtesy of the CSMC).

The Auditor General's report notes that Mangles Bay seagrass health has been a known problem for many years, but there is no clearly identifiable single source contributing to excessive nutrient loads. The report identified Lake Richmond stormwater drain as a significant contributing factor to the nutrient enrichment at Mangles Bay, but also highlighted poor water circulation.

The results of seagrass health monitoring at four sites in Mangles Bay in 2011 undertaken for the Proposal further indicate considerable spatial variability in the 'health' of the seagrass meadows in Mangles Bay (i.e. in addition to the variability with time noted by the Auditor General's Report), as assessed using shoot density counts. As noted earlier, three sites (SG1, SG2 and SG3) met the 1 year EQS for a high ecological protection area, but site SG4 did not.

12.2.3 Seagrass Transplantation in Mooring Scars

Historical analysis of seagrass loss due to mooring scars

As part of preliminary environmental work for the Mangles Bay marina, the extent to which the number of moorings and associated seagrass loss in Mangles Bay has increased over the years was documented. This information had the two-fold purpose of emphasising the need for better management of boating activities, and assessing the potential area of mooring scars available for seagrass transplantation. Historical aerial photography was used for this purpose, to produce a time series of mooring scar damage of seagrass in Mangles Bay (refer Appendix 5).

Of the available aerial imagery for the Mangles Bay region, six years were considered suitable for historical analysis:

- March 1967 (Figure 90)
- May 1972
- June 1981
- March 1999
- March 2002
- March 2008 (Figure 91).

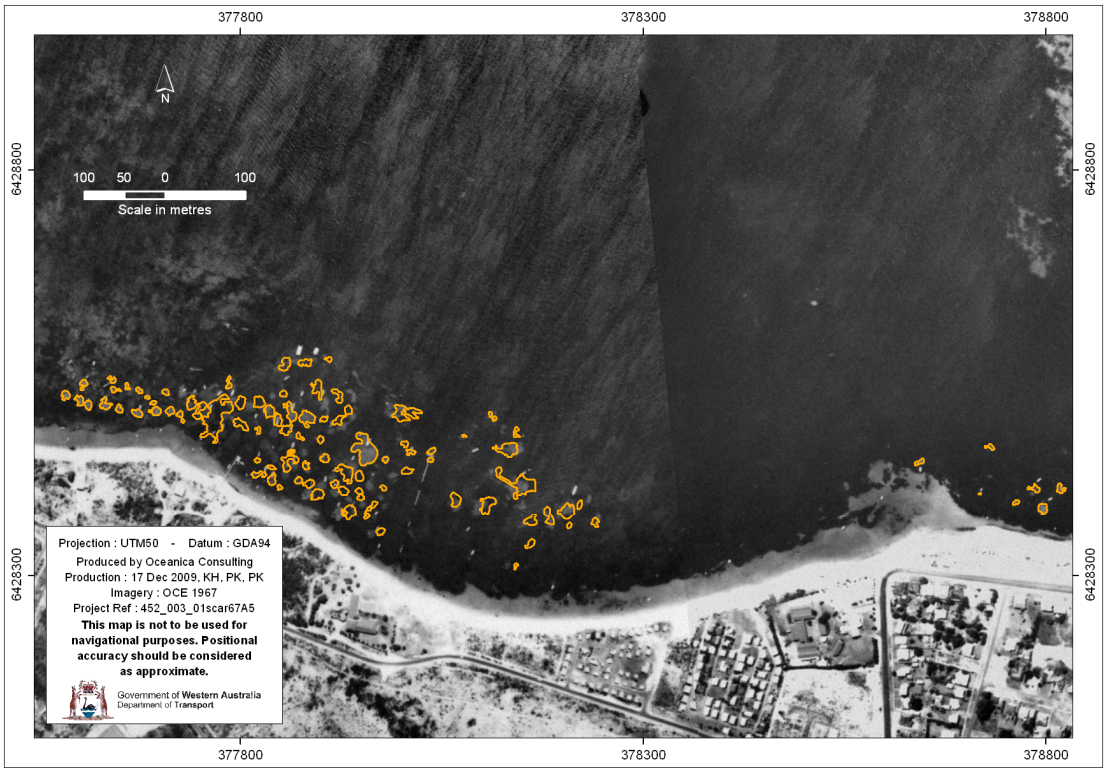


Figure 90 1967 aerial imagery with digitised mooring scars

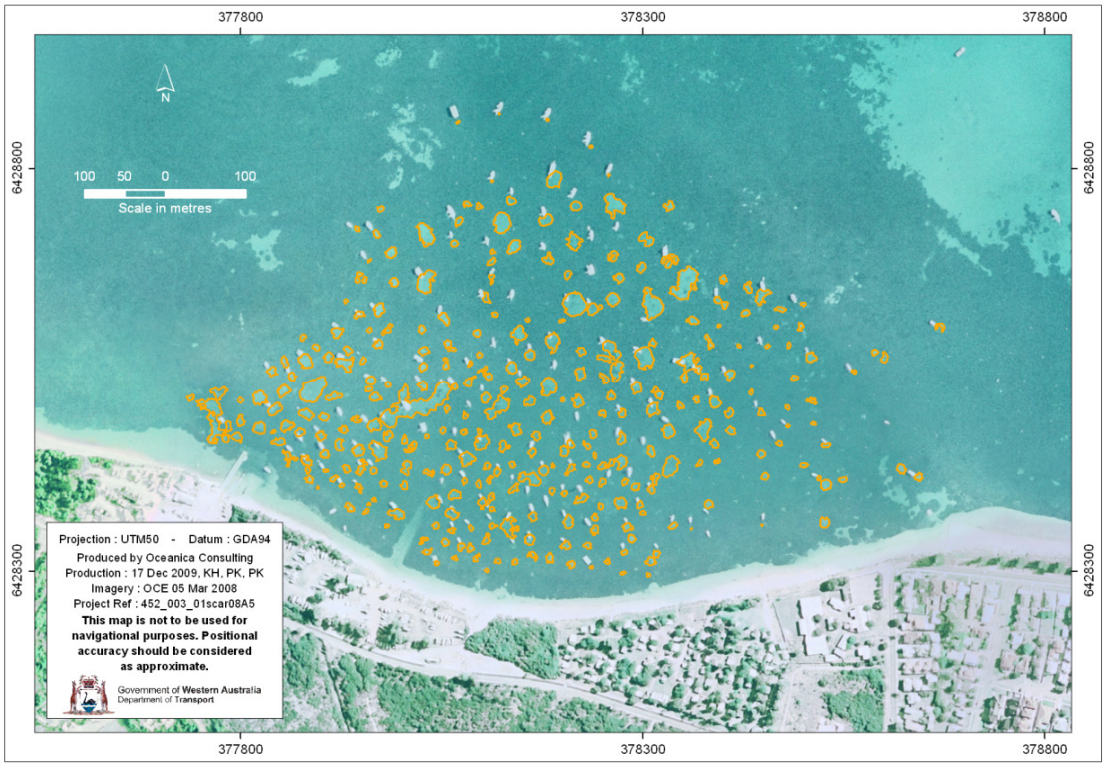


Figure 91 2008 aerial imagery with digitised mooring scars

The results of the analysis showed a considerable increase in the number of mooring scars and subsequent increase in the area of seagrass loss over the investigated period (Table 51). It should be noted that in some cases one mooring scar might cover two or more moorings, while some moorings in the Mangles Bay region are of environmentally friendly design and have no associated mooring scar, hence the disparity with the approximately 600 moorings presently registered with the Department of Transport for Mangles Bay.

Table 51 Historical changes in number of mooring scars and associated seagrass loss in Mangles Bay, Cockburn Sound

Characteristic	Year					
	1967	1972	1981	1999	2002	2008
No. of mooring scars	93	93	114	199	249	312
Area of seagrass loss (ha)	1.06	1.60	2.14	2.71	3.04	3.20

Transplantation trials in mooring scars

Seagrass transplant rehabilitation trials in Mangles Bay were initiated by LandCorp (prior to the appointment of Cedar Woods as the Proponent) in April 2010 to provide local data on the success rate of seagrass transplanting. Seagrass transplantation requires suitable bare substrate to transplant into. Potential transplantation areas identified for the Proposal included the numerous mooring scars in the seagrass meadows of Mangles Bay.

The heavy mooring chains of traditional-style moorings 'scythe' seagrass when a boat swings around on its mooring, and this leaves a characteristic circular bare patch within the seagrass meadow. If traditional-style moorings are replaced by more modern, environmentally-friendly moorings, then the 'scything' effect no longer occurs and the mooring scar is potentially suitable for seagrass to re-grow. Natural re-growth of seagrass meadows into mooring scars can also occur, but is not guaranteed and can be very slow even if it does occur.

Existing moorings were replaced with environmentally-friendly 'Ezyrider' moorings (Figure 92) at three mooring scars (8184, 8185 and 8304, Figure 93) in March 2010, and then transplanted with seagrass by MAFRL. The three mooring scars selected by MAFRL were all in similar water depth (2.7 m), had a similar size scar (~10 m diameter), and were all surrounded by meadows of the seagrass *Posidonia sinuosa* (Oceanica 2012).

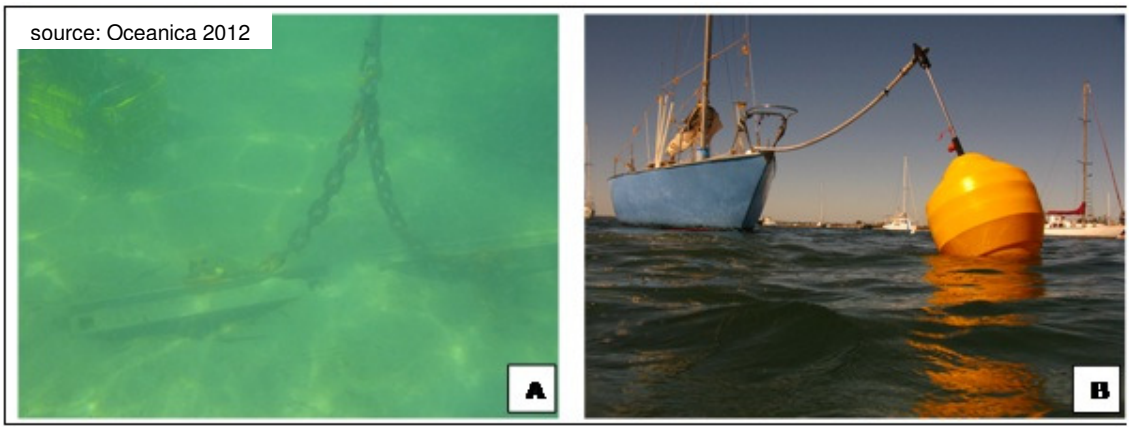


Figure 92 Ezyrider moorings bases (a) beneath and (b) above the water at Mangles Bay

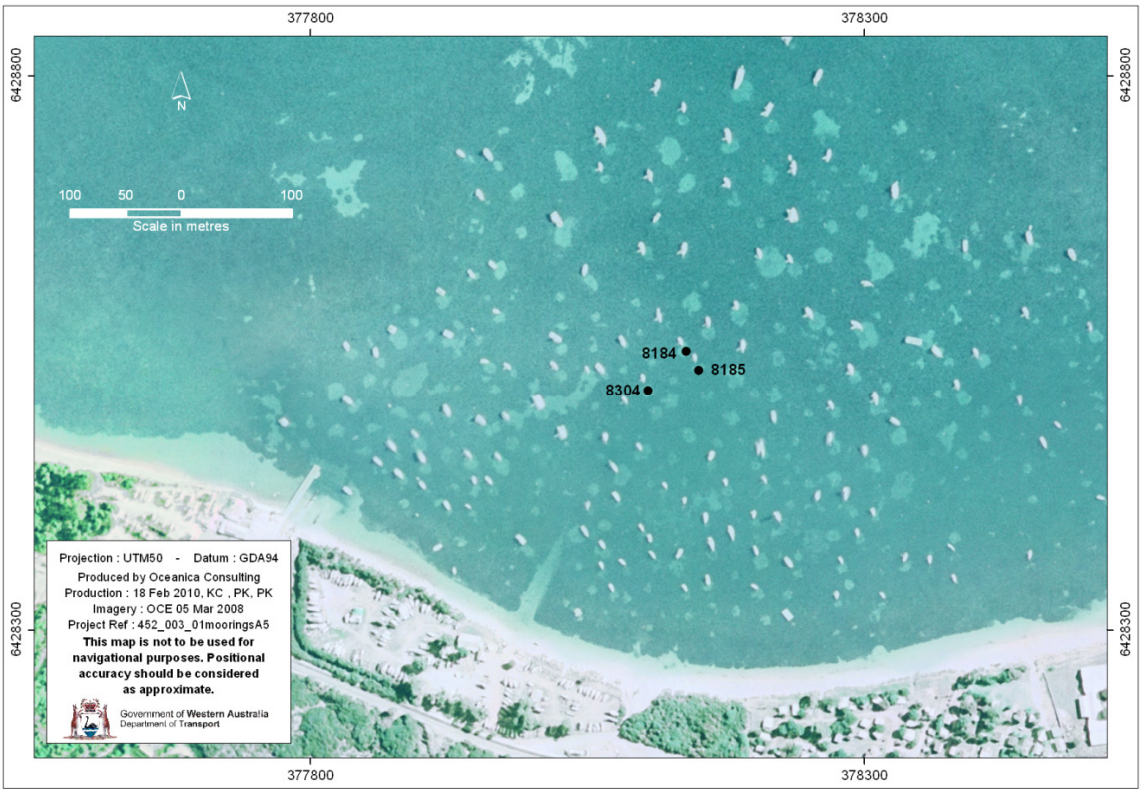


Figure 93 Aerial photograph showing the mooring scars in Mangles Bay for seagrass transplantation trials

The large-scale seagrass rehabilitation techniques developed by MAFRL have undergone considerable improvements in recent years, and based on these results the target species used for the transplanting exercise was *Posidonia australis*. This locally endemic species is found within Cockburn Sound, and is more robust for handling and anchoring than *P. sinuosa*, and therefore better survival and growth are achieved. Once the *P. australis* meadow is established, natural colonisation processes are likely to result in *P. sinuosa* ultimately invading and out-competing the transplanted *P. australis* in the longer-term (Oceanica 2012).

Donor material (*P. australis*) was harvested from an area that has been partially dredged on Parmelia Bank at a depth of 5-6 m (Figure 94a). MAFRL's seagrass rehabilitation research has also shown that donor meadows readily recover from harvesting within approximately two years, and the area used for donor material was located within an area approved for dredging by Cockburn Cement Limited.

Sprigs[12] were harvested from the donor material and then tied to a purpose-designed wire peg (30 cm in length) using two or three biodegradable cable-ties (Figure 94b). Sprigs were collated into groups of five before being secured with string to enable accurate quantification, transport, handling and planting at the planting site (Figure 94c and d). Details on the seagrass transplantation of the three mooring scars, including scar diameter, number of sprigs (*P. australis*) planted and spacing of sprigs is provided in Table 52. The size difference of the sprig and the differing planting densities resulted in a varying amount of sprigs planted in the individual mooring scars.

[12] 'Sprig' refers to 10-20 cm lengths of seagrass rhizome (underground stem) with roots and shoots attached.

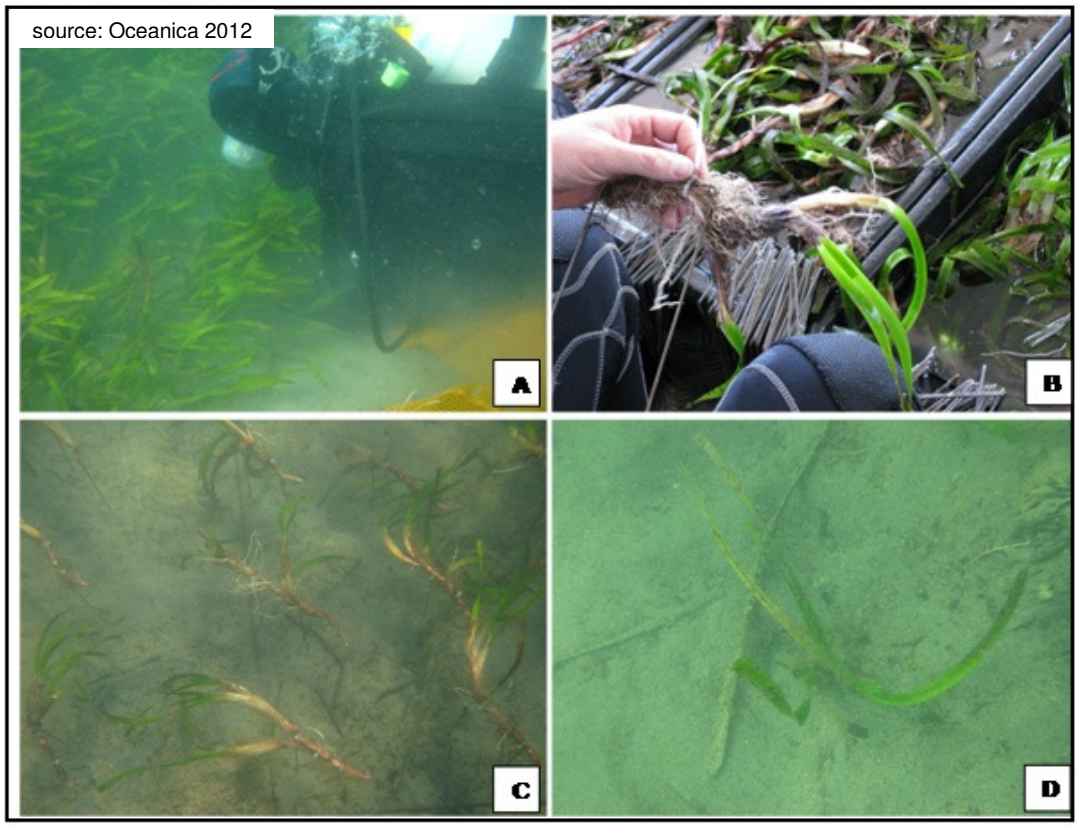


Figure 94 Seagrass rehabilitation techniques: (a) diver harvesting seagrass material from meadow edge, (b) tying sprig onto wire peg, (c) sprigs prior to burial and (d) transplanted seagrass sprig in mooring scar.

Table 52 Mooring scar seagrass transplantation details

Mooring scar	Scar diameter	Number sprigs transplanted	Spacing of transplanted sprigs[1]
8184	9 m	934	0.25 m
8185	8 m	600	Between 0.25 m and 0.5 m
8304	9.5 m	607	Between 0.25 m and 0.5 m

[1] Sprigs initially spaced at 0.5 m and were then filled in with remaining sprigs, resulting in a density between 0.25 m and 0.5 m.

Monitoring of seagrass transplants has been conducted by MAFRL at 3, 6 and 12 months after planting to confirm survival and growth of sprigs (Table 53). Results were as follows:

1. Three months after initial planting the overall survival was 70 %, and casual observations showed bioturbation, low hydrodynamic activity and low light availability as a potential threat of survival in this area.
2. Six months after the initial planting the overall survival was 55.3%, with a decline of nearly 15% since July 2010. Shoots that had survived had grown, with an increase from the initial 2.4 ± 0.1 shoots/sprig in March 2010 to 4.8 shoots/sprig ± 0.63 (mean ± SE [standard error]) in September 2010. Several shoots were observed to be flowering. Observations again showed evidence of bioturbation, low hydrodynamic activity and low light availability as a potential threat of survival of newly planted sprigs in this area, as well as large areas of algal growth.
3. One year after planting, overall survival was 48.2%, and surviving shoots had grown, with an increase from the original 2.4 ± 0.1 shoots/sprig in March 2010 to 7.5 ± 0.7 shoots/sprig (mean ± SE) in March 2011.

Table 53 Survival of seagrass transplants (% survival)

Mooring Scar	July 2010 (3 months)	September 2010 (6 months)	March 2011 (12 months)
8184	74.5 %	56.4 %	46.7 %
8185	63.7 %	50.6 %	59.1 %
8304	70.2 %	58.8 %	38.8 %

Survival expressed as percentage of original number of sprigs initially planted in March 2010.

The survival rates are less than typically found by MAFRL for transplants on nearby Southern Flats in Cockburn Sound, but MAFRL research also indicates that if transplants survive for a year (i.e. they do not get uprooted or washed away by the storms of winter), transplantation is likely to be successful. Casual observations also showed natural re-growth into the mooring scars from the surrounding seagrass beds around the perimeter of the scars, with growth of 25-50 cm from the base markings (Figure 95). Based on the regrowth of existing mature plants into the scars alone, the “infilling” of the scars is estimated by MAFRL to take approximately seven years. The combination of growth of transplanted seagrass and natural regrowth into the scars is estimated by MAFRL to reduce the time it takes to fill in the scars to around four to five years.

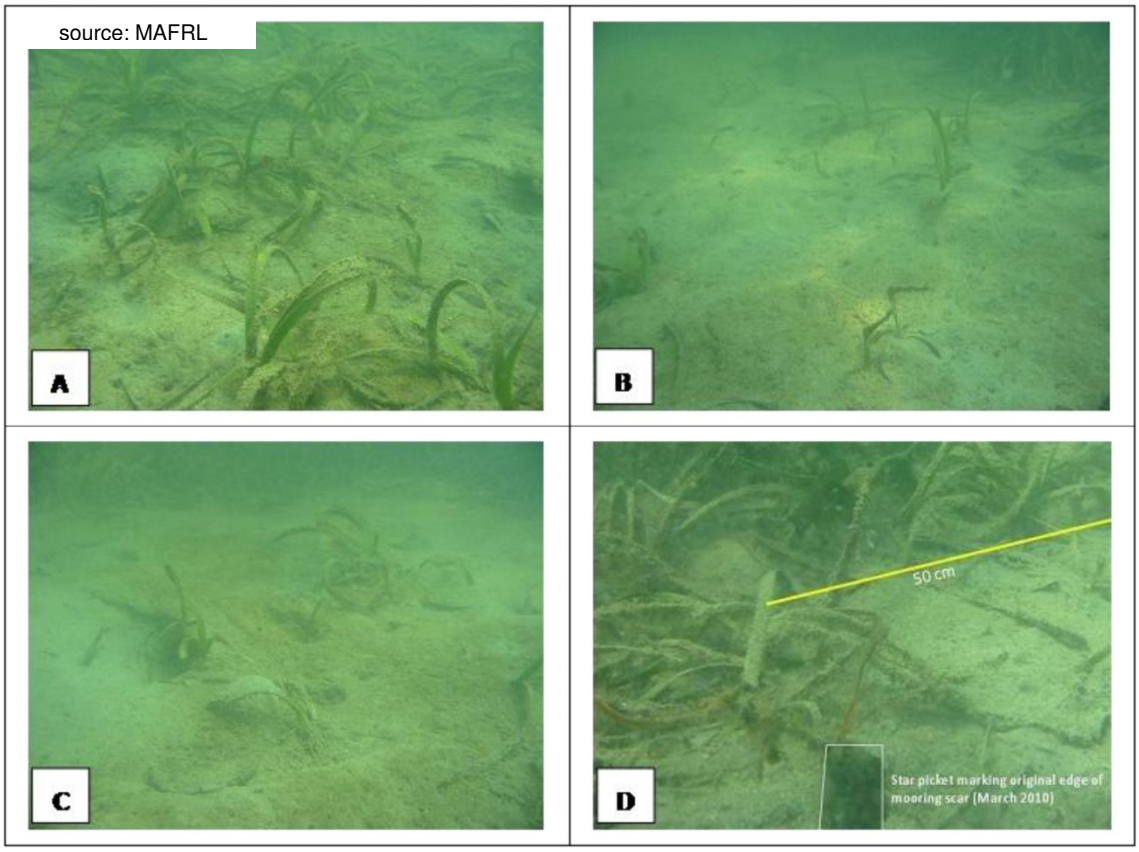


Figure 95 Transplanted shoots at mooring (a) 8184, (b) 8304, (c) 8185 and (d) extension of growth into scar 8184 from surrounding seagrass

12.3 Evaluation of options or alternatives to avoid or minimise impact

The Proposal has undergone a number of variations in order to minimise the environmental impact.

12.3.1 Site selection

Other sites were considered, however the current location was selected because it is an area currently used intensively for recreational boating. As discussed above, the presence of approximately 600 (illegal and legal) moorings within Mangles Bay has resulted in a significant amount of scarring in the seagrass meadows (Section 12.2.1). The location of the Proposal within this already disturbed area is preferable in contrast to other areas with more intact seagrass meadows.

12.3.2 Proposal layout design

The design of the Proposal was selected based on constraints between engineering, planning and the environment. Alternative design concepts have been considered in consultation with the community during the 2005 and 2006 process and the development of the current Proposal. All options involved an inland marina, however each differed with respect to layout and the extent of land footprint. In 1992 as offshore marina option in Mangles Bay was not considered acceptable by the EPA due to the substantial loss of seagrass, even with rehabilitation of seagrass.

A number of adjustments have been made to the Proposal throughout the course of the environmental impact assessment process. A key change has been the shortening the access channel and breakwaters, which serves to create a smaller offshore footprint area and thus a lessened impact in terms of area of seagrass disturbed.

12.3.3 Dredging program

The proposed dredging program for the marina has been designed to avoid or minimise impact on seagrass communities including:

1. Critical windows of environmental sensitivity (defined in EAG No. 7, EPA 2010a) for seagrasses have been considered. The time of year when dredging is proposed to take place is approximately between May and July 2011 when the seagrasses are not actively growing during the winter months.
2. The duration of the dredging program is predicted to be approximately two to three months duration, which is much less than the time taken for shoot loss to occur in *Posidonia sinuosa* even when heavily shaded .
3. Silt curtains will be used (weather and sea conditions permitting) during the dredging process, to control turbidity release and dispersion.

Maintenance dredging is proposed to take place should trigger values indicate it is required. Appendix 1 further details maintenance dredging requirements.

12.4 Assessment of likely direct and indirect impacts

The following aspects of the proposal that have the potential to affect BPPH values include:

- direct removal of seagrass to allow for the construction of the marina access channel and breakwaters
- indirect impacts to seagrass meadows as altered patterns of sediment movement and water flow due to the breakwaters result in the erosion or smothering of seagrass, creating a 'halo' effect around breakwaters
- indirect impacts to seagrass meadows due to the turbidity generated during dredging, and any return water from the settlement basins where dredged material is placed
- indirect impacts due to the relocated and redesigned Lake Richmond drain
- indirect impacts to seagrass meadows as a result of alteration in water quality within Mangles Bay as a result of the creation of the marina
- indirect impacts to seagrass meadows due to the turbidity generated during maintenance dredging
- direct impacts to seagrass meadows due to altered and increased boat movements (e.g. due to keel drag and anchor damage).

The Proposal has been estimated to involve up to 5.66 ha of total seagrass loss (refer Section 12.5), comprising direct seagrass removal of up to 5.36ha, and indirect loss (based on a 15 m halo effect around the breakwaters) of up to 0.3 ha. The target for the total area of seagrass rehabilitation will exceed the total losses (refer Section 12.6.1). There are no impacts to BPPH expected as a result of construction of the marina, due to turbidity plumes (as discussed in the marine water quality in Section 10) or the relocation and redesign of the Lake Richmond drain. Nor are ongoing additional impacts to BPPH expected due to altered and increased boat movements, turbidity generated during maintenance dredging, or outflow of lesser quality water from the marina. These potential effects are discussed further below.

As the Proposal lies outside the boundary and is within the sheltered southern end of Cockburn Sound, it is not expected that the construction and operation phases will have an impact on the SIMP.

12.4.1 Direct losses

Losses due to the development footprint (access channel and breakwaters)

The Proposal involves the direct removal of seagrass through dredging for the construction of the breakwaters, reclamation areas, channel and batters (Figure 7). The channel will be dredged using a "cutter suction dredge" in winter and the works are anticipated to take less than three months. Dredged material will be pumped to settlement and infiltration basins located within the Proposal area adjacent to the coast (Figure 9). As there will be no placement of dredge material directly either side of the dredge operation area, the area of seagrass directly impacted will be confined to the cut areas.

Losses due to altered and increased boat movements

Present boating activities in Mangles Bay have resulted in some seagrass loss, largely due to boat launching (and associated keel drag) across the beach adjacent to the premises of the local yacht club (The Cruising Yacht Club) and fishing club (Mangles Bay Fishing Club). Losses due to boat launching are particularly evident at the boat launching site 200 m east of the Mangles Bay Fishing Club jetty.

The Proposal involves the planned removal of the yacht club and fishing club's private boat ramps (and relocation to premises within the Proposal), and the cessation of most boat launching on the beach (it is proposed that the junior sailors can continue to launch their sailcraft from the beach). This should reduce scouring damage in the area and allow natural regeneration of seagrass.

Boating activity can also cause damage to seagrass due to keel drag and anchor drag. At present, recreational boating pressure within the shallow waters of Mangles Bay is largely due to the boats associated with the 650 registered moorings in the Bay (fishing occurs from moored boats, refer Section 16.2.2), boats launched from the private boat ramps of the yacht club and the fishing club in Mangles Bay, and boats launched at Cape Peron public boat ramp and Palm Beach public boat ramp (the two public boat ramps closest to Mangles Bay) (refer Figure 112).

The Proposal will not result in any further increases in trailerable boats other than those due to the regional population growth predicted by the Department of Transport, but will potentially result in an additional 128 non-trailerable boats in the medium-term (by 2018) (refer Section 16.4.3). The non-trailerable boats in the marina are expected to be stay within the access channel and not add to boat movements over seagrass meadows in Mangles Bay: mooring congestion to the east of the access channel will discourage movements into this area, and keel clearance will prohibit movement into the very shallow waters west of the access channel. The non-trailerable boats in the marina are expected to head out the marina access channel to Southern Flats, to the SIMP via the northern Causeway entrance, or to eastern side of Garden Island.

12.4.2 Indirect losses

Losses due to construction dredging

There are no indirect losses of seagrass expected due to turbidity generated during construction activities, as water quality modelling indicates this will be minimal (values of 5 mg/L or less only occurring outside the access channel footprint for 1% of the time for the duration of the dredging program), as well as being highly localised and short-lived (three months) (refer Section 10.4).

Additionally recent research undertaken on the effects of shading on *Posidonia sinuosa* in Cockburn Sound (Collier *et al* 2009) indicates that it can tolerate much greater periods of heavier shading than conditions anticipated during the proposed dredging for the Proposal. The time taken for shoot loss to occur in *P. sinuosa* is generally longer than for other seagrass species (3–6 months), with some shoots surviving over 12 months under conditions below minimum light requirements (Collier *et al*. 2009 and references contained therein). Results of the experiments showed that shoot density declined by 82%

within 105 days under the heavy shade treatment, though 6% of shoots remained after 198 days. Collier *et al*. (2009) estimate that complete shoot loss in high shade would have taken two years.

Dredged material will be placed in settlement basins within the Proposal area and the marine water allowed to infiltrate, but some water will be returned to the ocean via overflow channels. The water quality and velocity levels at the overflow will be managed such that they do not impact on the marine environment (refer to Section 10.4), therefore no losses of seagrass are anticipated due to turbidity associated with the return water.

Losses due to maintenance dredging

The Proposal is located in an area of minimal sediment movement (refer Section 11.1.6) and it is therefore anticipated that maintenance dredging will be required (see Appendix 1). Maintenance dredging will also be of less duration (i.e. involving less material) than construction dredging. As construction dredging is not predicted to cause indirect losses due to turbidity, no losses are expected due to maintenance dredging.

Losses due to a 'halo' effect around breakwaters

Habitat may be smothered due to altered patterns of longshore sediment transport adjacent to the breakwater, and/or eroded by bottom shear stresses due to wave shoaling and reflection in front of the breakwater. These effects typically result in a bare sand 'halo' around most breakwaters and groynes located in seagrass meadows.

Due to the low energy environment of Mangles Bay, the 'halo' effect is likely to be minimised. A conservative allowance of 15 m around the breakwaters has been allowed for the halo effect. Empirical evidence for Mangles Bay indicates that the halo effect is likely to be less than this: seagrass is present less than 10 m from the Causeway, and the Hymus Street groyne.

Losses due to the relocated and redesigned Lake Richmond drain

The Lake Richmond drain presently discharges near the Mangles Bay Fishing Club jetty, and is planned to be relocated to Hymus Street, to discharge to the east of the marina (Figure 28). The realigned drain may potentially impact on habitat due to changes in water quality and possible scouring in the vicinity of the discharge point, but the risk is considered minimal as seagrass loss in the vicinity of the present discharge point appears to be more associated with boat launching activities such as the above mentioned losses due to keel drag during boat launching across the beach. The new location of the drain can also be selected so that it is placed within an area where seagrass is already set further back from the shore, so that the potential for impacts is minimised.

Effects due to alteration of water quality within Mangles Bay

There are no indirect losses of seagrass expected due to the outflow of lesser quality water from the Proposal once it is constructed, since modelling indicates that any impact on water quality outside of the marina will be occasional, slight, and highly localized, extending several 100 metres along shallow nearshore waters towards the Causeway (refer Section 10.4). Seagrasses in this area are also in very shallow waters, and therefore less susceptible to adverse effects from lesser water quality.

Habitat may be smothered by longshore sediment transport adjacent to the breakwater, and/or eroded bottom shear stresses due to wave shoaling and reflection in front of the breakwater. Due to the low energy environment of Mangles Bay, the 'halo' effect is likely to be minimised.

As the Proposal lies outside the boundary and is within the sheltered southern end of Cockburn Sound, it is not expected that the construction and operation phases will have an impact on the SIMP.

12.5 The extent of seagrass loss (total direct and indirect losses) from the Proposal and potential for and nature of any cumulative impacts

In Cockburn Sound, approximately 80% of the seagrasses have been historically lost either due to water quality changes or direct physical impact (EPA 2006b). In view of this, any proposal that is predicted to result in further losses of seagrass will be considered in the context of a Category F area – areas where the cumulative loss threshold has been significantly exceeded (EPA 2009b). The EPA's environmental objective in these areas is to ensure no net loss of BPPH and where possible, to generate a net gain in the area of BPPH and/or their associated BPP communities. The Proponent proposes to address the EPA's environmental objective for Category F areas by including a program of seagrass rehabilitation of an equivalent area that will be lost as a result of the proposal (refer Section 12.6.3), which will form part of an environmental offsets package.

An assessment was undertaken of the potential cumulative impacts for BPPH in Cockburn Sound. Cumulative seagrass loss based on the final marina design has been calculated, based on the EPA's methods for determining cumulative impact on BPPH (EPA 2009b). The seven required steps to calculate losses are described below.

Step 1: What is the Local Assessment Unit?

The LAU has been defined as Cockburn Sound, the total area of this LAU is 10 541 ha (105 km^2).

Step 2: What is the current area of each BPPH within the LAU?

Benthic habitat mapping of Cockburn Sound has been undertaken in considerable detail using aerial photography, extensive spot dives and towed-video ground-truthing and side-scan sonar. The most recent work was conducted in 2008 and provides the most recent description of the dominant habitats across Cockburn Sound, reproduced courtesy of Fremantle Ports (refer Oceanica 2010).

The dominant habitat types were identified and subject to detailed characterisation, including photographic documentation and estimation of spatial coverage:

1. Fine sediment (depth >10 m).
2. Fine sediment (depth <10 m).
3. Seagrass *(Posidonia sinuosa*; *P. australis; P. coriacea;* mixed *P. australis* and *P. sinuosa; and* mixed *Amphibolis* sp. and *Posidonia* sp.
4. Turf algae.
5. Reef (dredge spoil reef and low relief reef).

Spatially, fine sediment (>10 m depth) and fine sediment (<10 m depth) were the most dominant habitats, comprising 64.7% and 27.7% of the management unit area, respectively, followed by seagrass comprising 7% (768 ha) of the area. All other habitats spatially comprised less than 1% of the LAU area (Table 54) and (Figure 96).

Table 54 Current area of habitats within Cockburn Sound (105 km^2)

Habitat	Area (ha)	Area (%)
Fine sediment (>10m)	6821	64.7
Fine sediment (<10m)	2917	27.7
Seagrass	768	7.3
Reef	33	0.3
Algae	2	0.0
Total	**10 541**	**100**

Source: Fremantle Ports

Step 3: What area of each BPPH was originally within the LAU?

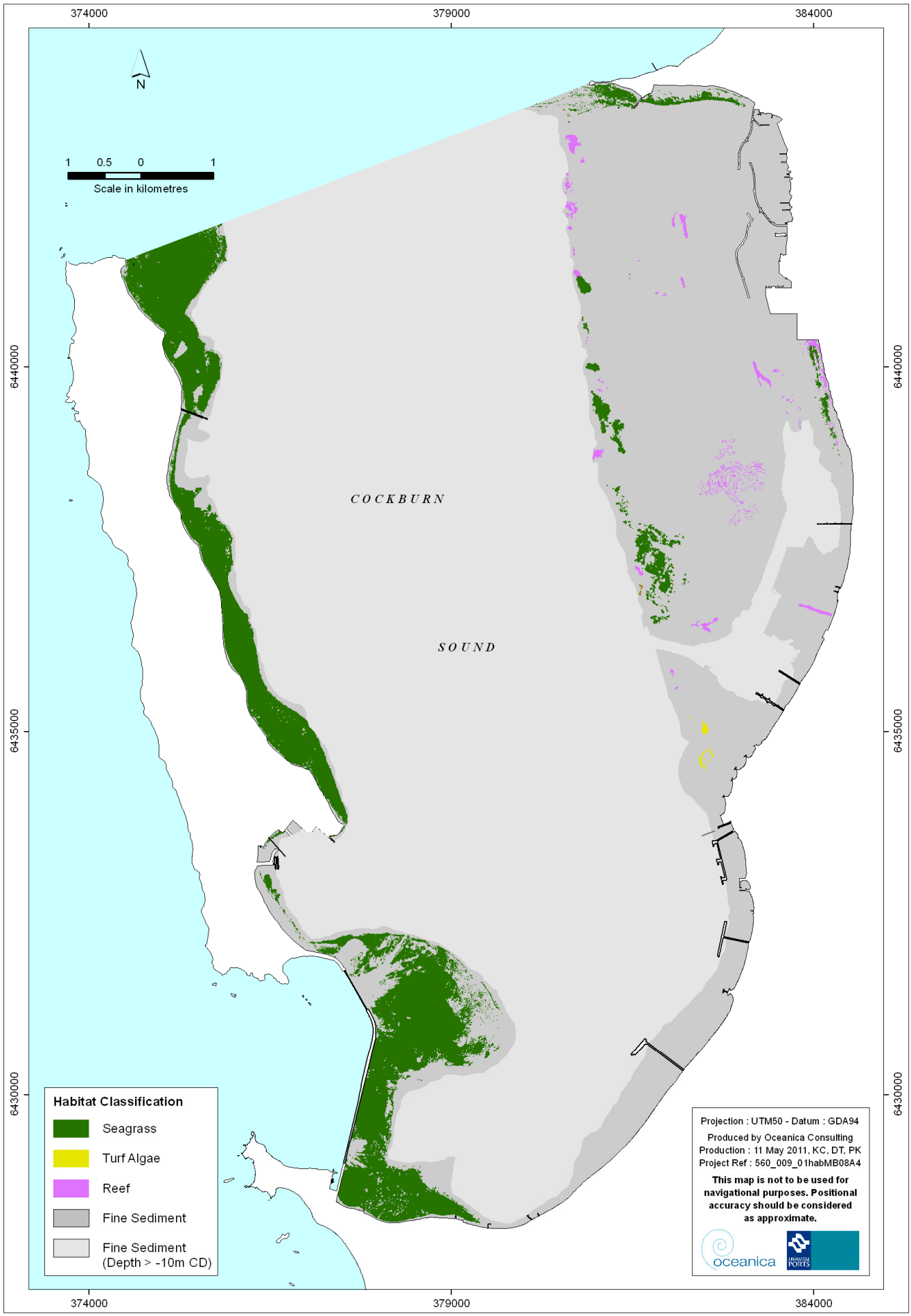
An estimate of the extent of each of the BPPH types present prior to European habitation has been derived for the LAU to establish the baseline for cumulative impact assessment. The pre-impact benthic habitat map is shown in Figure 97 and the habitat coverage areas are shown in Table 55. In estimating these losses, the following assumptions have been made:

1. Reef areas mapped in 2005 were also present before European habitation. Dredge spoil reef areas created by past dredge material disposal have not been included with natural reef features.
2. All sandy areas shallower than -10 m (Chart Datum) in 1944 were colonised by seagrasses. A similar assumption was used by the DEP (1996) in the Southern Metropolitan Coastal Waters Study (DEP 1996).

Table 55 Pre-impact habitat coverage in Cockburn Sound

Habitat type	Area (ha)	Percentage (%)
Deeper than 10 m	6831	46.4
Seagrass	3760	25.6
Reef	15	0.1
Total	**10 605**	**100**

Source: Fremantle Ports



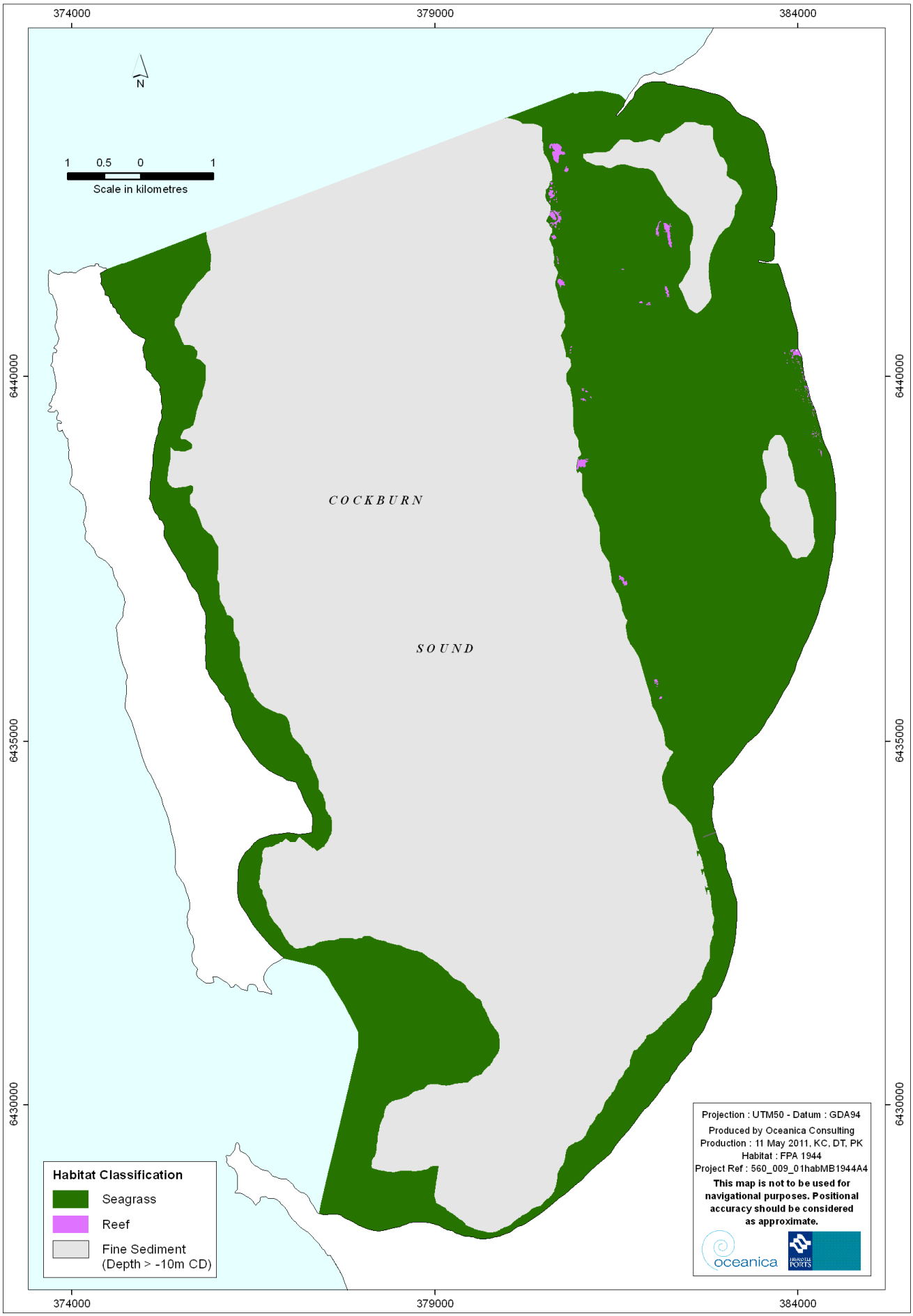
STRATEGEN

Mangles Bay Marina Based Tourist Precinct

Habitat map of Cockburn Sound

Figure 96

strategen
Oct-2011



STRATEGEN

Mangles Bay Marina Based Tourist Precinct

Habitat map for Cockburn Sound prior to European habitation

Figure 97

strategen
Oct-2011

Step 4: What percentage of the original area of each BPPH is present now?

The major causes of past habitat loss in Cockburn Sound include dredging (Stirling and Calista Channels, Australian Marine Complex, Armaments Jetty), reclamation (Woodman Point, Careening Bay and Australian Marine Complex) and loss due to nutrient enrichment. Changes in shoreline position, both natural and following construction of breakwaters and groynes has also resulted in changes in the coverage of marine habitats.

The calculations show that approximately 80% of the original (pre-European habitation) area of seagrass has been lost (Table 56). This is equivalent to the seagrass loss estimates (80%) made by the EPA (EPA 2005b).

Table 56 Estimated BPP losses within Cockburn Sound since European habitation

Habitat	Cumulative losses of each habitat type	
	Change in Area (ha)	Change in area (%)
Fine sediment (<10m)	+2917	N/A
Fine sediment (>10m)	-10	0.2
Reef	+17	N/A
Seagrass	-2992	80

Source: Fremantle Ports

Loss indicated by a negative value, gain indicated by a positive value. Losses/gains of fine sediment (>10m shown for information only, although this is not a BPPH.

Step 5: How much more will be lost?

Habitat losses (seagrass and bare sediment) due to the Proposal are shown in Table 57. A total loss of 7.4 ha of habitat is expected, with ~7.0 ha direct loss and 0.4 ha indirect loss. Direct losses includes breakwaters, reclamation areas, channel and batters, and indirect loss includes a 15 m halo effect around the breakwaters.

Ground truth survey data from dives undertaken at selected locations within the study area enabled definition of two benthic habitat assemblages occurring within and adjacent to the Proposal area, which will be impacted:

1. Dense seagrass (primarily perennial[13] species *Posidonia sinuosa*, with smaller areas of *Posidonia australis* interspersed) (~5.7 ha).
2. Bare sediment (i.e. unvegetated habitat), primarily consisting of mooring scars (~1.7 ha).

Table 57 Habitat losses (ha) due to the Proposal

Habitat type	Direct	Indirect	Total
Seagrass	5.36	0.30	5.66
Fine sediment (<10 m)	1.63	0.06	1.69
Total	7.00	0.36	7.35

Direct loss includes breakwaters, reclamation, channel and batters. Indirect loss is a 15 m halo effect around the breakwaters.

[13] Perennial refers to plants that live from year to year.

Step 6: How much would be lost in total if project proceeds?

In order for impacts to be considered as a result of the Proposal, BPPH losses have been calculated including all existing and EPA approved proposals, as shown in Table 58; however proposals currently being assessed by the EPA were not included. The cumulative impacts considered as a result of these projects, in addition to losses since European habitation are shown in Table 59.

Table 58 Potential BPPH losses (ha) due to currently approved projects and the Proposal

Habitat	James Point Stage 11	Port Rockingham2	The Proposal	Total loss
Fine sediment (<10 m)	27.9	9.1	1.69	**38.7**
Fine sediment (>10 m)	39.9	0	0	**39.9**
Seagrass	0	0	5.66	**5.66**
Total	**67.9**	**9.1**	**7.35**	**84.3**

[1] James Point Stage 1 proposal received environmental approval on 17th November 2004: Ministerial Statement 669 (EPA 2004e). Area calculations include reclamation and channel works.

[2] Port Rockingham proposal received environmental approval on 18th February 2010: Ministerial Statement 826 (EPA 2010b).

Table 59 Current cumulative losses of BPPH in Cockburn Sound

Habitat	Original area (ha)	Cumulative losses of each habitat type	
		Change in Area (ha)	Change in area (%)
Fine sediment (<10 m)	N/A (all assumed to be seagrass)	+2878	*N/A*
Fine sediment (>10 m)	6831	-50	0.7
Reef	15	+17	N/A
Seagrass	3 760	-2997	80

Step 7: Comparison with cumulative loss guideline.

Cockburn Sound is classified as a Category F as the cumulative loss guidelines have been significantly exceeded (Table 59) (EPA 2009b). The EPA's environmental objective is therefore to ensure no net loss of BPPH and, where possible, to generate a net increase. Accordingly, the loss of an additional 5.66 ha of seagrass associated with the Proposal must be offset by seagrass transplantation of at least this amount.

12.6 Management measures and performance standards

12.6.1 Construction management

Design and management measures will be applied to the construction, as outlined in the CEMP (Appendix 5). Seagrass health and water quality will be monitored during construction and if management criteria are exceeded, contingency measures will be implemented to avoid permanent impacts to seagrasses.

The construction of the breakwaters for the Proposal will involve the use of construction machinery, including excavators, loaders and trucks. Only trained operators will be employed to operate the machinery to ensure that materials are placed on the seabed in the correct location to ensure that loss of BPPH does not exceed the predicted footprint area. This will be the responsibility of the Proponent. A CEMP will be prepared to outline in detail the proposed breakwater and other construction methods and proposed management measures.

In addition to these management measures, the planned removal of the yacht club and fishing club's private boat ramps, and the cessation of boat launching on the beach, will also reduce scouring damage in these areas and allow natural regeneration of seagrass. It is proposed that the junior sailors can continue to launch their sailcraft from the beach.

Dredging Program

In accordance with EAG No. 7 (EPA 2010a), predictions of environmental impacts will be linked to environmental monitoring and adaptive management that will be executed during dredging operations and will be detailed in the CEMP.

12.6.2 Operational monitoring

Seagrass losses due to the halo effect

The extent of the 'halo' effect around the breakwaters will be determined after construction for a period of two years. Seagrass extent will be monitored through high resolution vertical digital imagery (captured from a plane).

Maintenance dredging

Predictions of environmental impacts during maintenance dredging will be linked to environmental monitoring and adaptive management, based on Department of Transport protocols for the maintenance dredging of its coastal facilities in Western Australia. A maintenance dredging management plan will be prepared, and monitoring will include seagrass health and water quality, as appropriate.

12.6.3 Seagrass transplantation and monitoring

In order to meet EPA guidelines, any loss of seagrass in Cockburn Sound will be offset by rehabilitation of at least an equal area of seagrass within Cockburn Sound. The total area proposed for seagrass replanting is 6 ha, which is greater than the 5.6 ha of seagrass area being removed. As work undertaken for the Proposal indicates there should be gradual natural reestablishment of seagrass within the mooring scars (Section 12.2.3) the Proponent will concentrate the replanting of 6ha in other areas agreed with OEPA and CSMC. A comprehensive seagrass rehabilitation plan will be developed (subject to environmental approval for the Proposal) describing the rehabilitation sites, seagrass species to be used, transplanting units and techniques, spacing of planting units and the proposed monitoring and management measures for the transplanted seagrass.

Target and performance indicators

It is proposed that completion criteria for any seagrass rehabilitation program be linked to a specific percentage survival of planting units for four years, to confirm that survival and growth are sufficient to attain 6 ha of seagrass of 75% average cover within 10 years following planting. Performance indicators will include percentage survival of transplanted seagrass sprigs and shoot density. These criteria are in accordance with projects already approved to undertake seagrass rehabilitation (e.g. Ministerial Statement 846 for Albany Port Expansion Project and Ministerial Statement 787 for the Albany Protected Harbour Development).

Rehabilitation techniques

Seagrass rehabilitation techniques will be in accordance with techniques previously established for seagrass rehabilitation in Cockburn Sound (refer Oceanica 2012) and previously described in Section 12.2.3 for transplantation of the mooring scars. These same techniques would be used for the rehabilitation of seagrass from the offshore footprint of the Proposal.

Selection of donor material

All donor material will be sourced from within the offshore footprint of the Proposal, from the seagrass beds that will be lost due to the development. This will be undertaken prior to construction affecting the seagrass. If infill (top up) planting is required in subsequent years as a contingency measure, then suitable donor material will need to be sourced from either Owen Anchorage or Cockburn Sound. If this is required, appropriate donor sites and donor bed monitoring requirements will be identified.

Site selection

Suitable sites for seagrass transplantation will be identified and surveyed to ensure suitable substrate, water quality and flow conditions. Potential sites for seagrass rehabilitation previously identified for the Proposal (Strategen 2006) included moorings, historical barge scars and existing mooring scars in Mangles Bay, as well as areas on nearby Southern Flats (Figure 98). There are over 500 moorings in Mangles Bay, which potentially create over 3 ha of mooring scars that could be used for seagrass rehabilitation if existing moorings were replaced by seagrass friendly moorings. However as work undertaken for the Proposal indicates there should be gradual natural reestablishment of seagrass within the mooring scars, the replanting of 6ha is likely to be in other areas agreed with OEPA and CSMC.

On Southern Flats, near the Garden Island causeway, an existing Seagrass Research and Rehabilitation Plan undertaken for Cockburn Cement Ltd and the State Government has also successfully transplanted 3 ha of seagrass, and suitable sites for seagrass rehabilitation for the Proposal lie immediately adjacent to this area (refer Oceanica 2012, Appendix 5).

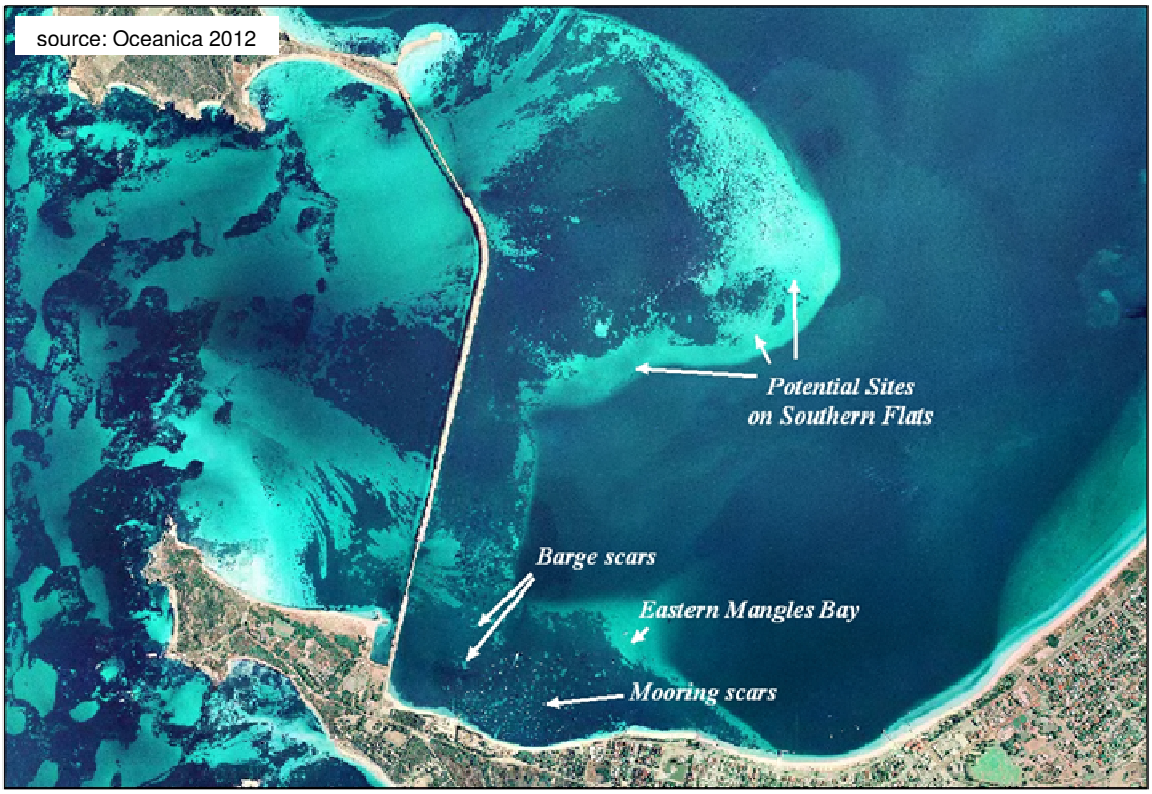


Figure 98 Aerial photograph showing potential sites for seagrass rehabilitation

Maintenance transplanting

Maintenance (or infill) planting may be required to ensure the performance targets are met. Seagrass material will be sourced from nearby seagrass meadows and transplanted using the same techniques.

Previous studies have indicated no detrimental changes in meadows at donor beds after the limited removal of donor material from the leading edge of the meadows. Donor bed recovery appears to be complete by approximately 2.5 years after harvesting (Oceanica 2012). Although no detrimental effects on donor beds are anticipated if maintenance planting is required, the donor beds will be monitored annually for two years to confirm this.

Monitoring

A monitoring program for the seagrass rehabilitation will be implemented on completion of construction activities and include monitoring of the survival and shoot density of rehabilitated seagrass annually for four years to confirm that survival and growth are sufficient to attain seagrass meadow of 75% average cover within 10 years following completion of planting.

The proposed monitoring program is outlined in Table 60 and includes:

- monitoring of the survival and growth of the rehabilitated areas planted to offset the seagrass losses
- monitoring of donor beds – only if maintenance planting is required.

Table 60 Proposed monitoring program for seagrass rehabilitation

Parameter	Frequency	Location	Purpose	Parameter
Area of seagrass loss due to development footprint	Monitored annually for the first two years	Dredge and marina area and immediately adjacent seagrass meadows	To quantify direct losses of seagrass due to the proposal footprint	Area of seagrass loss due to proposal footprint
% survival of rehabilitated seagrass planting units	Monitored annually in summer/autumn for four years after planting, then every two years until target shoot density (i.e. similar to natural meadows) is reached.	Rehabilitated seagrass sites in Cockburn Sound	To confirm that seagrass planting units will meet rehabilitation performance criteria % survival	% survival of rehabilitated seagrass planting units
Shoot density of rehabilitated seagrass planting units	Monitored annually in summer/autumn for four years then every two years until target shoot density (i.e. similar to natural meadows) is reached.	Rehabilitated seagrass sites in Cockburn Sound	To confirm that seagrass planting units are actively growing and expanding such that they will meet performance targets	Shoot density of rehabilitated seagrass planting units
Shoot density of donor beds*	Monitored annually in summer/autumn for following two years to ensure regrowth is occurring.	Donor seagrass sites in Owen Anchorage/Cockburn Sound	To confirm that recovery of shoot density in donor seagrass meadows is as expected	Shoot density of donor beds*

12.7 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

The construction of the Proposal will potentially result in approximately 5.66 ha of direct and indirect seagrass loss. Approximately 1.7 ha of bare, unvegetated habitat (primarily mooring scars) will also be removed. These losses will be offset by rehabilitation of 6 ha of seagrass in Cockburn Sound, resulting in no net loss of seagrass in Cockburn Sound in the medium to long-term. As the seagrass losses will be offset with seagrass rehabilitation, there is not expected to be any significant impact on marine flora, in accordance with the EPA objective for BPPH (refer Section 12.1.1). In addition, the *Shoalwater Islands Marine Park Management Plan 2007–2017* (DEC 2007) performance measures and long-term targets for seagrass will be met (refer Section 12.1.1).

13. Marine fauna impact assessment

13.1 Relevant environmental objectives, policies, guidelines, standards and procedures

13.1.1 EPA objectives

The EPA objective for marine fauna is:

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

The EPA does not have a specific environmental objective in relation to introduced marine species (IMS[14]), other than their broader objective for Land (Marine), which is:

To maintain the integrity, ecological functions and environmental values of the seabed and coast

To conserve WA's marine environment by managing and reducing the impacts of introduced marine species and by preventing further introductions and spread.

13.1.2 Legislation, policy and guidance

State Protection

The preservation and conservation of fauna is covered by the following Western Australian legislation:

- *Wildlife Conservation Act 1950*
- *Conservation and Land Management Act 1984.*

The DoF is responsible for managing the State's finfish and crab stocks to ensure long-term sustainability and sustainable use of resources; this is done on the basis of sustainability assessments i.e. ensuring that fishing does not cause long-term decline of the resident population. The DoF is also responsible for coordinating WA's IMS control and management actions.

Commonwealth Protection

The Federal EPBC Act protects species listed under Schedule 1 of the Act. In 1974, Australia became a signatory to CITES. As a result, an official list of endangered species was prepared and is regularly updated. This listing is administrated through the EPBC Act. The current list differs from the various State lists; however, some species are common to both.

The EPBC Act also protects a range of shorebirds listed under the JAMBA and CAMBA Migratory Bird Agreements. Most of these are associated with saline wetlands or coastal shorelines. However, some migratory birds not associated with freshwater wetlands are also listed on these international treaties.

[14] Introduced Marine Species (IMS) are species that are not indigenous to Australia (or particular habitats within Australia) but have been transferred to local waters and have either established or have the potential to establish (DAFF, 2009). Introduced marine pests (IMP) are those foreign species that pose a significant risk to environmental values, biodiversity, ecosystem health, human health, fisheries, aquaculture, shipping, ports or tourism (DAFF, 2009).

Threatened marina fauna listed under State and/or Commonwealth

Marine fauna that are listed as threatened species under the Commonwealth (EPBC Act) and/or State WC Act, and that are considered likely to occur in Cockburn Sound and the SIMP, are:

- *Caretta caretta* (loggerhead turtle), listed as Endangered and Migratory under the EPBC Act, and is a Schedule 1 species under the WC Act
- *Dermochelys coriacea* (leatherback turtle), listed as Endangered and Migratory under the EPBC Act, and is a Schedule 1 species under the WC Act
- *Chelonia mydas* (green turtle), listed as Vulnerable and Migratory under the EPBC Act, and is a Schedule 1 species under the WC Act
- *Balaenoptera musculus* (blue whale), listed as Endangered and Migratory under the EPBC Act, and is a Schedule 1 species under the WC Act
- *Eubalaena australis* (southern right whale), listed as Endangered and Migratory under the EPBC Act, and is a Schedule 1 species under the WC Act
- *Megaptera novaeangliae* (humpback whale), listed as Vulnerable and Migratory under the EPBC Act, and is a Schedule 1 species under the WC Act
- *Carcharias taurus* (grey nurse shark), listed as Vulnerable and Migratory under the EPBC Act, and is a Schedule 1 species under the WC Act
- *Carcharodon carcharias* (great white shark), listed as Vulnerable and Migratory under the EPBC Act, and is a Schedule 1 species under the WC Act
- *Neophoca cinerea* (Australian sea lion), listed as Vulnerable under the EPBC Act, and listed as a Schedule 4 species under the WC Act (specially protected fauna).

The three species of marine turtles are seen occasionally in Cockburn Sound, being visitors brought southwards from tropical waters by storms and/or the southward flowing Leeuwin Current (refer also Section 13.2.1).

The Southern Right whale is often seen in Perth coastal waters during its annual southwards migration from late autumn to early spring: this species may occasionally enter Cockburn Sound (refer Figure 3 in Cannell 2004) but is highly unlikely in the southern end of Cockburn Sound due to the restriction posed by the Causeway. The Humpback whale is likely to occur offshore of Garden Island during its southward spring migration or northward autumn migration, but is unlikely to enter Cockburn Sound (refer Figure 2 in Cannell 2004). Two subspecies of the Blue Whale are thought to exist in the Southern Hemisphere, including the Southern Blue Whale and the Pygmy Blue Whale. Blue Whale sightings in Australia are widespread and they are believed to occur around the full extent of the continent. In Western Australia, Pygmy Blue Whales aggregate in deepwater habitat on the northern side of the Perth Canyon where the Leeuwin current causes eddies and downwelling and compensating upwelling as it passes over the canyon. The two species of sharks are likely to be occasional visitors to Cockburn Sound.

A male colony of Australian sea lions uses the waters of the SIMP waters to feed, and the islands as haul-out sites (refer Figure 8 in Cannell 2004), during the non-breeding season. Sea lions are also often seen in waters around Garden Island (including Cockburn Sound) (refer also to Section 13.2.1).

State Environmental (Cockburn Sound) Policy 2005

The State Environmental Policy for Cockburn Sound (SEP) protects the environmental quality within Cockburn Sound, using a framework of Environmental Values (EV) and EQO. Refer to Section 12.1.2 for further details on the SEP. Ecosystem health was identified as an EV, with the EQO for this being:

Maintenance of ecosystem integrity: "*The level of ecological protection to be maintained for ecosystem integrity is described in terms of structure (e.g. biodiversity, biomass and abundance of biota) and function (e.g. food chains and nutrient cycles)*".

The area of Cockburn Sound adjacent to the proposed site for the marina (i.e. Mangles Bay) has been assigned a high level of ecological protection, which allows small changes in the quality of water, sediments and biota.

The waters within the marina are classified as an artificial inland waterway, and therefore not zoned for ecological protection under the SEP. The objective for marina waters will therefore be to ensure that water quality exiting the marina does not compromise the relevant EV and EQO for Mangles Bay. Water quality within the marina comes under WA Planning Commission (WAPC) Policy No. DC1.8, which provides Guidelines for approval of canal estates and other artificial waterway development: this is discussed further in Section 10.

Shoalwater Islands Marine Park

The SIMP (refer Figure 57) borders Mangles Bay at the Garden Island causeway and therefore may potentially be impacted by the Proposal. *The Shoalwater Islands Marine Park Management Plan 2007–2017* (DEC 2007) lists management objectives, strategies, performance measures and targets to achieve, including the following management objectives in relation to marine fauna.

Finfishes

- to manage targeted finfish species for ecological sustainability in the SIMP
- to ensure non-targeted finfish species are not significantly impacted by recreational and commercial fishing in the SIMP.

Marine invertebrates

- to manage targeted invertebrate species for ecological sustainability in the SIMP
- to ensure non-targeted invertebrate species are not significantly impacted by recreational and commercial fishing in the SIMP.

Cetaceans (whales and dolphins)

- to ensure the abundance of cetaceans is not significantly impacted by future human activities in the SIMP.

Little penguins

- to ensure the abundance of the little penguin is not significantly impacted by a reduction in available prey species or from physical disturbance by boats or boat-strikes in the SIMP.

Australian sea lion

- to ensure Australian sea lions frequenting the SIMP waters are not injured, killed or significantly disturbed by human activities or interactions.

Introduced Marine Species (IMS)

The Management Plan's objective for water and sediment quality '*To ensure that water and sediment quality is not significantly impacted by future human activities in the marine park*' recognises that the presence of large ships in Cockburn Sound increases the potential for non-Indigenous marine species to be introduced to the SIMP via ballast water discharge and hull fouling, and hence may affect water and sediment quality in the SIMP.

Shoalwater Bay island nature reserves

The Shoalwater Bay islands are a chain of islands between Cape Peron and Becher Point, and include Penguin Island, Shag Rock, Seal Island, Gull Island, Bird Island, White Rock, The Sisters, Passage Rock, Third Rocks, First Rock and Second Rock. It covers an area of about 16ha. The Islands have significant conservation value. Penguin Island supports the largest breeding population of little penguins on the west coast of Australia, and the Australian sea lion uses Seal Island and occasionally other Islands as 'haul-out' or resting sites.

The islands consist of four nature reserves and vacant crown land that are managed under the *Shoalwater Islands Management Plan 1992–2002* (CALM 1992). Penguin Island is closed for the peak laying period of the Little Penguin (the winter months), and Seal Island is closed to the public to protect the Australian sea lions.

Carnac Island nature reserve

Australian sea lions use Carnac Island as a haul-out area during the non-breeding season. There is a small visitor exclusion zone on the beach at Carnac Island to allow sea-lions a sanctuary area where they can escape from people if they choose. The island also is an important nesting habitat for several species of seabirds, including little penguins.

Fisheries Resources Management Act 1994 (WA)

This Act provides for the declaration of certain aquatic species as "noxious fish," and makes it unlawful for an individual or body corporate to have, consign, keep or convey such species in Western Australia, or any designated part of Western Australia. Under Regulation 176 of the Fish Resources Management Regulations 1995, a person must not bring into the State a species of fish not endemic to the State without the written approval, or written authority, of the Chief Executive Officer of the DoF. The Act defines fish as "*an aquatic organism of any species (whether alive or dead) and includes:*

- the eggs, spat, spawn, seeds, spores, fry, larva or other source of reproduction of offspring of an aquatic organism; and
- a part only of an aquatic organism (including the shell or tail), but does not include aquatic mammals, aquatic reptiles, aquatic birds, amphibians or (except in relation to Part 3 and Division 1 of Part 11) pearl oysters[15]."

Amendments to the Act in 2006 broadened the definition to include "*live rock and live sand*".

13.2 Species of significance

13.2.1 Key species of marina fauna

Fish and invertebrates

The key potential impacts of the Proposal identified for fish and invertebrates (prior to the implementation of management measures), in order of importance were:

1. Increased human access and fishing pressure.
2. Loss of benthic habitat (seagrass).
3. Build up in chemical contaminants (bioaccumulation).

[15] It is proposed that "pearl oysters" specifically excluded in the existing definition should be only pearl oysters of the species *Pinctada maxima.*

Dolphins

The key potential impacts of the Proposal identified for dolphins (prior to the implementation of management measures), in order of importance were:

1. Loss or change in prey species.
2. Entanglement in ropes, nets and lines, and other marine debris.
3. Increased human-dolphin interactions and change in behaviour.

Little penguins

The key potential impacts of the Proposal identified for little penguins (prior to the implementation of management measures), in order of importance were:

1. Increased vessel movements, leading to displacement of penguins from feeding areas and/or to vessel strikes.
2. Loss or change in prey species.
3. Entanglement in ropes, nets and lines, and other marine debris.
4. Build up in chemical contaminants (bioaccumulation).

13.2.2 Other marine fauna

Marine turtles breed and are generally found from Shark Bay and northwards. They are only occasionally seen in the Perth Metropolitan area, with their presence thought to be largely due to a combination of storms and the southward flowing Leeuwin Current. The loggerhead has the most southerly nesting range of all species nesting in Western Australia (Shark Bay), and is also the most commonly observed marine turtle species in southwest region of Western Australia. The loggerhead turtle is considered a migratory visitor to the southwest region of Western Australia, with adult and large sub-adult turtles seen between Rottnest Island and Geographe Bay (DEWHA 2008). It is possible that the loggerhead turtles occasionally seen in the Perth Metropolitan area (usually in summer) are using these waters as seasonal foraging grounds (when the water temperature is warmer) and foraging further north in winter. However, marine turtles have not been identified as key species likely to be affected by the Proposal, as Mangles Bay is neither a nesting area nor a resident foraging area. This approach is consistent with other approved developments in Cockburn Sound, including James Point Port: Stage 1 (JPPL 2001) and the Port Rockingham Marina PER (RPS 2009), and with the SIMP Management Plan (DEC 2007; which notes that some species of marine turtles are occasional visitors to the park, but has no specific management objective for them).

The Australian sea lion is endemic to Australia. A colony of male sea lions uses the islands of the SIMP as haul-out sites. The haul-out sites are used during the non-breeding season, with Seal and Carnac islands being the primary sites in the Perth Metropolitan area (refer to Figure 8 in Cannell 2004). Australian sea lions are excellent divers and spend their time at sea foraging close to or on the seabed. They can feed in depths that can exceed 300 metres, but also use SIMP waters to feed (DEC 2007). Their feeding is opportunistic with fish, sharks, squid, octopus, cuttlefish, lobster and even occasionally birds and turtles making up their diet. Although Australian sea lions are often seen in waters around Garden Island (including Cockburn Sound), the area adjacent to the proposed Mangles Bay marina is very shallow and has high boat traffic, and therefore is not considered to be a key feeding area or habitat for Australian sea lions.

The current major pressure on Australian sea lions, as listed in the SIMP Management Plan (DEC 2007), is physical disturbance from human interaction (e.g. tourism and vessel activity, noise and boat strike). Boat strike is also a recognised risk to marine turtles. The marina will result in some increase in recreational boat traffic in Cockburn Sound and, to a lesser extent, the SIMP (see Section 16), so although marine turtles and the Australian sea lion are not considered key species at risk due to the Proposal, the potential impacts of recreational boating will still need consideration in the operational management of the

marina. The construction management plan for the marina will also need to include fauna observation protocols for sea lions and turtles.

13.2.3 Introduced marine species

Introduction of marine pests due to the Proposal has been identified as a potential risk to marine fauna. The introduction of marine species into areas outside their native range is a serious risk to Australia's native marine life, and can also greatly impact on commercial fisheries and aquaculture industries (ABS 2001). The two primary mechanisms by which IMS can be introduced to a new location are through ballast water and biofouling[16].

13.3 Findings of surveys and investigations

The information contained in this section has primarily been prepared based on information from the following reports:

- fish and marine invertebrates (McLean 2012)
- dolphins (Finn 2011)
- little penguins (Cannell 2011).

13.3.1 Fish

The majority of the following information on fish (this section) and invertebrates (Section 13.3.2) has been summarised from a report by McLean (2011). In addition, a meeting was held with personnel from the Fisheries Research Division of the DoF, Oceanica Consulting and Mindabbie Marine on 13 March 2011 to discuss the proposed Mangles Bay marina and possible effects on fish. The key issues discussed at this meeting were increases in boat traffic, increased fishing pressure and loss of habitat (seagrass), which are discussed below and in Section 13.5.

Fish community of Mangles Bay

Over the past 30 years there have been a number of studies that have examined single fish species or assemblages of fish within Cockburn Sound (e.g. Dybdahl 1979; Hyndes *et al*. 1998; Vanderklift and Jacoby 2003; Valesini *et al*. 2004; Smith *et al*. 2008; Wakefield 2006; Breheny 2009; Wakefield *et al*. 2009). Few have provided information on fish specifically for the Mangles Bay area, but from these it is clear that the sheltered waters of Mangles Bay provide significant habitat for a wide range of fish species (Hyndes *et al*. 1998; Whitehead 2000; Valesini *et al*. 2004; Smith *et al*. 2008). Compared to the broader Cockburn Sound area, Mangles Bay is considered to have high fish diversity and abundance (Valesini *et al*. 2004; Smith *et al*. 2008). Mangles Bay is also an important nursery ground for a range of fish species, including those heavily targeted by fishers (Hyndes *et al*. 1998; Valesini *et al*. 2004; Smith *et al*. 2008), and is only one of a few known fish nursery ground locations within Cockburn Sound (Hyndes *et al*. 1998; Valesini *et al*. 2004).

The fish community in the shallow, predominantly seagrass habitat in Mangles Bay is characterised by: whiting (*Sillaginidae* spp.), trumpeters (*Teraponidae* spp.), tarwhine (*Sparidae*), mullet (*Mugilidae* spp.), hardy heads (*Atherinidae* spp.), gobies (*Gobiidae* spp.), flounder (*Bothidae*), toadfish (*Tetraodontidae* spp.), leatherjackets (*Monacanthidae* spp.) and cardinalfish (*Apogonidae* spp.) (Vanderklift and Jacoby 2003; Valesini *et al*. 2004). These fish species utilise the seagrass beds in Mangles Bay for shelter and/or a food source (mostly the large numbers of small invertebrates present, and decaying organic matter from

[16] Ballast water refers to water that a ship takes on board at a port before commencing a voyage in order to provide stability in unladen ships, with marine organisms taken on board as well. Biofouling refers to the attachment of biological material (microorganisms, plants, algae and animals) on submerged structures such as ships hulls and internal areas.

seagrass and algae, although a few species feed on seagrass and attached algae (Vanderklift and Jacoby 2003).

High numbers of juveniles from a wide range of species have been recorded in the seagrass meadows of Mangles Bay, including early juvenile King George whiting (*Sillaginoides punctulatus*) (Whitehead 2000). Late stage King George whiting larvae are considered to utilise the southern entrance of Cockburn Sound to enter into the sheltered waters of Mangles Bay to settle – a process that may be hindered by the Causeway which has almost closed off this entrance (Whitehead 2000). Fish larval assemblages in the seagrass meadows of Mangles Bay are considered to be quite different to those of the seagrass meadows of eastern Garden Island, possibly due to the presence of a clockwise gyre (wind driven circulation) causing localised upwelling in this area (Breheny 2009). The sheltered conditions of Mangles Bay may also simply provide favourable spawning sites for adults. The significance of Mangles Bay as a nursery habitat is also likely due to its high degree of shelter, as well as extensive seagrass meadows close to shore (providing protection from predators) and a high availability of food (invertebrate prey) (Hyndes *et al*. 1998; Valesini *et al*. 2004).

The DoF has undertaken annual surveys of juvenile fish abundance in Mangles Bay (among other areas) since 1999 (see Smith *et al*. 2008), and since mid-2005 has specifically focused on seven key fishery species: tailor (*Pomatomus saltatrix*), Australian herring (*Arripis georginaus*), Australian salmon (*Arripis truttaceus*), King George whiting (*Sillaginoides punctulatus)*, yellow-fin whiting (*Sillago schomburgkii)*, sea mullet (*Mugil cephalus)* and yellow-eye mullet (*Aldrichetta forsteri)*. Surveys are conducted monthly from September to April each year (Smith *et al*. 2008) and results confirm those of Valesini *et al*. (2004) in finding that Mangles Bay had the highest fish diversity and abundance of all sites surveyed on the southwest and south coast. Smith *et al*. (2008) suggest that many fish species might spawn exclusively at west coast sites such as Mangles Bay, which likely act as a source for south coast populations, and so any change to breeding stocks in Mangles Bay has the potential to affect the status of south coast inshore fish populations and fisheries.

The deeper waters off Mangles Bay also appear to be an important nursery area for a range of baitfish species, with eggs of whitebait (*Hyperlophus vittatus*), and the juveniles of whitebait, blue sprat (*Spratelloides robustus*) and Australian anchovy (*Engraulis australis*) found in this area (Valesini *et al*. 2004; Smith *et al*. 2008). From 2006–2008, the DoF undertook repeat trawls in 10-20 m deep water at seven sites in southern Metropolitan waters: Owen Anchorage, an area at the NE edge of the Central Basin, Garden Island North, Garden Island South, Jervoise Bay, James Point and Mangles Bay. Anchovy were found in trawls at the Mangles Bay site (approximately 1.5 km offshore), and were second in abundance only to the Garden Island South site, yet anchovy were not listed as a common and widespread species within the Sound (Johnston *et al*. 2008). Another study in 2007 and 2008 sampled many sites within Cockburn Sound to determine larval fish assemblages associated with pink snapper (*Pagrus auratus*) spawning associations. Areas with high abundance of anchovy larvae varied between years: for example, abundance was lower overall in 2008 compared to 2007, and the highest abundance was found in the central basin of Cockburn Sound in 2007 and at James Point in 2008 (Figure 99; Breheny 2009). Similar variability occurred for other larval fish (Figure 100; Breheny 2009). Anchovy larvae were, however, found in similar abundances in the Mangles Bay area in both years, indicating the deeper waters (depth 10-20 m) off Mangles Bay may serve as a more consistent site for anchovy (Figure 99).

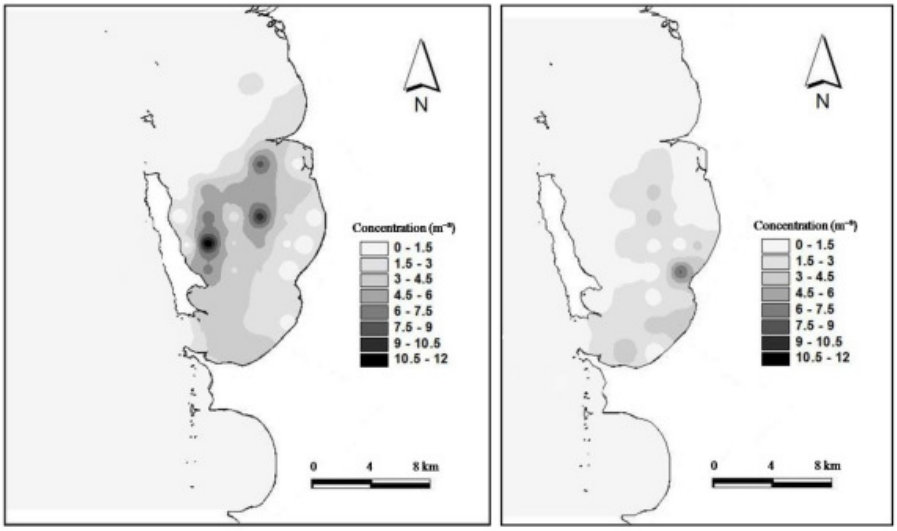


Figure 99 Spatial distribution of anchovy larvae, 10 – 12 November 2007 (left) and 27-28 November 2008 (right), source: Breheny 2009

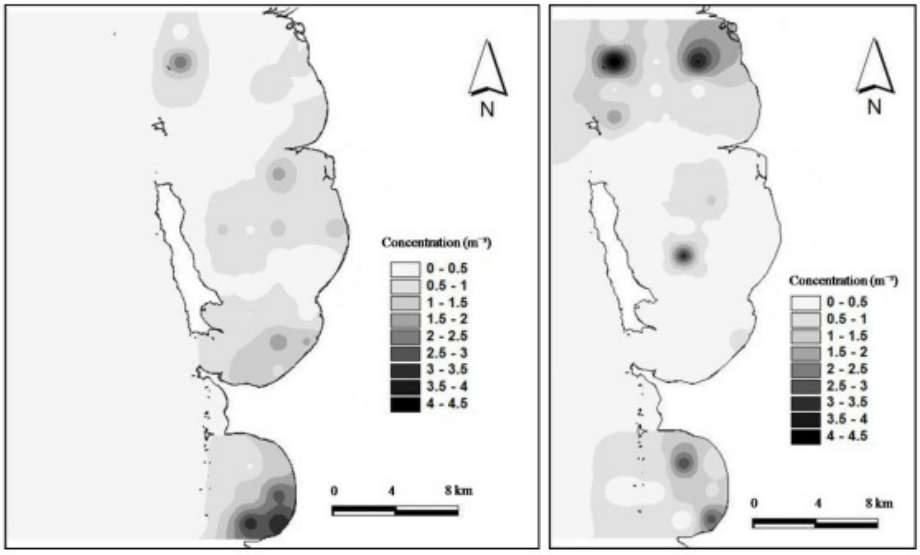


Figure 100 Spatial distribution of all larval fish species, excluding anchovy, 10-12 November 2007 (left) and 27-28 November 2008 (right)

Mangles Bay is not an important spawning or nursery habitat for pink snapper (*Pagrus auratus)*, which is perhaps the most important recreational and commercially targeted fish species in Cockburn Sound (Wise *et al*. 2007). The broader Cockburn Sound embayment is one of only a few known spawning grounds and nursery areas for the pink snapper in the West Coast Bioregion (Wakefield 2006; Lenanton *et al*. 2009; Wakefield *et al*. 2009).

Spawning times for important fish species in Mangles Bay are as follows:

- King George whiting spawn from winter to early spring (Hydnes *et al*. 1998)
- peak spawning for whitebait occurs from winter to spring, with egg concentrations also reportedly high at this time throughout Cockburn Sound
- spawning of Australian anchovy - and many other fish species (e.g. whiting species except King George whiting, leatherjackets, herring, wrasse, trevally, flounder) - is synchronous with the (temperature-dependent) spawning times for pink snapper, from October – December (Breheny 2009)
- Blue sprat spawn during the summer months (when they are most common in the diet of Penguin Island penguins; Cannell 2011).

Commercial fishing in Cockburn Sound

There are two managed commercial fisheries that operate wholly and target finfish within the broader region of Cockburn Sound:

1. Cockburn Sound Line and Pot fishery (13 licences).
2. Cockburn Sound Fish Net fishery (1 licence) (Smith and Brown 2010; D. Brown *pers comm*.).

The majority of the catch comprises garfish, herring and pink snapper.

Two additional fisheries also operate partly within Cockburn Sound:

1. West Coast Beach Bait Managed Fishery.
2. West Coast Purse Seine Managed Fishery (Smith and Brown 2010).

The first fishery targets whitebait, blue sprat, sea mullet, yellow-finned whiting, garfish and yellow-eye mullet (Smith and Brown 2010). The second fishery mainly captures pilchards (*Sardinops sagax*) and tropical sardine (*Sardinella lemuru*), with smaller catches of other species also reported (Molony and Lai 2010).

Commercial fishers do not operate within Mangles Bay itself, but the bay is an important nursery area for the whole of Cockburn Sound. As noted earlier, any changes that affect the suitability of this area as a nursery or that result in a decline in juvenile abundance have the potential to affect commercial fisheries in the broader Cockburn Sound area and even on the south coast.

Recreational fishing in Mangles Bay and surrounding areas

Recreational fishers in Mangles Bay and surrounding areas target a number of fish species, primarily Australian herring, King George whiting, skipjack trevally (*Pseudocaranx* spp.), pink snapper, tailor and garfish (*Hyporhamphus melanochir*). Recreational fishing is very popular in Mangles Bay (refer also Section 16) with fishing taking place from boats on moorings, boats at anchor, boats at drift and from the beach both during the week and on weekends (Dybdahl 1979; L. Dettagello [Mangles Bay Fishing Club] pers. comm.).

13.3.2 Marine invertebrates

Marine invertebrates include a very broad range of fauna such as molluscs (shellfish), crustaceans, anemones, sponges, sea urchins and worms. A number of benthic invertebrate surveys have been carried out in Cockburn Sound (Marsh 1978a; b; Devaney 1978; Wells and Threlfall 1980; Vanderklift and Jacoby 2003; Valesini *et al*. 2004; Johnston *et al*. 2008), however, findings have differed somewhat, largely as a result of the different sampling equipment used and habitats surveyed.

The trawl net study of Johnston *et al*. (2008) found Mangles Bay was dominated by few macroinvertebrate species, including: crabs (*Portunus pelagicus* and *P. rugosus),* orange sea pen (*Cavernularia* spp), prawns (*Metapenaeopsis fusca, M. lindae, Melicertus latisulcatus),* mantis shrimp (*Belosquilla laevis)* and seastars (*Astropecten preissi).* Present in lower abundances were: southern calamari squid (*Sepioteuthis*

australis), cuttlefish (*Sepia novaehollandiae),* sponges (*Tethya* cf. *ingalli,* unidentified spp*)*; tube anemones (*Pachycerianthus sp.)*: and, sea pens (*Sarcoptilus grandis).*

Valesini *et al*. (2004) used a variety of techniques (sediment cores, plankton nets, sleds) to study invertebrate fauna within a range of nearshore habitats in Cockburn Sound, including shallow sheltered seagrass habitats such as Mangles Bay. Benthic macroinvertebrate assemblages in sheltered seagrass habitats were characterised by polychaetes (segmented worms), with high densities of other worms also present, particularly nematodes (small, thread-like unsegmented worms) and amphipods (small crustaceans). Polychaetes are sub-surface deposit feeders often abundant in sheltered environments that are high in sedimentary organic matter (such as Mangles Bay). Valesini *et al*. (2004) also reported juvenile decapods (e.g. crabs, prawns) and capitellid worms in sheltered seagrass habitats. Conversely, Valesini *et al*. (2004) found that zooplankton (a major food source for fish) were least abundant in sheltered seagrass habitats.

The most important recreational and commercially targeted invertebrate species in Cockburn Sound is the blue swimmer crab, *Portunus pelagicus.* This species lives from the intertidal zone to at least 50 m depth, in habitats ranging from sand and mud to seagrass (Edgar 1990; in Sumner and Malseed 2004). Blue swimmer crab are scavenging, opportunistic bottom-feeding carnivores (Kangas 2000). Mangles Bay and Jervois Bay are reported to have high abundances of blue swimmer crab in comparison to other locations within Cockburn Sound. These sites are also identified as important recruitment areas (Johnston *et al*. 2008).

Blue swimmer crabs spawn between October and January, with larvae settling up to 6 weeks later (Kangas 2000). Stocks of blue swimmer crab in Cockburn Sound have been shown to be genetically independent of other stocks in the state (Chaplin *et al*. 2001) and therefore overfishing or detrimental environmental changes could have severe consequence for these populations.

Commercial fishing of invertebrates in Cockburn Sound

Blue swimmer crabs are fished under the Cockburn Sound Crab Managed Fishery (12 licences; Johnston *et al*. 2011), using purpose-designed crab traps and are managed by input controls (Johnston and Harris 2010). This fishery was closed for two seasons 06/07 and 08/09 following a rapidly depleting catch. The decline was attributed to combined influences of irregular cool water temperatures and fishing practices (gear used, level and timing of fishing) (Johnston *et al*. 2011). A limited level of fishing was permitted during 2010 following sufficient recruitment and recovery of residual stock (Johnston and Harris 2010).

Other targeted invertebrates in Cockburn Sound include octopus (*Octopus tetricus*), southern calamari squid (*Sepioteuthis australis)* and mussels (*Mytilus edulis*). Commercial fishing for octopus occurs through the Cockburn Sound Line and Pot Fishery where there is currently no limit on the number of traps used. The Cockburn Sound Line and Pot Fishery also target squid using jigs, however fishing for squid mainly occurs in the recreational sector. Mussels are farmed in Cockburn Sound (near the CBH grain terminal, and also on Southern Flats) by collecting wild spat that is then attached to longlines for grow-out to market size (Lawrence 2005).

Recreational fishing in Mangles Bay

The main invertebrate targeted by recreational fishers in Mangles Bay is the blue swimmer crab (mainly from boats). Recreational fishers use drop-nets, or dive for crabs, with this fishery managed by size, catch and pot limits. Within Cockburn Sound, recreational crabbing effort is reported to be highest in the Mangles Bay area (Sumner and Malseed 2004, refer also Section 16). Jigging for squid (mainly from boats) is also popular. Recreational fishing restrictions for squid and octopus include a bag limit of 15 and a boat limit of 30.

13.3.3 Dolphins

Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) are generally found within in-shore and coastal areas throughout the Perth Metropolitan area and the southwest region, and common bottlenose dolphins (*T. truncatus*) are typically found in off-shore environments.

Studies in both 1993-7 and 2008 have identified more than 150 individual bottlenose dolphins within Cockburn Sound and Owen Anchorage, including a resident community in Cockburn Sound. Distinctive features of the ecology of bottlenose dolphins in Cockburn Sound include long-term site fidelity[17] and limited home ranges (e.g. less than 100 to 150 km^2). The dolphins forage throughout Cockburn Sound and use a broad range of habitats (refer Figure 101 and Figure 102). They use a variety of behaviours to capture prey (which allows them to adapt to seasonal changes in the prey availability), and feed on prey as small as 'baitfish' (e.g. anchovies) and as large as pink snapper. There are three broad habitat areas for dolphins within Cockburn Sound:

- the deep (18+ m) central basin extending from Mangles Bay northwards to Success Bank
- the Kwinana Shelf (Eastern Flats) in the northeast corner (James Point northwards to Woodman Point)
- seagrass meadows running along the western margin (Southern Flats and Garden Island).

The distribution and habitat-use patterns of dolphins vary seasonally, and these patterns are likely to reflect changes in the abundance and distribution of fish in the locations. For example, large feeding aggregations are common on the Kwinana Shelf from autumn to spring, probably targeting schools of baitfish that are seasonally present. The food requirements of dolphins are considerable; making them quite sensitive to factors that make it more difficult for them to find and capture prey.

[17] Site fidelity describes the tendency of an animal to use a defined area for a long period of time (often their entire life-time) and is a common characteristic of bottlenose dolphins inhabiting inshore and coastal ecosystems.

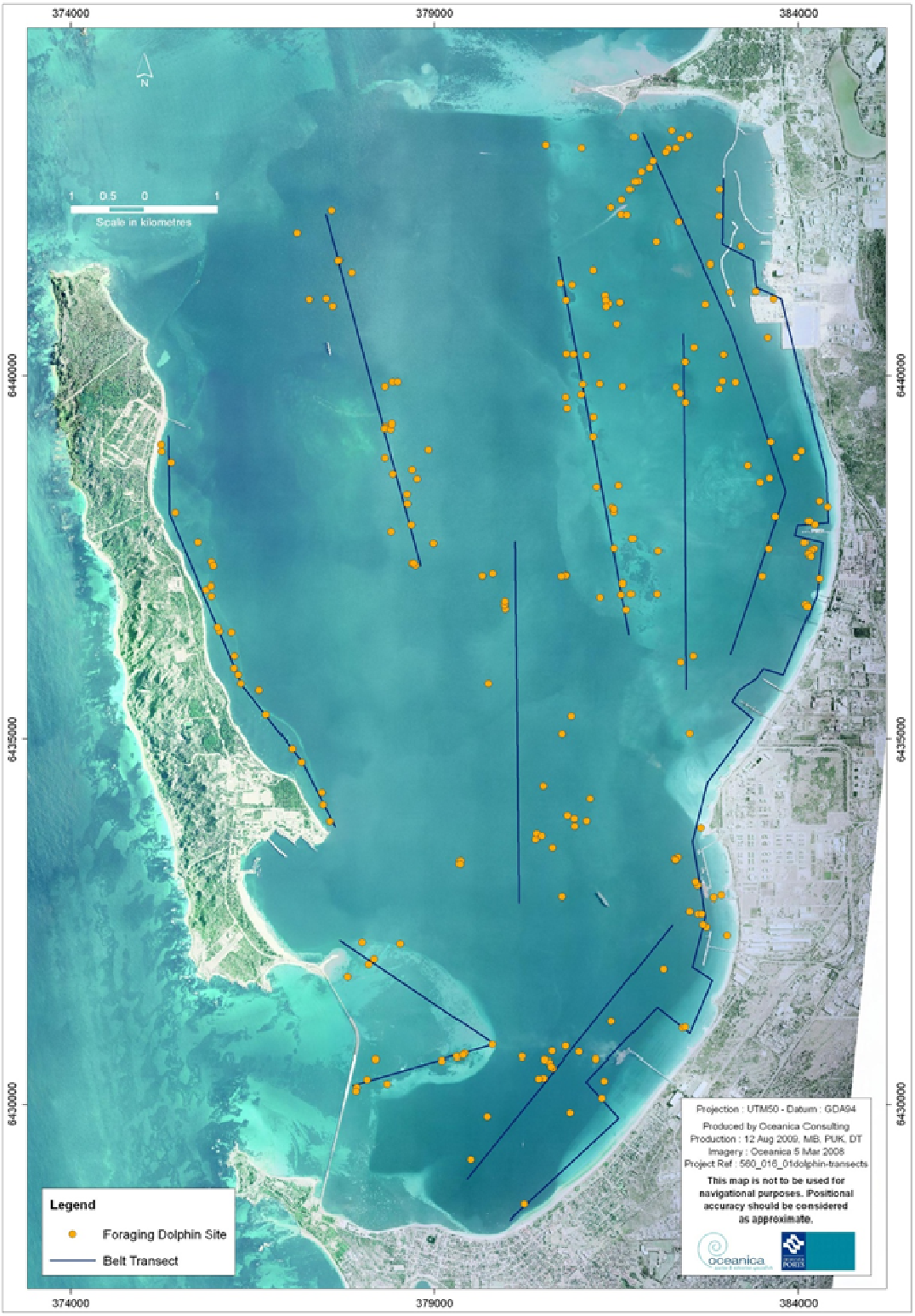


Figure 101 Indicative locations of dolphin sightings during a transect based study from June 2000 to April 2001 (source Finn 2011)

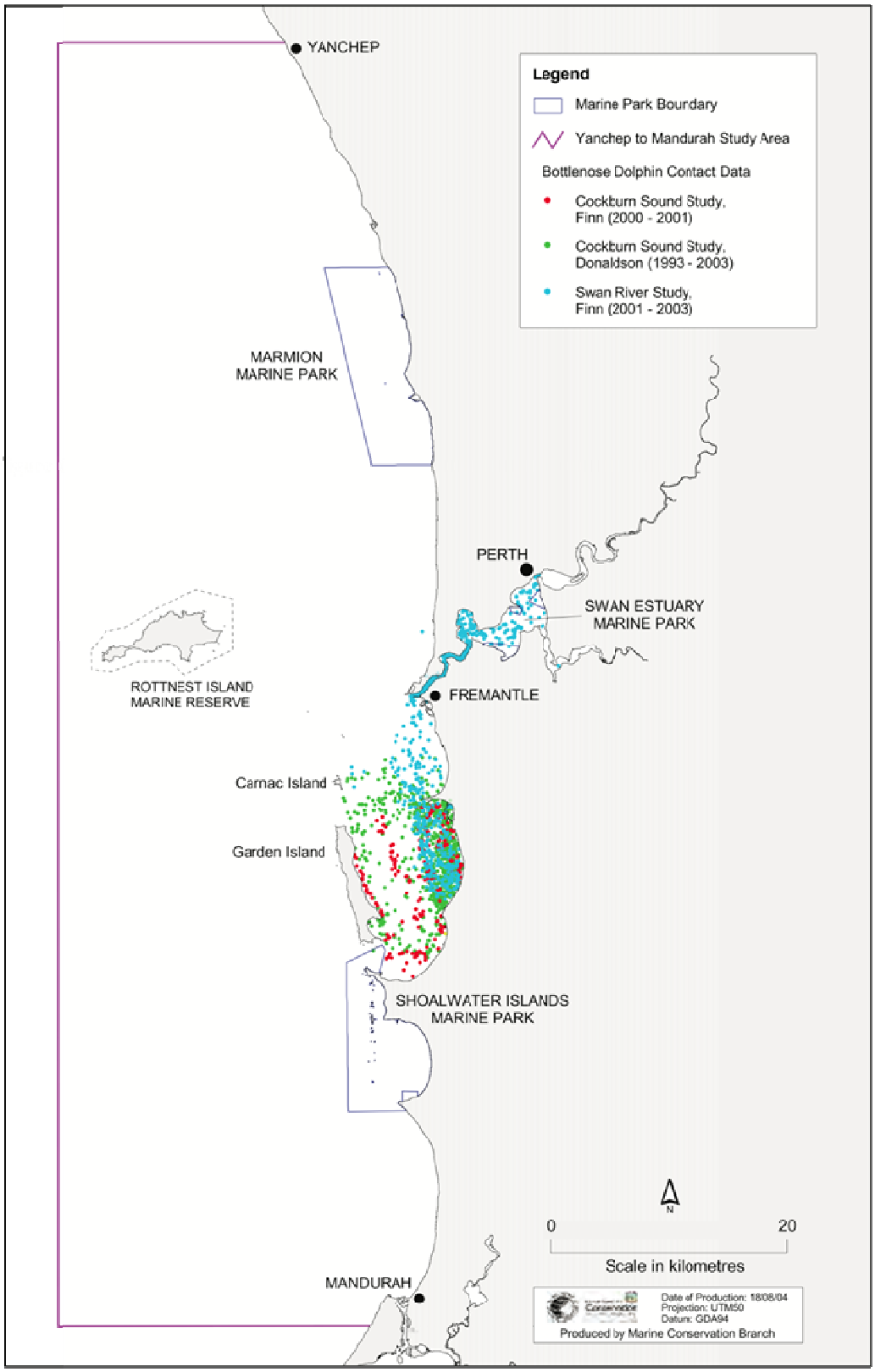
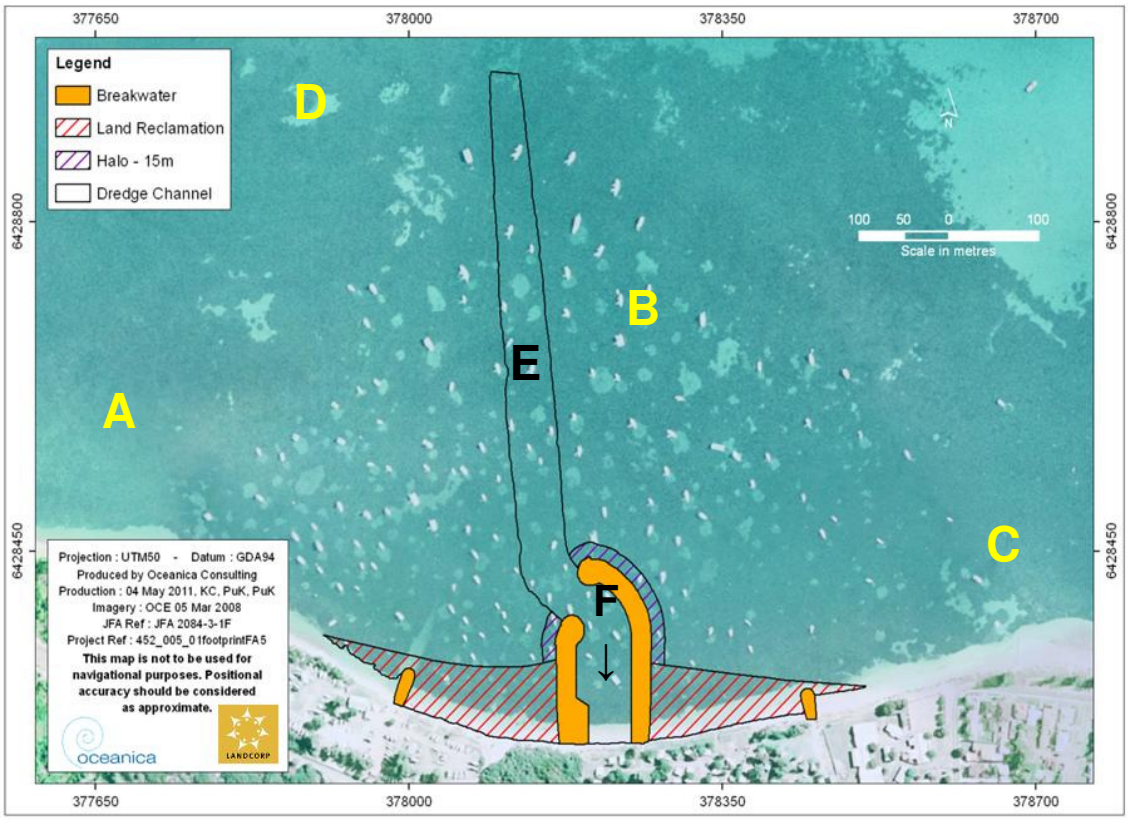


Figure 102 Locations for dolphins observed within the Swan Canning Riverpark and the southern Metropolitan coastal waters (source: Cannell 2004)

Previous research on dolphins has not focused on the shallow flats of Mangles Bay, but dolphins are known to utilise this part of Cockburn Sound. Observations of dolphins in the general Mangles Bay area have involved small groups of dolphins:

- moving through the area of moored parts ('B' in Figure 103)
- feeding in the border area between the seagrass areas and deeper basin areas of Mangles Bay
- travelling parallel with the shoreline.

These foraging behaviours and modes of movement are typical of dolphins in Cockburn Sound. Dolphins are also likely to use new habitats created by the Proposal, such as the dredged channel and the pens and jetties within the marina itself (Figure 103).



Note: Existing foraging habitats comprise shallow seagrass meadows (A), seagrass & sand with boats and moorings (B), sandy beach/shoreline (C) and patches of open sand (D). Potential foraging habitats comprise dredged channel (E) and boat pens within the marina (F).

Figure 103 Existing foraging habitats (in yellow font) for dolphins in the Proposal area, and potential foraging habitats (in black font) associated with the Proposal

The shallow flats of Mangles Bay adjacent to the Proposal do not appear to be a key feeding area for dolphins (refer Figure 99 and Figure 100), but is still of reasonable ecological significance to dolphins, mainly because seagrass areas in Cockburn Sound provide important breeding and nursery areas for fish and also sustain assemblages of dolphin prey species like herring, mullet, garfish, squid and whiting.

13.3.4 Little penguins

The largest colony of little penguins in Western Australia is found in the Perth Metropolitan region on Penguin Island, where population size has recently been estimated to be 1500 – 2500 penguins (Cannell et. al in prep.). Colonies are also found on Garden and Carnac islands. Currently, the total size of the colony on Garden Island could be 500 – 600 individuals or greater; these mainly inhabit Careening Bay, with a smaller nesting area at Colpoys Point (Figure 104).

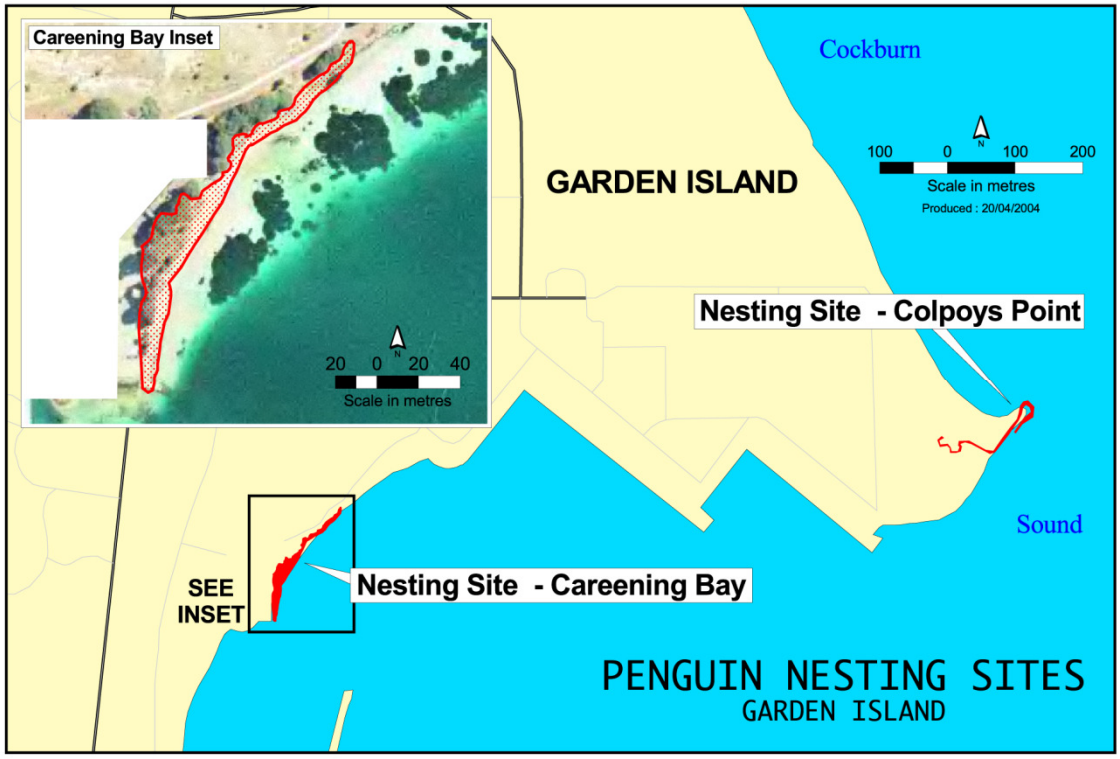


Figure 104 The major nesting site of little penguins at Careening Bay, and smaller site at Colpoys Point, Garden Island (Cannell 2011)

Cockburn Sound could potentially play an important role in the long-term maintenance of little penguins in the Perth region, as penguins on Garden Island generally have a higher breeding success than those on Penguin Island, and a higher proportion of the colony that breeds twice a year (Cannell 2011.). Little penguins on Garden Island can lay two clutches in a year, the first usually in June and the second usually in September. Generally two eggs are laid with incubation an average of 36 days. Chick guarding is shared by both parents (Chiaradia and Kerry 1999), while the other is at sea feeding. Chicks are guarded constantly for 2-3 weeks, and raised for an average of eight weeks (Stahel & Gales 1987).

After breeding, the adult penguins moult between November and February, replacing all their feathers. This is a critical process which the penguins must undergo every year. The moult takes 2 – 3 weeks, during which the penguins are confined to land. As they are unable to feed during the moult, the penguins must build up their fat reserves prior to moult, and can double their mass. Low body mass during moult can result in the penguins dying from starvation.

Penguins leave the colony before dawn and spend the day foraging at sea, where they can dive more than 100 times per hour searching for prey (Ropert-Coudert *et al.* 2003; Cannel 2011), and in between dives they rest on the surface. Penguins usually return to the colony after sunset (Cannell 2003), or can remain at sea overnight. Very limited dietary information is available for the Garden Island penguins, but results suggest anchovy predominate the diet, although scaly mackerel, pilchard, blue sprat and sandy sprat have

also been found. Penguin Island penguins feed on a range of fish including pilchards, garfish, anchovy, blue sprat and sandy sprat.

The movements of Garden Island penguins have been tracked using satellite tags: adults guarding chicks in 2007 and 2008, and incubating adults in 2008 and 2009. Preliminary analysis of the data show that regardless of the time spent at sea, the penguins remained within Cockburn Sound, and the area used extended from the northern end of the Central Basin south to Mangles Bay. In both 2007 and 2008, the penguins guarding chicks almost exclusively used the southern half of Cockburn Sound. There were fewer locations on the Kwinana Shelf and in the northern Central Basin. Penguin Island penguins could also be foraging in Cockburn Sound, with those that nest on the northeast side of Penguin Island more likely to forage in Cockburn Sound than those penguins nesting in other areas on Penguin Island (Cannell 2011).

There are not sufficient data to fully determine the importance to penguins of the shallow flats of Mangles Bay compared to other areas in Cockburn Sound, although available data indicate that the deeper waters of southern Cockburn Sound are more important (e.g. Figure 105). However, as for dolphins, the shallow flats of Mangles Bay are ecologically important to penguins in providing important breeding and nursery areas for fish and also sustaining of assemblages of prey species. The shallow flats of Mangles Bay has been identified as an important nursery areas for blue sprat, sandy sprat and garfish, while deeper waters (depth 10–20 m) off Mangles Bay are areas where larval and older anchovy have been consistently found (refer Section 13.3.1).

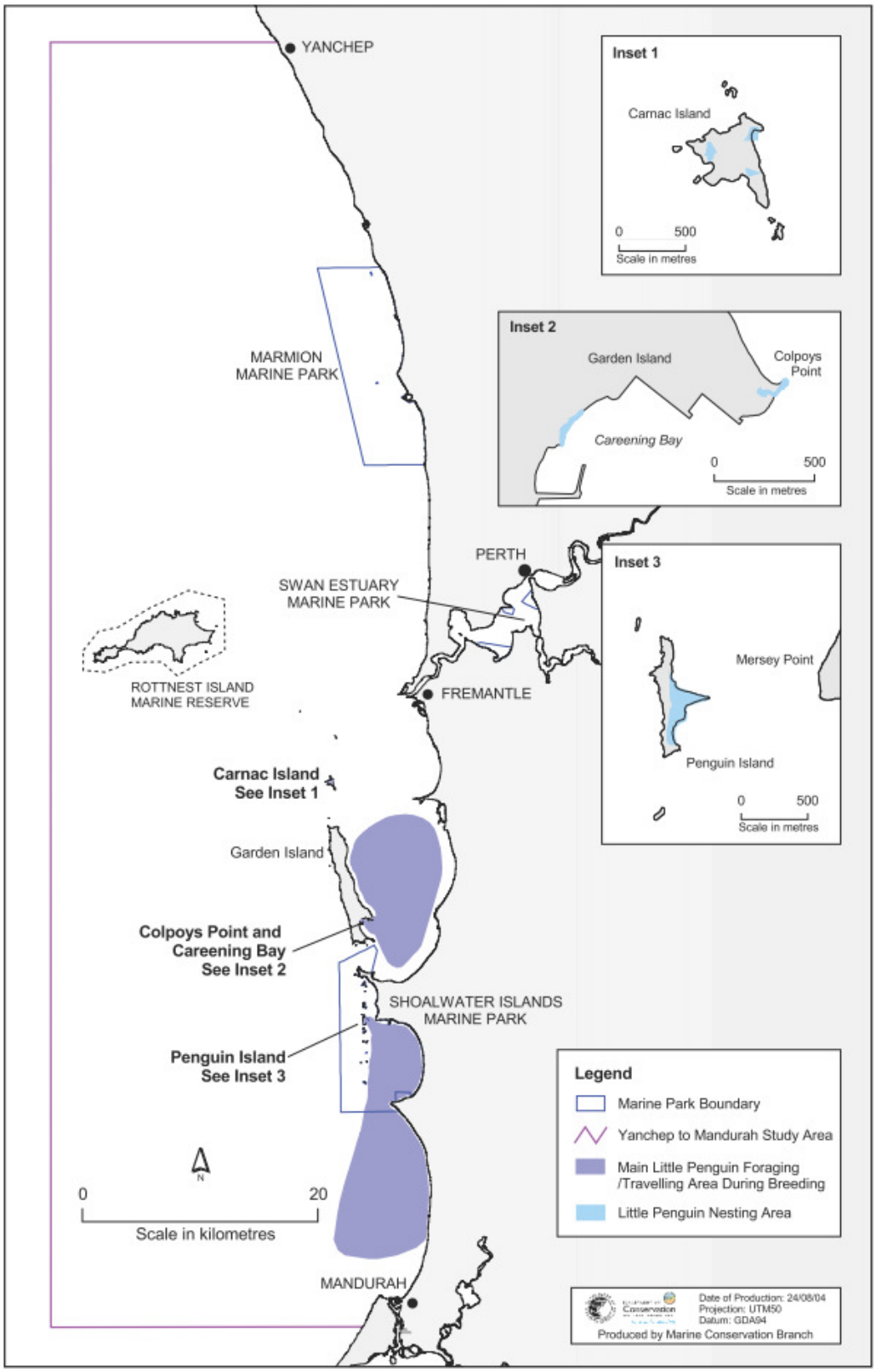


Figure 105 Locations of little penguin activity within southern Metropolitan coastal waters during breeding (Source: Cannell 2004)

13.3.5 Introduced marine pests

In 2000 Fremantle Ports undertook an IMS baseline study within port waters and adjacent coast (Hewitt *et al.* 2000). The survey found two pest species, the European fan worm *(Sabella spallanzanii)*, and the Asian date mussel (*Musculista senhousia)*, while the dinoflagellate species (*Alexandrium tamarense)* was also detected albeit in low concentrations.

Huisman *et al*. (2008) identified 60 IMS from Western Australia, 46 of which were found in the Fremantle (including Cockburn Sound and the lower Swan River) region, however only four are on the NIMPCG target list[18]:

1. The date mussel (*Musculista senhousia)*.
2. The European fan worm (*Sabella spallanzanii)*.
3. The toxic dinoflagellate (*Alexandrium minutum)*.
4. The European shore crab (*Carcinus maenas)*.

In 2007 Fremantle Ports partnered with the DoF to reassess the abundance and distribution of IMS (McDonald and Wells, 2009). Despite previous records of the European shore crab (*Carcinus maenas)* and the date mussel (*Musculista senhousia)* in this region, the investigation found no evidence of either species (McDonald and Wells, 2009). The European fan worm, (*Sabella spallanzanii)*, had actually increased its geographic spread up the Swan River, although the densities of this species in the more open waters of Cockburn Sound were much reduced from those reported in the early 1990's. Dinoflagellate pest species were not targeted due to difficulties with identification.

In April 2011, DoF undertook an IMS survey in Cockburn Sound, including Mangles Bay. Preliminary results are yet to be released; however preliminary data suggest that no additional IMP of concern were detected, other than those listed above (McDonald Principal Biosecurity Consultant pers. comm.,).

13.4 Evaluation of options or alternatives to avoid or minimise impact

13.4.1 Marina design and construction management

The marina access channel has been designed to minimise habitat loss. The marina has also been designed to maximise the flushing of inner marina waters. This will reduce the extent of nutrient enrichment and anoxia within the marina, and the likelihood of poor quality waters entering Mangles Bay and impacting on marine fauna. Contaminant inputs to marina waters will be minimised using 'best practice' measures for facility design and management, and strict regulations regarding general boating related activities. Water quality impacts are discussed in more detail in Section 10.

The construction of the breakwaters for the Mangles Bay marina will involve the use of construction machinery, including excavators, loaders and trucks. Only trained operators will be employed to operate the machinery to ensure that materials are placed on the seabed in the correct location to ensure that loss of habitat does not exceed the predicted footprint area and reduce available habitat for marine fauna. This will be the responsibility of the Proponent. There are no impacts to habitat expected as a result of turbidity plumes and associated smothering and light attenuation.

A CEMP will be prepared to specify the proposed breakwater and other construction methods and proposed management measures. The CEMP will include fauna observation protocols for dolphins, little penguins, sea lions and turtles during the dredging of the marina access channel.

[18] For the purposes of this document, IMP are defined as those species listed on the National Introduced Marine Pests Coordination Group's (NIMPCG) target list of 55 potential pest species (DAFF, 2009) and must be considered for a monitoring program for a given location in Australia.

13.4.2 Dredging program

The proposed dredging program for the marina has been designed to avoid or minimise impact on marine fauna communities including the following alternatives listed below:

1. The short duration of the dredging program over three months will reduce the time period of elevated turbidity levels, and noise – both of which may lead to avoidance of the area by marine fauna. Turbidity associated with dredging is predicted to be minimal (refer Section 10), and silt curtains will also be used (weather and sea conditions permitting) during the dredging process, to further control turbidity release and dispersion, thereby minimising potential impacts on fish stocks and foraging behaviour of marine fauna.
2. Impacts on fish eggs and larvae in the proposed development area will be minimised by timing dredging activities to avoid peak spawning and recruitment periods. The dredging has been proposed to occur between May and July, to reduce the impact on fish and invertebrate species. Spawning and recruitment generally occur for a number of important fish and invertebrate species (e.g. King George Whiting, pink snapper, blue swimmer crab) from late winter to late summer.
3. There is some conflict between preferred timing for fish and little penguins, since the peak penguin breeding time occurs in winter. This will be minimised by the planned dredging sequence (beginning from the outermost edge of the access channel, then moving shorewards) and could be further minimised by commencing the dredging in late autumn.

A dedicated Marine Fauna Observers (MFO) will be engaged during dredging and marine-related construction works who must:

- demonstrate a knowledge of marine wildlife species in the Perth metropolitan region, particularly species listed under the Wildlife Conservation Act 1950 and associated notice
- be on duty at all times during dredging and marine-related construction works
- maintain a log of observations of marine fauna, including injured or dead fauna (of any species) within 500 m of dredging and construction, which is to be submitted to DEC at the completion of dredging and construction.

No dredging will commence until the MFO has verified that no dolphins or sea lions have been observed within a radius of 500 m of dredge machinery or the construction site during the 30 minute period immediately prior to commencement of dredging or construction work. If the MFO observes a dolphin or sea lion entering within 500 m of dredging or construction work, the dredging or construction work is to be suspended.

Dredging and construction work that has been suspended as above, shall not recommence until the dolphin has moved on of its own accord beyond 500 m from the dredging or construction area, or has not been seen within 500 m for 30 minutes.

Dredging and construction will only occur during daylight hours to enable an adequate level of observation by the Marine Fauna Observer. Dredging and marine construction works will occur outside the months of September to March to avoid the peak dolphin calving period (refer above).

13.4.3 Introduced marine pest (IMP) inspections

Consideration of options or alternatives to avoid or minimise the impact of IMP establishment is restricted to the use of commercial vessels during the construction phase (i.e. dredging equipment and construction vessels) since there are currently no guidelines applicable to recreational vessels during the operation phase. Prior to any dredging plant or equipment entering State Waters, the Proponent shall arrange for an inspection by an appropriately qualified expert (on advice of DoF) to ensure that:

- there is no sediment on the dredging equipment
- ballast water (if applicable) has been managed according to the AQIS ballast water requirements
- any fouling organisms on the dredging equipment do not present a risk to the ecosystem integrity of the marine waters of Cockburn Sound.

13.5 Assessment of likely direct and indirect impacts

13.5.1 Potential sources of impact

The following aspects of the Proposal may potentially affect marine fauna:

- temporary changes in water quality during construction (turbidity, nutrient-related water quality, contaminants) due to dredging and the discharge of return water
- ongoing changes in water quality due to outflow of lesser water quality from the marina into Mangles Bay
- direct and indirect loss of habitat due to construction of the access channel and breakwaters of the marina
- increased risk of IMS due to increased numbers of large recreational vessels berthing in the marina
- increased human access causing littering
- increased vessel numbers causing increased fishing pressure and the potential for boat strike
- increased marine noise levels due to pile driving and rock dumping during construction.

In order to define key environmental risks and potential impacts to key faunal groups (fish, invertebrates, little penguins and dolphins) in Mangles Bay and identify appropriate measures to manage or mitigate those risks to acceptable levels, a risk assessment workshop was held on 18 April 2011. Participants at the workshop were from Oceanica Consulting, Strategen, Dr McLean (Mindabbie Marine), Dr Cannell (Murdoch University) and Dr Finn (Murdoch University). The key potential environmental issues associated with the overall Proposal were identified as:

- loss of BPPH – predominantly seagrass
- increased recreational fishing pressure on fish stocks and thus food availability for dolphins and penguins
- increased vessel movements and therefore increased vessel strikes on fauna
- entanglement in ropes, nets and lines, and other marine debris.

This assessment was based on the assumptions that potential impacts due to dredging (noise, turbidity and release of contaminants) will be minimal (refer to Section 10), and that the quality of water entering Mangles Bay from the marina will not be harmful to marine fauna (refer to Section 10).

This section discusses the potential risks posed to marine fauna in Mangles Bay through the development of the Proposal, specifically in relation to key species of marine fauna. The key species are considered to be fish and marine invertebrates (due to the importance of Mangles Bay as a fish and invertebrate habitat), and dolphins and little penguins (iconic species that maintain significant resident population in Cockburn Sound). This section also includes an assessment of the risk from IMS.

13.5.2 Loss of benthic habitat and associated prey species

The benthic habitat in the shallow flats of Mangles Bay is mainly dense seagrass, but it has a large number of mooring scars consisting of bare sand where boat swing moorings have scoured the seafloor. There are also bare areas adjacent to the boat launching areas of the yacht club and fishing club where boat hulls have scoured the seagrass (refer to Section 12).

The Proposal will result in the loss (direct and indirect) of 5.66 ha of seagrass meadow and 1.69 ha of unvegetated sediment (Section 12). The loss of habitat (seagrass) may potentially cause a reduction in fish stocks due to egg loss and/or larval mortality. In turn, loss of fish biomass or change in fish communities may lead to reduced reproductive success and survivorship of dolphins and little penguins in Cockburn Sound (due to lower availability of prey species). However not all impacts on dolphin feeding

habitat will necessarily be adverse. Dolphins are likely to use new, modified, and unaffected habitats within the marina and access channel as a feeding habitat.

13.5.3 Increased recreational fishing pressure

Increased human access will place a variety of pressures on marine fauna, primarily through a higher usage of boats and increased people traffic. There is likely to be an increase in recreational boating in the area as a result of the provision of boat pens, a refuelling station and the residential canal development. This is likely to lead to higher levels of recreational fishing that will place pressure on already heavily targeted species and indirectly on non-targeted species, and potentially cause a change in fish assemblage composition.

Increased recreational fishing pressure due to increased population is predicted for the waters of Cockburn Sound and SIMP, irrespective of whether the Proposal goes ahead or not. The population of suburbs immediately adjacent to Cockburn Sound and the SIMP is expected to increase from 171,751 in 2010 to 221,759 in 2020 and to 249,145 in 2025 (DPI 2007). Shore-based recreational pressure will increase accordingly. Recreational boating numbers are predicted to increase by 18–45% in the medium-term (by 2018) to long-term (by 2025) (refer to Section 16). Department of Transport (DoT) predictions (refer to Section 16) for the suburbs immediately adjacent to Cockburn Sound and the SIMP – without the marina - are:

- the number of trailerable boats will increase by 1,506 – 3,901 over the medium-term (2018) to long-term (2025), and about three quarters of this increase will be in the Rockingham region
- the number of non-trailerable boats will increase by 112 – 258 vessels over the medium-term (2018) to long-term (2025) and about two-thirds of this increase will be in the Rockingham region.

Increased recreational fishing pressure due to the Proposal will constitute only a small proportion of that predicted due to population increase: this is discussed further below. Increased recreational fishing pressure in Cockburn Sound and the SIMP is a regional issue that comes under the jurisdiction of the DoF, in collaboration with the DEC (for the SIMP).

Recreational fishing pressure in Cockburn Sound and Shoalwater Islands Marine Park

The marina will not result in an increase in trailerable boats in the waters of Cockburn Sound and the SIMP above the anticipated numbers predicted by the DoT due to the regional population growth, but it will increase the number of large vessels. Of the up to 500 pens/berths within the marina, approximately half will be for the new marina club and the remainder for the public and marina residents. The marina is expected to add 128 more boats than DoT predictions based on regional population growth. DoT data also indicate that about 20% of registered boats are launched each day during peak times in summer (refer to Section 16). The marina will thus increase recreational boat traffic, over and above that due to the regional population growth in the medium-term, by approximately 26 boats/day during peak times in summer, all due to large vessels. This would represent 19% of traffic due to large (non-trailerable) vessels in Cockburn Sound and the SIMP in the medium-term, but about 1% of total recreational boat traffic (trailerable and non-trailerable boats). The marina will have no effect on regional levels of boat traffic in the long-term (2025).

Recreational fishing pressure in the shallow waters of Mangles Bay

Shore-based recreational fishing does not constitute the majority of fishing pressure in Mangles Bay. Although shore-based fishing takes a greater proportion of the total recreational catch of finfish (about three quarters) than boat-based fishing effort in Cockburn Sound, it is focussed around jetties and the northern half of the Sound, especially Woodman Point (Fletcher and Santoro 2007). Boat-based fishing effort for crabs far outweighs shore-based effort (Williamson 2005, cited Oceanica 2007). Predictions of changes in shore-based fishing effort with the marina are also difficult. Access to the shore adjacent to the proposed marina is presently limited due to the local yacht club, fishing club, and chalet accommodation. Shore-based fishing is probably mainly by persons using these facilities, with some use by persons accessing the area by walking along the beach. The Proposal will interrupt pedestrian access along the

beach shoreline (due to the marina access channel and breakwaters), interfering with the continuous shoreline of Mangles Bay, but will allow improved access to the beach via the marina development itself. It is, however, likely that the Proposal will result in some increase in shore-based recreational fishing pressure.

At present, boat-based recreational fishing pressure within the shallow waters of Mangles Bay is largely due to the boats associated with the 600 swing moorings in the Bay (fishing from the moored boats is popular, refer to Section 16), boats launched from the private boat ramps of the yacht club and the fishing club in Mangles Bay, and boats launched at Cape Peron public boat ramp and Palm Beach public boat ramp (the two public boat ramps closest to Mangles Bay).

The marina is likely to cause a small increase in recreational boat pressure within the shallow waters of Mangles Bay due to the trailerable boats owned by marina residents (91 boats, assuming the 2,000 marina residents have the same level of ownership of trailerable boats as Rockingham residents; refer to Section 16). The non-trailerable boats in the marina are not expected to add to recreational fishing pressure in the shallow waters of Mangles Bay as their keel clearance will prohibit movement into the very shallow waters west of the marina access channel, while the existing mooring congestion will discourage movements to the east of the access channel. The non-trailerable boats in the marina are expected to head out the marina access channel to Southern Flats, to the SIMP via the northern Causeway entrance, or to eastern side of Garden Island. Non-trailerable boats will thus contribute to recreational fishing pressure within the broader region of Cockburn Sound and the SIMP (see above), rather than the shallow waters of Mangles Bay.

The above information is summarised in Table 61, and indicates that although the marina will cause a small increase in boat-based recreational fishing pressure within the shallow waters of Mangles Bay, it will not constitute the major source of recreational pressure.

Table 61 Potential sources of recreational boat pressure within the shallow waters of Mangles Bay at present, and in the medium-term (2018) to long-term (2025)

Source of recreational boating pressure	Potential boat numbers during peak times at present	Potential boat numbers at peak times in the marina in the medium-term to long-term
Swing moorings in Mangles Bay	600 moorings, a large proportion with boats.	600 moorings, a large proportion with boats. Level of usage continues.
Cruising Yacht Club ramp	unknown	Level of usage continues – club members use marina boat ramp
Mangles Bay Fishing Club ramp	unknown	Level of usage continues – club members use marina boat ramp
Cape Peron public boat ramp	100-175 boats launched at peak times. Proportion entering Mangles Bay unknown, but area popular for trailerable boats.	118-254 boats[1] launched at peak times. Proportion entering Mangles Bay unknown, but area popular for trailerable boats.
Palm Beach public boat ramp	100 boats launched at peak times. Proportion entering Mangles Bay unknown, but area popular for trailerable boats.	118–145 boats[1] launched at peak times. Proportion entering Mangles Bay unknown, but area popular for trailerable boats..
Mangles Bay marina – resident's trailerable boats	Not applicable	9 boats during peak times in summer[2], also assumes they all stay in Mangles Bay

1. Based on predicted increases in recreational boat ownership of 18–45% in the medium-term (2018) to long-term (2025)
2. Assumes 10% of boats are launched during peak times. This is higher than the 5% typically used by the DPI (2009), but has been used as a conservative estimate of the higher level of boat usage of marina residents.

13.5.4 Increased interactions between humans and marine fauna

Dolphins

The proposed development will result in a small increase (1%) in the number of vessels able to access Cockburn Sound and the SIMP in the next 10–15 years (within the context of predicted increases of boat ownership; see above) and as such, it will also increase the amount of human-dolphin interaction that occurs. Some interactions will be adverse (e.g. disturbance, harassment, illegal feeding) and some may cause injury or mortality (e.g. entanglement in discarded fishing line, vessel strikes). While the overall impact of this increase in human interactions may not exert a biologically significant effect on the dolphin population in Cockburn Sound (and the SIMP), it will add to the human-related stress that animals experience in this ecosystem. Increased human interactions may cause a change in feeding behaviour or the displacement of dolphins from feeding areas.

Other marine fauna

The small increase (1%) in the number of vessels able to access Cockburn Sound and the SIMP in the next 10–15 years will also lead to increased human interactions with other marine fauna within the waters of Cockburn Sound and the SIMP, and on the Shoalwater Bay and Carnac Island nature reserves, Point Peron and the northern end of Garden Island. As for dolphins, some interactions will be adverse (e.g. disturbance, harassment, illegal feeding) and some may cause injury or mortality (e.g. entanglement in discarded fishing line, vessel strikes).

The majority of boating activity in Cockburn Sound and the SIMP is associated with recreational fishers, and most boats focus on waters within Cockburn Sound and east of Garden Island compared to the SIMP (refer Section 16.2.2). The increased level of human interaction with other marine fauna in the SIMP and island nature reserves should therefore be minor (within the context of predicted regional increases of boat ownership), but will add to the human-related stress that animals experience in this region.

13.5.5 Entanglement and marine debris

An increase in the people utilising the foreshore area of the Proposal's tourist precinct and the broader area of Cockburn Sound and the SIMP may increase the litter in these areas (such as plastic bags, fishing line and other fishing gear). Litter can affect marine fauna such as dolphins, little penguins and sea lions by ingestion, and entanglement in discarded fishing line or plastic. The effects can include death, injury, adverse behavioural and physiological changes, and reduced body condition and/or immune function to individual fauna. These processes may also interact with the natural processes such as disease and predation.

13.5.6 Increased vessel strikes

The proposed development will result in a small increase (1%) in the number of vessels able to access Cockburn Sound and the SIMP in the next 10–15 years (within the context of predicted increases of boat ownership due to population increase; see above). An increased number of vessels using Cockburn Sound is likely to result in an increase in the number of marine fauna (particularly penguins) injured or killed from collisions with the vessels. Increased vessel movements could also cause an interruption of a penguin's resting period on the surface, or make it move away from feeding areas, potentially causing long-term impacts on the penguin's energetic costs and lowering the carrying capacity of penguins in Cockburn Sound. Little penguins are often very difficult to observe at sea because they are low in the water when at the surface and also swim much slower than most boats (Bethge *et al.* 1997), making it difficult for them to get out of the way of vessels. Injuries as a result of increased vessel strikes could result in the death of individuals, or affect a penguin's ability to catch prey, and thus its ability to successfully raise chicks or maintain itself.

Although the Proposal will result in a small increase in the number of vessels in Cockburn Sound and the SIMP, this increase will be due to larger vessels that are more likely (than smaller vessels) to traverse

Southern Flats and move northwards up the eastern side of Garden Island, or pass through the northern Causeway entrance to the SIMP. Boats moving up the eastern side of Garden Island will traverse waters that penguins regularly cross to feed in southern Cockburn Sound, when they are incubating eggs or feeding chicks. Boats travelling out through the northern Causeway entrance may also interact with Penguin Island penguins.

The penguin breeding season (June to November) is outside peak boat activity time (summer), and so boat numbers will be less (≤2% registered boats launched each day, outside of peak times in summer; refer to Section 16). As with increases in recreational fishing pressure, population-driven increases in recreational boating will cause an increased risk of vessel strikes, irrespective of whether the Proposal proceeds or not. Assuming 2% registered boats are launched each day during the penguin breeding season, in the medium-term the Proposal will result in about 14 large vessels/day versus 11 large vessels/day from population-driven increases alone and 14 vessels/day with or without the Proposal in the long-term. The expected number of small vessels in off-peak periods in the medium-term to long-term is 190-235/day (with or without the Proposal), but it is not known what proportion would travel up the eastern side of Garden Island. However the data of Sumner *et al.* (2008) for recreational fishing catches from boat ramp surveys in 2005-06 indicate that an appreciable number of trailerable boats do fish the waters west of Garden Island, particularly for dhufish, pink snapper, breaksea cod, herring and whiting.

13.5.7 Chemical contamination (bioaccumulation)

With increased boating traffic and berthing of vessels there is a risk of higher levels of organic and inorganic chemicals than presently exists in the area. Water quality within the marina, and in waters entering Mangles Bay from the marina, will potentially be influenced by factors within the marina itself such as the combustion of fuel in boat engines, stormwater run-off from impermeable surfaces, boat maintenance and sewage (Scott 2003). Boats are potentially a significant source of organic and inorganic chemicals (e.g. trace elements, TBT, polychlorinated biphenyls, and petroleum hydrocarbons). Many of these compounds can also accumulate in marina sediments where they have the capability to adversely affect benthic fauna (McGee *et al*. 1995), and fauna that feed on them.

13.5.8 Introduced marine pests

The major potential impacts of introduced marine pests are:

- reduction or loss of biodiversity
- reduction or loss of ecosystem function
- increase in the cost of maintaining infrastructure (for example cleaning biofouling from seawater intake pipes).

The increased number of vessel movements associated with dredging and construction could represent an increased threat of exposure to IMS. The introduction of IMS could lead to irreversible detrimental impacts to the composition and function of the natural ecosystem through changes in competition, predation, or habitat modification.

13.5.9 Marine Noise

The Proposal plans to utilise pile driving during jetty construction and rock dumping during breakwater construction. Curtin University Centre for Marine Science and Technology were approached regarding the impacts of this noise on the marine environment and were of the opinion that noise associated with these construction methods will not be of detriment to marine fauna in the area. It is thought that some noise during construction may cause temporary avoidance of the area by some marine fauna, but that the depth of water and sheltered nature of Mangles Bay will mean that no significant physiological impacts on marine fauna will occur. (*pers comm*. Dr Alec J Duncan, Curtin University August 2011). A full copy of the letter report by Curtin University is included in Appendix 5.

13.6 Potential for and nature of any cumulative impacts

In evaluating the impacts specific to the Proposal, consideration also needs to be given to the cumulative impact of other projects, and a general increase in boating and recreational activity in Cockburn Sound due to population increase. Cumulative impacts relate primarily to an increase in fishing pressure and habitat loss. The proposal will also have a cumulative impact in terms of vessel movements, with a predicted increase in the number and size of vessels. As noted above, the larger vessels berthed at the marina are likely to exit Cockburn Sound to the SIMP and/or deeper waters offshore, either through the Causeway or by travelling up the eastern side of Garden Island.

The cumulative impacts of benthic habitat loss are discussed in Section 12, and the cumulative impacts of boating and recreational pressures due to population increase have been incorporated in the sections above. The other potential source of recreational boating pressure that will contribute to cumulative impacts in the region is the approved (Ministerial Statement 826) Port Rockingham marina, adjacent to the Wanliss Street and Rockingham Beach Road intersection (Figure 106).

The Port Rockingham Marina will provide 500 pens for non-trailerable boats (RPS 2009). The Mangles Bay marina and Port Rockingham Marina will potentially result in about a two-fold increase in non-trailerable boats in the medium-term (by 2018) to long-term (by 2025) but minor increases in total boat numbers (trailerable boats comprise the large majority of boat numbers, so increases in total boat numbers are driven mainly by regional population increases). The large vessels in both marinas are more likely to move into the SIMP and/or deeper waters offshore via the northern Causeway entrance, or to travel up the eastern side of Garden Island. The cumulative increase in larger vessels could therefore potentially cause an increase in vessel strikes on marine fauna (especially penguins) that is proportionally higher than their contribution to boating traffic (refer Section 13.5.6).

Figure 106 Location of Port Rockingham Marina (Source: RPS 2009)

13.7 Management measures and performance standards

13.7.1 Loss of benthic habitat and associated prey species

Possible management measures that could be undertaken to reduce the potential impact of habitat loss associated with the Proposal on fish stocks (and any associated loss or change in prey species for dolphins and little penguins) include:

- improvement in the habitat value of the seagrass meadows of Mangles Bay by rehabilitation of areas where seagrass has been lost due to mooring scars (refer Section 12.6.3 in BPPH section). The associated removal of the yacht club and fishing club's private boat ramps, and reduction in boat launching across the beach, will also reduce scouring damage in these area and allow natural regeneration of seagrass
- seagrass transplantation in other suitable areas of Cockburn Sound, such as Southern Flats (refer Section 12.6.3)
- no removal of sea wrack, which also provides habitat for fish species
- establishment and enforcement of no-wake zones in shallow surface waters.

13.7.2 Increased fishing pressure

The Proposal's main long-term potential impact to fish and macroinvertebrate assemblages in Mangles Bay is the increase in recreational fishing effort, although this is expected to be minor compared to the existing recreational fishing pressures and future pressures predicted due to regional population increase (refer Section 13.5.3). Impacts of the Proposal on regional fisheries will also be minor compared to future pressures predicted due to regional population increase.

The assessment of changes in recreational fishing effort and fish assemblage structure is a regional issue for the management of Cockburn Sound and the SIMP, irrespective of whether the Proposal proceeds, as is monitoring of animals that rely on fish and invertebrates for food (e.g. little penguins, dolphins). With the appropriate information, the DoF will be able to adjust recreational fisheries regulations to help protect targeted species, prevent assemblage structure change and flow-on effects through the ecosystem.

The Proposal will also offer opportunities for decreased stress on the marine ecosystem by supporting better management of impacts due to recreational fishing pressure through:

- promoting/displaying information about ecological values and appropriate behaviour in the marine environment, including sustainable fishing practices
- promoting/displaying information about recreational fishing regulations (e.g. catch limits, legal fish size etc)
- providing a base for surveillance, monitoring and research in the marine environment, including the impacts of recreational use and management activities.

13.7.3 Increased interactions between humans and marine fauna

The Proposal will offer cost-effective opportunities to encourage appropriate behaviour towards dolphins (and other fauna such as little penguins and sea lions) by recreational users, and therefore help avoid, mitigate or offset possible impacts due to increased human interactions. The opportunities include:

- promoting/displaying information to encourage appropriate behavior, and informing users of relevant wildlife regulations
- feeding of dolphins will be prohibited in the marina, and users of the marina facility will be warned that they risk losing privileges if observed feeding dolphins or violating other environmental regulations.

13.7.4 Entanglement and marine debris

Potential management measures that could be implemented to avoid, mitigate, or offset possible impacts from the Proposal on marine fauna (primarily dolphins and little penguins) due to entanglement or ingestion of marine debris include:

- implementing educational measures to encourage appropriate disposal of fishing line through fishing line discard bins and information signs (similar to those developed by Coastcare) at marina
- regular patrolling of the marina to remove line or other entanglement sources and support clean-up measures around fishing 'hot spots' in and around Mangles Bay
- prohibiting fishing within the main marina waterbody in order to avoid entanglement in fishing lines
- prohibiting feeding of dolphins within the marina
- implementing strict environmental management standards for the marina, including regular clean-up of debris from the marina waters
- induction of all construction workers about correct waste management procedures.

13.7.5 Increased vessel strikes

Possible management measures that could be undertaken to reduce the potential impact of increased vessel movements and vessel strikes on marine fauna (primarily little penguins) as a result of the marina development include:

- promoting/displaying information about ecological values (e.g. including daily cycles of penguins, where they forage, potential for displacement by watercraft and vessel strikes) and appropriate behaviour in the marine environment (including appropriate boat speeds to minimise boat strike on penguins, dolphins and sea lions)
- providing a base for surveillance, monitoring and research in the marine environment, including the impacts of recreational use and management activities
- encouraging recreational boat owners to participate in filling out observation sheets of penguins at sea, with observation sheets collected quarterly by marina manager and sent to nominated researcher
- charter operators in the marina are required to fill in observation sheets of penguins at sea, collected quarterly and sent to nominated researcher (these data will help to determine effect of vessels on penguin use of areas).

13.7.6 Chemical contamination

The potential effects of chemical contamination (toxicants) on marine fauna will be minimised by implementing 'best practice' measures and/or having strict regulations regarding general boating related activities (e.g. fuelling facilities and their locations, minor oil spills, bilge water, detergents, stormwater runoff, cleaning vessels on hardstand etc) within the marina.

The Proposal also offers opportunities for education programs for the public about the impact their boating-related activities have on the marine environment.

13.7.7 Introduced marine pests

In the event that introduced marine pests or significant amounts of fouling organisms or sediment (as deemed by an Officer of DoF, accredited biofouling inspector or suitably qualified marine expert) are found on a vessel or equipment, the following management actions will be taken:

- the DoF, DEC, OEPA: DoF must be notified within 24 hours of any known or suspected marine pest detection in West Australian State waters
- DoF will provide direction and advice on management options for the IMP detection
- potential management options include removal of vessel or equipment from State waters, dry docking and cleaning of vessel or in water cleaning. All of these options would be required within specific timeframes and will be under the direction of DoF. In-water cleaning in West Australian State waters and Commonwealth waters will not be approved when introduced marine pests are detected or suspected on vessel or equipment
- if cleaning occurs, a post-clean inspection performed by an accredited biofouling inspector or suitably qualified marine expert will be required and submitted to DoF for assessment
- if DoF is satisfied that the level of vessel or equipment hygiene represents a low risk and all conditions have been met to the satisfaction of DoF, a vessel movement clearance will be issued by DoF, with specific timeframes for movements, depending on the risk profile of the vessels current location
- IMP monitoring may be required for the location/s of the detected introduced marine pest and associated vessel movements, as directed by DoF.

13.8 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

During construction of the Proposal there will be some temporary turbidity and noise associated with dredging. Effects on marine fauna are expected to be minimal (refer Section 10), and will be covered under an appropriate CEMP that includes fauna observation protocols for dolphins, little penguins, sea lions and turtles during dredging. The marina will also be designed and managed to minimise potential impacts on marine fauna due to poor quality water entering Mangles Bay from the marina (refer Section 10).

The Proposal will result in a loss (direct and indirect) of 5.66 ha of seagrass meadow and 1.69 ha of bare sediment. The loss of seagrass may lead to associated reductions in fish stocks due to egg loss and/or larval mortality, and in turn may lead to reduced reproductive success and survivorship of dolphins and little penguins in Cockburn Sound due to lower food availability. To ensure there is no net loss of seagrass, the losses will be offset by replanting an area equal to that removed in nearby areas of Cockburn Sound (e.g. Southern Flats). Further, seagrass rehabilitation of swing mooring scars and scouring from boat launching facilities will be considered as part of the final offset package.

The Proposal will also result in impacts on marine fauna due to increased shore-based and boat-recreational activity, and recreational fishing pressure. The increases due to the Proposal will be minor in comparison to increases that will occur irrespective of the project due to increases in population and the level of boat ownership in the region, but can also be offset by:

- provision of better management and facilities (tourism, recreational use, boating activity and fishing pressure are largely unregulated at present, or enforcement of regulations is under-resourced)
- provision of increased opportunities for promoting/displaying information to encourage appropriate behavior by recreational users, and informing them of relevant wildlife regulations
- use of 'best practice' measures and strict regulations for the Proposal, to ensure minimal inputs of contaminants to the marine environment.

With the above management and offsets, it is considered that the Proposal will meet EPA objectives and SIMP objectives for marine fauna.

14. Matters of National Environmental Significance impact assessment

14.1 Relevant environmental objectives, policies, guidelines, standards and procedures

The Proposal has the potential to affect the following Matters of NES:

- threatened species
- migratory species
- TEC 'Sedgelands in Holocene dune swales of the southern Swan Coastal Plain' (occurring around Lake Richmond)
- TEC 'Thrombolite (microbial) community of coastal freshwater lakes of the Swan Coastal Plain (Lake Richmond)'
- Ramsar Wetlands.

The EPBC Act objectives are to:

- provide for the protection of the environment, particularly Matters of NES
- promote ecologically sustainable development through the conservation and ecological sustainable use of natural resources
- control the international movement of wildlife, wildlife specimens and products made or derived from wildlife.

14.1.1 Australian Government Protection

The Australian Government EPBC Act protects species listed under Schedule 1 of the Act. In 1974, Australia became a signatory to the CITES. As a result, an official list of endangered species and TECs was prepared and is regularly updated. This listing is administrated through the EPBC Act. The current list differs from the various State lists; however, some species are common to both. There is no direct State protection of TECs.

The EPBC Act aims to prevent significant impacts occurring to Matters of NES, including threatened species through assessment of proposed actions against the *Matters of National Environmental Significance: Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (DEWHA 2009).

14.1.2 International Agreements

JAMBA, CAMBA and ROKAMBA Treaties

The Japan-Australia Migratory Bird Agreement (JAMBA), China Australia Migratory Bird Agreement (CAMBA) and Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) are Treaties for the protection of certain migratory bird species. The Treaties require each country to take appropriate measures to preserve and enhance the environment of bird species subject to the Treaty provisions. Most of birds listed in these agreements are associated with saline wetlands or coastal shorelines; however; some migratory birds not associated with freshwater wetlands are also listed on these international treaties.

All species listed under the JAMBA, CAMBA and ROKAMBA Treaties are subject to the legislative protection of the EPBC Act. Species listed under JAMBA Treaty are also protected under Schedule 3 of the WC Act.

Ramsar Conventions on Wetlands of International Importance

The Ramsar Convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation of wetlands and their resources. Australia was one of the first countries to sign the Convention, adopted in 1971, and has been an active member since it came into force in 1975.

Signatories to the Ramsar Convention commit to maintaining the ecological character of Wetlands of International Importance, and to plan for the "wise use" of all of the wetlands in their territories. The closest Ramsar wetland to the Proposal site is the Becher Point Wetlands located approximately 7 km south of the site. Forrestdale and Yangebup Lakes and the Peel-Yalgorup Wetlands are Ramsar wetlands within the same catchment as the Proposal. Lake Richmond is not a Wetland of International Importance or a Wetland of National Importance.

14.2 Findings of surveys and investigations

Based on previous surveys, database and literature searches from within 10 km of the Proposal area: two TECs; 20 Threatened species; 9 Migratory terrestrial species; and 5 Migratory marine species listed under the EPBC Act may occur within the Proposal area (Table 62). Several of these species have been recorded within or adjacent to the Proposal area during previous fauna surveys (Table 62).

A fauna survey undertaken by ENV (2011a) summarises all the available survey data and information available within the Rockingham area of the Proposal. The following description of the likelihood of species is adapted from ENV (2011a) unless otherwise stated. Copies of surveys that include the Proposal area are located within Appendix 5.

Table 62 Summary of potential presence of conservation significant species identified with Protected Matters Search Tool

Species identified with Protected Matters Search tool (August 2010)	Status under EPBC Act	Likelihood to occur within Proposal area
Wetlands of international significance		
Becher Point Wetlands.	Ramsar.	Approximately 7 km south of the Proposal area.
Forrestdale and Thomsons Lakes.	Ramsar.	Approximately 10 km northeast of the Proposal area.
Peel-Yalgorup System.	Ramsar.	Approximately 18 km south of the Proposal area.
Threatened Ecological Communities		
Sedgelands in Holocene dune swales of the southern Swan Coastal Plain.	Endangered.	Expected to occur approximately 200 m, from proposed action footprint.
Thrombolite (microbial) community of coastal freshwater lakes of the Swan Coastal Plain (Lake Richmond).	Endangered.	Not within proposed action footprint, but approximately 200 m from proposed action footprint and 400 m from the marina.

Species identified with Protected Matters Search tool (August 2010)	Status under EPBC Act	Likelihood to occur within Proposal area
Birds		
Calyptorhynchus banksii naso (forest red-tailed black cockatoo).	Vulnerable.	The fauna survey undertaken by ENV in 2009 (2011a) did not record this species during the survey. Potential habitat for this species is present within and outside the Proposal area as individual tuart species. The potential habitat within the Proposal area is located within the 'area to remain uncleared' with Tuart species present within the TEC "*Callitris preissii* (or *Melaleuca lanceolata*) forest and woodlands'. Tuart species are also present in PEC SCP30b 'Quindalup *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands'. The Proposal does not propose to clear any Tuart individuals and the Proposal is unlikely to indirectly impact Tuarts.
Calyptorhynchus latirostris (Carnaby's cockatoo, short-billed black-cockatoo).	Endangered.	Investigations undertaken by ENV (2011a) did not record evidence of these species in the survey area and indicated a lack of potential habitat within the proposed action footprint. The species however, is known to occur within the Rockingham area with species recorded by Birds Australia and historical surveys within 10 km of the Proposal area (ENV 2011a). The potential habitat distribution, within and surrounding the Proposal area for this species is similar to the Forest Red-tailed Black Cockatoo described above.
Diomedea exulans gibsoni (Gibson's albatross).	Vulnerable.	Unlikely to occur. Only occurs in Australia between Coffs Harbour and Wilson's Promontory (Environment Australia 2001). The ENV fauna survey (2011a) did not record this species during the survey and did not identify this species in either Birds Australia, DEC or NatureMap database searches and previous fauna survey records within 10 km of the Proposal area. It is unlikely that this species would be found within or surrounding the Proposal area as the area does not support ideal habitat for this species.
Macronectes giganteus (south giant-petrel).	Endangered.	Likely. The species was not recorded during the ENV 2010 survey however is listed as occurring in the Rockingham area and SIMP (NatureMap). The species may potentially occur within the Proposal area but is likely only an infrequent visitor.
Macronectes halli (northern giant-petrel).	Vulnerable.	Likely. The Northern Giant Petrel was not recorded during the ENV 2010 survey however is recorded as occurring in the Rockingham area by NatureMap. Given the availability of suitable habitat, it is possible that this species occurs in the Proposal area during the winter months of May to October however it is likely to be an infrequent visitor.
Thalassarche cauta cauta (shy albatross, Tasmanian shy albatross).	Vulnerable.	Likely. The Shy Albatross was not recorded by the ENV 2010 survey however is recorded by NatureMap as occurring in the coastal Metropolitan area. It is potentially only an infrequent visitor to the Proposal area.
Migratory bird species		
Ardea sacra (eastern reef egret)	Migratory	Likely. The beaches and rocky shores of the Proposal Area are typical habitat for this bird and it is likely to occur there.

Species identified with Protected Matters Search tool (August 2010)	Status under EPBC Act	Likelihood to occur within Proposal area
Plegadis falcinellus (glossy ibis)	Migratory	Likely. The area dry grassland within the Proposal Area contains suitable foraging habitat for the Glossy Ibis and it is likely to reside there from time to time.
Falco peregrinus (peregrine falcon)	Migratory	Likely. Peregrine Falcon is likely to only forage within the survey area and only as part of a larger home range.
Limosa limosa (black-tailed godwit)	Migratory	Likely. Fresh water and intertidal regions of the survey area provide an adequate habitat for this species and it is likely to occur during its migration.
Limosa lapponica (bar-tailed godwit)	Migratory	Likely. The habitat around the survey area is well suited for the Bar-tailed Godwit and it is likely to occur there during its migration.
Numenius phaeopus (whimbrel)	Migratory	Likely. The survey area contains habitat suitable for the Whimbrel and as such it is possible the Whimbrel may be found in this area on its migratory route.
Numenius madagascariensis (eastern curlew)	Migratory	Likely. The survey area does contain habitat suitable for the Eastern Curlew and it is possible the Eastern Curlew may be found in this area on its migratory route.
Tringa stagnatilis (marsh sandpiper)	Migratory	Likely. The marine and freshwater environments of the survey area are possible habitats for the Marsh Sandpiper during its migratory routes.
Tringa nebularia (common greenshank)	Migratory	Likely. The shorelines of the survey area are a suitable habitat for the Common Greenshank. As such it is likely to inhabit this area on its migratory route. Also likely to occur on Lake Richmond, which is located outside the Proposal Area.
Tringa glareola (wood sandpiper)	Migratory	Unlikely. The closest suitable habitat for the Wood Sandpiper is Lake Richmond, which is outside the Proposal Area.
Xenus cinereus (terek sandpiper)	Migratory	Confirmed. Recorded by ENV (2011a) Occurs on sandy beaches around the survey area.
Tringa brevipes (grey-tailed tattler)	Migratory	May inhabit the small areas of rocky coast within the Proposal Area that area suitable for the Grey-tailed Tattler on its migratory route.
Arenaria interpres (ruddy turnstone)	Migratory	The survey area only has small areas of rocky coast with seaweed, suitable for the Ruddy Turnstone. As such it may inhabit this area on its migratory route.
Calidris canutus (red knot)	Migratory	The tidal sands of the survey area are a suitable habitat for the Red Knot. As such it is likely to inhabit this area on its migratory route.
Calidris tenuirostris (great knot)	Migratory	The tidal sands of the survey area are a suitable habitat for the Great Knot. As such it may inhabit this area on its migratory route.
Calidris alba (sanderling)	Migratory	The sandy coastal beaches of the survey area are suitable habitats for the Sanderling. As such it may inhabit this area on its migratory route.
Calidris ruficollis (red-necked stint)	Migratory	The coastal waters of the survey area are suitable habitat for the Red-necked Stint. As such it may inhabit this area on its migratory route.

Species identified with Protected Matters Search tool (August 2010)	Status under EPBC Act	Likelihood to occur within Proposal area
Calidris subminuta (long-toed stint)	Migratory	Unlikely. Only Lake Richmond and other wetlands located outside the Proposal Area are suitable habitat for the Long-toed Stint. No wetlands are located within the Proposal Area.
Calidris acuminata (sharp-tailed sandpiper)	Migratory	Unlikely. It inhabits both coastal and inland areas but prefers non-tidal fresh or brackish wetlands, which occur outside the Proposal Area. No wetlands are located within the Proposal Area.
Calidris ferruginea (curlew sandpiper)	Migratory	Unlikely. Only Lake Richmond and other wetlands located outside the Proposal Area are suitable habitat for the Curlew Sandpiper. No wetlands are located within the Proposal Area.
Philomachus pugnax (ruff)	Migratory	Unlikely. Only Lake Richmond and other wetlands located outside the Proposal Area are suitable habitat for the Ruff. No wetlands are located within the Proposal Area.
Pluvialis fulva (Pacific golden plover)	Migratory	Likely. The beaches and rocky areas of the survey area are suitable habitats for the Pacific Golden Plover. As such it may inhabit this area on its migratory route.
Pluvialis squatarola (grey plover)	Migratory	Likely. The beaches and rocky areas of the survey area are suitable habitats for the Grey Plover. As such it may inhabit this area on its migratory route.
Charadrius mongolus (lesser sand plover	Migratory	Likely. The exposed sand of the survey area is suitable habitat for the Lesser Sand Plover. As such it may inhabit this area on its migratory route.
Charadrius leschenaultii (greater sand plover)	Migratory	Confirmed. Recorded by ENV (2011a) The exposed sand of the survey area is suitable habitat for the Greater Sand Plover. As such it may inhabit this area on its migratory route.
Haliaeetus leucogaster (white-bellied sea-eagle)	Migratory	Confirmed. Recorded by ENV (2011a)
Ardea modesta (great egret, white egret)*	Migratory	Unlikely. The Eastern Great Egret was recorded during the survey a number of times foraging at Lake Richmond, which is outside the Proposal Area.
Ardea ibis (cattle egret)	Migratory	Unlikely. The only suitable habitat that exists in the survey area was at Lake Richmond, which is located outside the Proposal Area.
Apus pacificus (fork-tailed swift)	Migratory	Likely. This species forages over the site from time to time, high in the airspace.
Acrocephalus australis (Australian reed-warbler)*	Migratory	Unlikely. The only sighting of this species was outside the Proposal area, adjacent to Lake Richmond. No suitable habitat occurs within the Proposal Area.
Merops ornatus (rainbow bee-eater)	Migratory	Likely to occur. Although the only sighting of this Species was outside the Proposal area near Lake Richmond, suitable habitat occurs in the sandy ground within the Proposal Area.
Pandion cristatus (eastern osprey)*	Migratory	Confirmed. One Osprey recorded by ENV (2011a), believed to be nesting in an offshore island.
Actitis hypoleucos (common sandpiper)*	Migratory	Confirmed. Recorded by ENV (2011a). Rocks and sandy beaches of the survey area are the preferred habitat for the Common Sandpiper.

Species identified with Protected Matters Search tool (August 2010)	Status under EPBC Act	Likelihood to occur within Proposal area
Sterna anaethetus (bridled tern)*	Migratory	Unlikely. It was recorded as part of an opportunistic survey during the current survey outside the Proposal Area on the very tip of Cape Peron. The coastal islands around the survey area are suitable breeding habitat for the Bridled Tern during its migration.
Insects		
Synemon gratiosa (GSM).	Endangered.	Occurs within proposed action footprint, however, regional population is unlikely to be impacted.
Mammals		
Balaenoptera musculus (blue whale).	Endangered.	Unlikely to occur, due to nature of proposed action.
Dasyurus geoffroii (chuditch, western quoll).	Vulnerable.	Unlikely to occur, due to lack of appropriate habitat.
Eubalaena australis (southern right whale).	Endangered.	Unlikely to occur, due to nature of proposed action.
Megaptera novaeangliae (humpback whale).	Vulnerable.	Unlikely to occur, due to nature of proposed action.
Neophoca cinerea (Australian sea-lion).	Vulnerable.	Unlikely to occur, due to nature of proposed action.
Phascogale calura (red-tailed phascogale.)	Endangered.	Unlikely to occur due to lack of habitat.
Setonix brachyurus (quokka).	Vulnerable.	Unlikely to occur due to lack of habitat.
Reptiles		
Caretta caretta (loggerhead turtle).	Endangered.	Unlikely to occur, due to nature of the Proposal.
Chelonia mydas (green turtle).	Vulnerable.	Unlikely to occur, due to nature of the Proposal.
Dermochelys coriacea (leatherback turtle, leathery turtle).	Endangered.	Unlikely to occur, due to nature of the Proposal.
Sharks		
Carcharias taurus (west coast population (grey nurse shark (west coast population)).	Vulnerable (migratory).	Unlikely to occur, due to nature of the Proposal.
Carcharodon carcharias (great white shark).	Vulnerable (migratory).	Unlikely to occur, due to nature of the Proposal.
Rhincodon typus (whale shark).	Vulnerable (migratory).	Unlikely to occur, due to nature of the Proposal.
Plants		
Centrolepis caespitosa.	Endangered.	Unlikely to occur, as targeted searches for conservation significant species (ENV 2011a) did not return results for this species.
Migratory Marine Species – mammals		
Balaenoptera edeni (Bryde's whale).	Migratory.	Unlikely to occur, due to nature of the Proposal.
Balaenoptera musculus (blue whale).	Migratory.	Unlikely to occur, due to nature of the Proposal.
Caperea marginata (pygmy right whale).	Migratory.	Unlikely to occur, due to nature of the Proposal.
Eubalaena australis (southern right whale).	Migratory.	Unlikely to occur, due to nature of the Proposal.

Species identified with Protected Matters Search tool (August 2010)	Status under EPBC Act	Likelihood to occur within Proposal area
Lagenorhynchus obscurus (dusky dolphin).	Migratory.	Unlikely to occur, due to nature of the Proposal.
Megaptera novaeangliae (humpback whale).	Migratory.	Unlikely to occur, due to nature of the Proposal.
Orcinus orca (killer whale, orca).	Migratory.	Unlikely to occur, due to nature of the Proposal.

Note: *indicates recorded by ENV (2011a) but not in search tool

14.2.1 Wetlands of international significance

The Peel Yalgorup Wetlands are located approximately 35 km south of the Proposal area (Figure 110). Groundwater and surface water flow directions in the Proposal area are northerly to westerly, towards the coast and away from these wetlands. These wetlands will not be affected by the Proposal.

Forrestdale Lake is located approximately 15 km northeast of the Proposal area (Figure 110). Groundwater and surface water flow directions in the Proposal area are northerly to westerly, towards the coast, and not towards these wetlands. The lake will not be affected by this Proposal.

Becher Point Wetlands located approximately 7 km south of the Proposal area (Figure 110). Groundwater and surface water flow directions are again away from this wetland (i.e. to the north and west, not the south). It is therefore considered that there is no groundwater connectivity between the Proposal area and the Becher Point Wetlands. This wetland will not be affected by the Proposal.

14.2.2 Threatened ecological communities (TECs)

Thrombolite TEC

The Thrombolite TEC is an association of microorganisms that aggregate in rock-like formations, formed by the deposition of calcium carbonate during growth and metabolic activity within the community micro-environment (Figure 31) (Moore 1991). The area of thrombolite habitat is not well defined. No formal mapping of the thrombolites has occurred (English V [DEC] 2011, pers. comm. 26 September).

Thrombolite structures at Lake Richmond occur from perhaps 0 mAHD to within the vegetated fringe of the lake (CALM 2003b). Old stranded thrombolites (no longer living) have been reportedly identified immediately to the east of Lake Richmond (CALM 2003b). It is therefore difficult to establish the veracity of the area covered by the active community or the ecological water requirements of the thrombolites. It is inferred that at least seasonal inundation and seasonal drying is required for thrombolites to persevere.

An unconfirmed observation made by a member of the public indicates that the Thrombolites have also established near the weir in the Lake Richmond Outlet Drain, since this was constructed in 1968. Whilst this is unsubstantiated (due to water levels being too high during the writing of this PER) (this potentially indicates that the community is capable of colonising new areas over time.

The survival and growth of the community is considered to be dependent upon light and a continuing supply of fresh water which is rich in calcium and bicarbonate/carbonate (ESSS 2007). Groundwater in the area contains these chemical components as a result of the dissolution of the shell fragments commonly found in the Safety Bay Sands (Davidson 1995). The thrombolites at Lake Richmond appear to be adapted to fresh or brackish water, and would be unlikely to survive major increases in salinity (ESSS 2007).

Lake Richmond receives surface water inputs from large urbanised catchments to the east, south and west of the lake (Figure 109). The lake receives groundwater inputs from the Safety Bay Mound to the east (DOE 2004) and limited inputs from the north and west in summer (MWH 2011a). The groundwater in the area is rich in calcium and bicarbonate/carbonate.

Sedgelands TEC

The Sedgelands TEC occurs in occurs in linear damplands and occasionally sumplands between Holocene dunes (Figure 109) (CALM 2002). Typical and common native species in the community include the shrubs *Muehlenbeckia adpressa* (Climbing Lignum), *Acacia saligna* (Orange Wattle) and *Xanthorrhoea preissii* (Grass Tree) and the herbs *Baumea juncea* (Bare Twigrush), *Ficinia nodosa* (Knotted Clubrush) and *Poa porphyroclados*. Approximately 11 ha of this TEC occurs around the edge of Lake Richmond (CALM 2002). The majority of this TEC is present in the Rockingham area, with 23 ha at the Port Kennedy Scientific Park and 60 ha located outside reserves in the Port Kennedy area (CALM 2002). Hydrological regime is considered to be the primary non-biological factor that influences the characteristics of this TEC (CALM 2002). Depth, timing and duration of flooding and length of the dry period all affect vegetation composition and distribution. Sedgelands in damplands and sumplands of the Holocene dune swales have relatively specific water regime requirements to maintain current biology, but are tolerant of seasonal and longer-term variations that reflect natural climatic patterns. Maintenance of water level and quality is considered critical for this TEC.

14.2.3 Birds

Forest red-tailed black cockatoo (Calyptorhynchus banksii naso) – vulnerable

Habitat preference

The Forest Red-tailed Black Cockatoo inhabits dense Jarrah, Karri and Marri forests receiving more than 600 mm average rainfall annually (DSEWPaC 2011d). This species is also known to occur in woodlands which include Blackbutt, Wandoo and Tuart species.

Results of fauna survey and likelihood of occurrence

The fauna survey undertaken by ENV in 2009 (2011a) did not record this species during the survey. Potential habitat for this species is present within and outside the Proposal area as individual tuart species. The ENV fauna survey (ENV 2011a) however, did not record potential foraging or breeding habitat with little roosting potential for cockatoo species within the Proposal area.

The potential habitat within the Proposal area is located within the 'area to remain uncleared' with Tuart species present within the TEC "*Callitris preissii* (or *Melaleuca lanceolata*) forest and woodlands'. Tuart species are also present PEC SCP30b 'Quindalup *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands*'*. The Proposal does not propose to clear any tuart species and the Proposal is unlikely to indirectly impact Tuarts given the minimal changes to groundwater levels and given that the saltwater intrusion is of a very limited nature.

Carnaby's cockatoo, short-billed black- cockatoo (Calyptorhynchus latirostris) – endangered

Habitat preference

Carnaby's black cockatoo inhabits native eucalypt woodlands that contain Salmon Gum and Wandoo and in shrubland or kwongan heathland dominated by Hakea, Dryandra, Banksia and Grevillea species (DSEWPaC 2011d). The species nests in hollows of smooth-barked eucalypts especially Salmon Gum (*Eucalyptus salmonophloia*) and Wandoo (*Eucalyptus wandoo*) but nests have also been found in other eucalypts including York Gum (*Eucalyptus loxophleba*), Flooded Gum (*Eucalyptus rudis*), Tuart (*Eucalyptus gomphocephala*) and the rough-barked Marri (*Corymbia calophylla*) (Johnstone and Kirkby date unknown). During the non-breeding season, the species roosts in tall native or introduced eucalypts, and occasionally in Marri and pines. Species known to be used for roosting include Flat-topped Yate (*E. occidentalis*), Salmon Gum, Wandoo, Karri (*E. diversicolor*), Blackbutt (*E. patens*), Tuart (*E. gomphocephala*), Blue Gum (*E. globulus*, introduced), *Pinus radiata* and *P. pinaster (*DSEWPaC 2011d).

Results of fauna survey and likelihood of occurrence

Investigations undertaken by ENV (2011a) did not record evidence of these species in the survey area and indicated a lack of potential habitat within the proposed action footprint. The species however, is known to occur within the Rockingham area with species recorded by Birds Australia and historical surveys within 10 km of the Proposal area (ENV 2011a).

The potential habitat distribution, within and surrounding the Proposal area for this species is similar to the Forest Red-tailed Black Cockatoo described above.

Gibson's albatross (Diomedea exulans gibsoni) - vulnerable

Habitat preference

Gibson's Albatross is marine, pelagic and aerial and breeds on Adams Island and Auckland New Zealand (DSEWPaC 2011d). On breeding islands, this species nests on coastal and inland ridges, slopes, plateaux and plains, often on marshy ground (DSEWPaC 2011d).

Results of fauna survey and likelihood of occurrence

Unlikely to occur. Only occurs in Australia between Coffs Harbour and Wilson's Promontory (Environment Australia 2001).

The ENV fauna survey (2011a) did not record this species during the survey and did not identify this species in either Birds Australia, DEC or NatureMap database searches and previous fauna survey records within 10 km of the Proposal area. It is unlikely that this species would be found within or surrounding the Proposal area as the area does not support ideal habitat for this species.

Southern giant petrel (Macronectes giganteus) - endangered

Habitat preference

The Southern Giant Petrel occurs mainly in Antarctic waters and during summer, it possibly concentrates north of 50° S in winter, as it is rare in waters of the southern Indian Ocean, but common off South America, South Africa, Australia and New Zealand. It occurs in both pelagic and inshore waters and is also attracted to land at sewage outfalls and scavenges ashore.

Results of fauna survey and likelihood of occurrence

The species was not recorded during the ENV 2010 survey, however, is listed as occurring in the Rockingham area and SIMP (NatureMap). The species may potentially occur within the Proposal area but is likely only an infrequent visitor.

Northern giant petrel (Macronectes halli) - vulnerable

Habitat preference

The Northern Giant-Petrel is marine and oceanic, occurring mainly in sub-Antarctic waters, but also regularly occurs in Antarctic waters of the south western Indian Ocean, the Drake Passage and west of the Antarctic Peninsula.

Its range extends into subtropical waters mainly between winter and spring and it frequents both oceanic and inshore waters near breeding islands and in the non-breeding range.

During its first year, it occurs mainly on continental shelves, slopes and cold eastern boundary currents off South America, South Africa, Australia and New Zealand. It may be more oceanic from its second year. It is attracted to land at sewage outfalls and scavenges at colonies of penguins and seals.

Results of fauna survey and likelihood of occurrence

The Northern Giant Petrel was not recorded during the ENV 2010 survey however is recorded as occurring in the Rockingham area by NatureMap. Given the availability of suitable habitat, it is possible that this species occurs in the Proposal area during the winter months of May to October however it is likely to be an infrequent visitor.

Shy albatross (Thalassarche cauta cauta) - vulnerable

Habitat preference

The Shy Albatross is a marine species occurring in sub-Antarctic and subtropical waters. Its preference for sea surface temperatures is not well known and it has been observed over waters ranging from 6.4 to 13.5º C. During the non-breeding season, it occurs around continental shelves around continents. It occurs both offshore and inshore and is known to enter harbours and bays.

Results of fauna survey and likelihood of occurrence

The Shy Albatross was not recorded by the ENV 2010 survey however is recorded by NatureMap as occurring in the coastal Metropolitan area. It is potentially only an infrequent visitor to the Proposal area.

14.2.4 Migratory birds

Eastern reef egret (Ardea sacra)

Habitat preference

The Eastern Reef Egret occurs in coastal areas along the entire Western Australia coast, although it is more common in the warmer regions to the north. The species inhabits beaches, rocky shores, tidal rivers and inlets, mangroves, and exposed coral reefs. Although it is listed as migratory, the Eastern Reef Egret is largely sedentary in nature (Johnstone and Storr 1998).

Results of fauna survey and likelihood of occurrence

Likely. The beaches and rocky shores of the Proposal Area are typical habitat for this bird and it is likely to occur there.

Glossy ibis (Plegadis haliaetus)

Habitat preference

The Glossy Ibis is listed as Migratory under the EPBC Act and inhabits areas of freshwater wetlands, estuaries and creeks, with occasional foraging in dry grasslands. This species is generally uncommon, but has a widespread and erratic distribution.

Results of fauna survey and likelihood of occurrence

Likely. The area dry grassland within the Proposal Area contains suitable foraging habitat for the Glossy Ibis and it is likely to reside there from time to time.

Peregrine falcon (Falco peregrinus)

Habitat preference

The Peregrine Falcon occurs mainly along coastal cliffs, rivers and ranges as well as wooded watercourses and lakes (Johnstone and Storr 1998). The Peregrine Falcon nests primarily on cliffs, granite outcrops and quarries, and feeds mostly on birds (Johnstone and Storr 1998). The coastal cliffs provide some potential nesting habitat and there is plentiful supply of prey items in the area.

Results of fauna survey and likelihood of occurrence

Likely. Peregrine Falcon is likely to only forage within the survey area and only as part of a larger home range.

Black-tailed godwit (Limosa limosa)

Habitat preference

The Black-tailed Godwit is an uncommon summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia (Geering *et al.* 2007). It inhabits fresh and brackish wetlands as well as intertidal mudflats (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

Likely. Fresh water and intertidal regions of the survey area provide an adequate habitat for this species and it is likely to occur during its migration.

Bar-tailed godwit (Limosa lapponica)

Habitat preference

The Bar-tailed Godwit is a relatively common summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia, including Garden Island which is situated just north of the survey area. It inhabits mudflats, sandy and sea-weedy beaches (Johnstone and Storr 1998).

Results of fauna survey and likelihood of occurrence

Likely. The habitat around the survey area is well suited for the Bar-tailed Godwit and it is likely to occur there during its migration.

Whimbrel (Numenius phaeopus)

Habitat preference

Whimbrel is a large non-breeding migratory shorebird, found commonly along the north coast of Western Australia and intermittently found on the south coast (Johnstone and Storr 1998).

It inhabits mudflats of estuaries or lagoons, particularly those with Mangroves where it often roosts (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

Likely. The survey area contains habitat suitable for the Whimbrel and as such it is possible the Whimbrel may be found in this area on its migratory route.

Eastern curlew (Numenius madagascariensis)

Habitat preference

Occurs commonly along the north coast of Western Australia, but is known to migrate south to Bunbury along the South Coast (Johnstone and Storr 1998). It inhabits a range of coastal habitats, but primarily intertidal mudflats, particularly on exposed seagrass beds or mudflats with burrowing crabs or shrimps (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

Likely. The survey area does contain habitat suitable for the Eastern Curlew and it is possible the Eastern Curlew may be found in this area on its migratory route.

Marsh sandpiper (Tringa stagnatilis)

Habitat preference

A summer, non-breeding, migratory shorebird that occurs in Western Australia along the coast, coastal plains, and less frequently inland (Johnstone and Storr 1998). It inhabits freshwater or saltwater wetlands but avoids open beaches and mudflats unless well protected (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

Likely. The marine and freshwater environments of the survey area are possible habitats for the Marsh Sandpiper during its migratory routes.

Common greenshank (Tringa nebularia)

Habitat preference

A non-breeding, migratory shorebird, common along most of the coast of Western Australia (Geering *et al.* 2007). It inhabits intertidal mudflats, as well as fresh and saltwater wetlands of the coast or inland (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

Likely. The shorelines of the survey area are a suitable habitat for the Common Greenshank. As such it is likely to inhabit this area on its migratory route. Also likely to occur on Lake Richmond, which is located outside the Proposal Area.

Wood sandpiper (Tringa glareola)

Habitat preference

A summer, non-breeding, migratory shorebird that occurs along the coastal and inland regions of Western Australia (Geering *et al.* 2007). It primarily inhabits freshwater wetlands and rarely on intertidal mudflats (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

Unlikely. The closest suitable habitat for the Wood Sandpiper is Lake Richmond, which is outside the Proposal Area.

Terek sandpiper (Xenus cinereus)

Habitat preference

The Terek Sandpiper is a summer non-breeding migratory shorebird that occurs along the north coast of Western Australia, but intermittently found as far south as Bunbury and Albany (Johnstone and Storr 1998). It inhabits exposed seagrass beds in estuaries and bays or on intertidal mudflats fringed by mangroves (Geering, Agnew and Harding 2007).

Results of fauna survey and likelihood of occurrence

Confirmed. Recorded by ENV (2011a). Occurs on sandy beaches around the survey area

Grey-tailed tattler (Tringa brevipes)

Habitat preference

A non-breeding, migratory shorebird, common on the north and west coasts of Western Australia, but rare on the south coast. It has been recorded on Garden Island which is situated just north of the survey area (Johnstone and Storr 1998). It inhabits sheltered coasts with reef and rock platforms or with intertidal mudflats (DSEWPaC 2011d). It often roosts in mangroves or artificial structures such as piers and breakwaters (Geering, Agnew and Harding 2007).

Results of fauna survey and likelihood of occurrence

May inhabit the small areas of rocky coast within the Proposal area that area suitable for the Grey-tailed Tattler on its migratory route.

Ruddy turnstone (Arenaria interpres)

Habitat preference

Summer non-breeding migratory shorebird that occurs on the coast of Western Australia and has been recorded on Penguin Island which is situated just south of the survey area (Johnstone and Storr 1998). It occurs primarily on rocky coasts and rocky reefs, as well as tidal mudflats and beaches and pebbly shores of near-coastal salt lakes and salt-work ponds (Johnstone and Storr 1998).

Results of fauna survey and likelihood of occurrence

The survey area only has small areas of rocky coast with seaweed, suitable for the Ruddy Turnstone. As such it may inhabit this area on its migratory route.

Red knot (Calidris canutus)

Habitat preference

Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia with records from Garden Island which is situated just north of the survey area (Johnstone and Storr 1998). It inhabits larger intertidal mud and sand flats (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

The tidal sands of the survey area are a suitable habitat for the Red Knot. As such it is likely to inhabit this area on its migratory route.

Great knot (Calidris tenuirostris)

Habitat preference

Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia with records from Garden Island which is situated just north of the survey area (Johnstone and Storr 1998). It inhabits larger intertidal mud and sand flats (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

The tidal sands of the survey area are a suitable habitat for the Great Knot. As such it may inhabit this area on its migratory route.

Sanderling (Calidris alba)

Habitat preference

Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia with records from Garden Island which is situated just north of the survey area (Johnstone and Storr 1998). This species inhabits sandy beaches, inlets, estuaries and coastal salt lakes (Johnstone and Storr 1998).

Results of fauna survey and likelihood of occurrence

The sandy coastal beaches of the survey area are suitable habitats for the Sanderling. As such it may inhabit this area on its migratory route.

Red-necked stint (Calidris ruficollis)

Habitat preference

Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia with records from Penguin Island which is situated just south of the survey area (Johnstone and Storr 1998). It inhabits a wide range of fresh and saltwater habitats (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

The coastal waters of the survey area are suitable habitat for the Red-necked Stint. As such it may inhabit this area on its migratory route.

Long-toed stint (Calidris subminuta)

Habitat preference

Summer non-breeding migratory shorebird that occurs along the mid West coast of Western Australia as far south as Busselton (Johnstone and Storr 1998). This species prefers coastal and inland swamps for habitat (Simpson and Day 2004).

Results of fauna survey and likelihood of occurrence

Unlikely. Only Lake Richmond and other wetlands located outside the Proposal Area are suitable habitat for the Long-toed Stint. No wetlands are located within the Proposal Area.

Sharp-tailed sandpiper (Calidris acuminata)

Habitat preference

Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia as far south as Busselton, and in well-watered parts of the interior and casually in the arid east south of Lake Gregory.

Results of fauna survey and likelihood of occurrence

Unlikely. It inhabits both coastal and inland areas but prefers non-tidal fresh or brackish wetlands, which occur outside the Proposal Area. No wetlands are located within the Proposal Area.

Curlew sandpiper (Calidris ferruginea)

Habitat preference

Summer non-breeding migratory shorebird that occurs along most of the coast of Western Australia (Geering *et al.* 2007). It inhabits exposed tidal mudflats, and less frequently on inland freshwater wetlands (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

Unlikely. Only Lake Richmond and other wetlands located outside the Proposal area are suitable habitat for the Curlew Sandpiper. No wetlands are located within the Proposal area.

Ruff (Philomachus pugnax)

Habitat preference

Summer non-breeding migratory shorebird that occurs along the south-west coast of Western Australia (Johnstone and Storr 1998). It inhabits tidal mudflats, sewerage farms and freshwater wetlands (Pizzey and Knight 2007).

Results of fauna survey and likelihood of occurrence

Unlikely. Only Lake Richmond and other wetlands located outside the Proposal area are suitable habitat for the Ruff. No wetlands are located within the Proposal area.

Pacific golden plover (Pluvialis fulva)

Habitat preference

A summer non-breeding migratory shorebird that occurs along the coast of Western Australia (Johnstone and Storr 1998). The Pacific Golden Plover inhabits marine waters such as beaches, mudflats and among rocky areas, sometimes inland (Simpson and Day 2004).

Results of fauna survey and likelihood of occurrence

Likely. The beaches and rocky areas of the survey area are suitable habitats for the Pacific Golden Plover. As such it may inhabit this area on its migratory route.

Grey plover (Pluvialis squatarola)

Habitat preference

Summer non-breeding migratory shorebird that occurs along the coast of Western Australia with records from Penguin Island which is situated just south of the survey area (Johnstone and Storr 1998). The Grey Plover inhabits coastal areas, preferring marine shores of estuaries or lagoons on broad open mudflats, sandy bars or beaches and rocky coasts as well as coastal salt lakes and swamps (Morcombe 2000). They occasionally are found in drying freshwater lakes (Johnstone and Storr 1998).

Results of fauna survey and likelihood of occurrence

Likely. The beaches and rocky areas of the survey area are suitable habitats for the Grey Plover. As such it may inhabit this area on its migratory route.

Lesser sand plover (Charadrius mongolus)

Habitat preference

Summer non-breeding migratory shorebird that occurs on the north and west coast of Western Australia as far south as Albany Johnstone and Storr 1998). It inhabits exposed sand and mud flats and often intermingles with flocks of the Greater Sand Plover (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

Likely. The exposed sand of the survey area is suitable habitat for the Lesser Sand Plover. As such it may inhabit this area on its migratory route.

Greater sand plover (Charadrius leschenaultia)

Habitat preference

Summer non-breeding migratory shorebird that occurs along the coast of Western Australia (Johnstone and Storr 1998). It inhabits exposed sand and mud flats (Geering *et al.* 2007).

Results of fauna survey and likelihood of occurrence

Confirmed. Recorded by ENV (2011a). The exposed sand of the survey area is suitable habitat for the Greater Sand Plover. As such it may inhabit this area on its migratory route

White-bellied sea-eagle (Haliaeetus leucogaster)

Habitat preference

The species is found in coastal habitats and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands. Preferred habitats are characterised by the presence of large areas of open water including large rivers, swamps, lakes and the sea (DSEWPaC 2011b). Terrestrial habitats include coastal dunes, tidal flats, grassland, heathland, woodland, forest (including rainforest) and even urban areas.

Results of fauna survey and likelihood of occurrence

Confirmed, recorded by ENV (2011a). Given the availability of suitable habitat, it is likely that this species occurs within the coastal area of Proposal area and within wetland habitat of Lake Richmond (ENV 2011a).

Rainbow bee-eater (Merops ornatus)

The Rainbow Bee-eater is a migratory, medium sized bird, the only bee-eater species to occur in Australia. It is found across much of Australia however is not found in Tasmania and is only thinly distributed in the most arid regions of central and Western Australia. The species nests in sandy country in south western Australia in September and October in holes in the ground.

Habitat preference

The Rainbow Bee-eater occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation (DSEWPaC 2011c). It usually occurs in open, cleared or lightly-timbered areas that are often, but not always, located in close proximity to permanent water. It also occurs in inland and coastal sand dune systems, and in mangroves in northern Australia, and has been recorded in various other habitat types including heathland, sedgeland, vine forest and vine thicket, and on beaches.

The wetland area of Lake Richmond, which is outside of the Proposal area, is typical habitat for the Rainbow bee-eater to forage in.

Results of fauna survey and likelihood of occurrence

The species was recorded outside of the Proposal area near Lake Richmond during a fauna survey in 2009 (ENV 2011a). It has also been recorded in the area by previous surveys. Given the proximity of the Proposal area to suitable foraging habitat at Lake Richmond, this species is considered likely to occur in the Proposal Area (ENV 2011a).

Eastern great egret (White Egret) (Ardea modesta)

Habitat preference

Eastern Great Egrets are widespread in Australia occurring in all states/territories of mainland Australia and in Tasmania. The area of occupancy in Australia is estimated at 408 400 km^2. The species occurs across a large part of Western Australia, including the south-west, Kimberley and Pilbara (Johnstone and Storr 1998). The Great Egret is common to very common in the well-watered Kimberley flatlands, and scarce to moderately common elsewhere within its range (Johnstone and Storr 1998). The Eastern Great Egret mainly inhabits shallow water bodies; both fresh (lakes, lagoons, swamps and floodwaters) and saline (mangrove creeks, estuaries and tidal pools) (Johnstone and Storr 1998).

Results of fauna survey and likelihood of occurrence

Unlikely. The Eastern Great Egret was recorded during the survey a number of times foraging at Lake Richmond, which is outside the Proposal area.

Eastern osprey (Pandion cristatus)

The Eastern Osprey is a medium sized raptor that breeds around the northern coast of Australia (including many offshore islands) from Albany in Western Australia to Lake Macquarie in NSW. The area of occupancy of the Eastern Osprey in Australia is estimated at 117 400 km^2.

Habitat preference

Eastern Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They are mostly found in coastal areas but occasionally travel inland along major rivers, particularly in northern Australia. They require extensive areas of open fresh, brackish or saline water for foraging and frequent a variety of wetland habitats including inshore waters, reefs, bays, coastal cliffs, beaches, estuaries, mangrove swamps, broad rivers, reservoirs and large lakes and

waterholes. They exhibit a preference for coastal cliffs and elevated islands in some parts of their range but may also occur on low sandy, muddy or rocky shores and over coral cays. They may occur over atypical habitats such as heath, woodland or forest when travelling to and from foraging sites.

Results of fauna survey and likelihood of occurrence

One Eastern Osprey was recorded during the 2009 fauna survey (ENV 2011a). A nest was also located on a small rocky island in Shoalwater Bay which is to the south of the survey area (ENV 2011a). Given the availability of suitable habitat and the single recording near the Proposal area, it is likely that the species may occur within the Proposal area.

Common sandpiper (Actitis hypoleucos)

The Common Sandpiper is a non-breeding migrant to Western Australia at any time of year, but predominantly from September to March in the southwest. It is a wader, which occurs along all coastlines of Australia and many areas inland, in small numbers. The Common Sandpiper breeds in Europe and Asia.

Habitat preference

The species utilises a wide range of coastal wetlands and some inland wetlands, with varying levels of salinity, and is mostly found around muddy margins or rocky shores and rarely on mudflats. The Common Sandpiper has been recorded in estuaries and deltas of streams, as well as on banks farther upstream, around lakes, pools, billabongs, reservoirs, dams and claypans, and occasionally piers and jetties. The muddy margins utilised by the species are often narrow, and may be steep. The species is often associated with mangroves and sometimes found in areas of mud littered with rocks or snags.

Generally the species forages in shallow water and on bare soft mud at the edges of wetlands, often where obstacles project from substrate such as rocks or mangrove roots. Birds sometimes venture into grassy areas adjoining wetlands.

Roost sites are typically on rocks or in roots or branches of vegetation, especially mangroves. The species is known to perch on posts, jetties, moored boats and other artificial structures and to sometimes rest on mud or 'loaf' on rocks.

The rocks and sandy beaches of the survey area are the preferred habitat for the Common Sandpiper (ENV 2011a).

Results of fauna survey and likelihood of occurrence

The Common Sandpiper was recorded during the 2009 fauna survey during an opportunistic search (ENV 2011a). The shoreline habitat may potentially provide foraging opportunities for this species, with the rocks and sandy beaches within and surrounding the Proposal area as preferred habitat. Therefore it is likely that this species will occur within the shores of Mangles Bay, rocky areas of Cape Peron and rocky islands of Shoalwater Bay. This species is also likely to occur within the wetland habitat of Lake Richmond.

Bridled tern (Sterna anaethetus)

Habitat preference

Bridled Terns occupy tropical and subtropical seas, breeding on islands, including vegetated coral cays, rocky continental islands and rock stacks. Bridled Terns are only rarely found in inshore continental waters and along mainland coastlines, though the species is reported to breed on the mainland of far southern Western Australia.

During the breeding season in south western Australia, birds forage over offshore, mid- and outer continental shelf waters, usually within approximately 70 km of breeding colonies but mostly within 20–40 km of a colony.

Results of fauna survey and likelihood of occurrence

Unlikely. It was recorded as part of an opportunistic survey during the current survey outside the Proposal area on the very tip of Cape Peron. The coastal islands around the Survey area are suitable breeding habitat for the Bridled Tern during its migration.

Australian reed-warbler (Acrocephalus australis)

The Australian Reed-warbler is only a rare visitor to Australia, but has been observed throughout Australia where suitable habitat occurs and also occurs from New Guinea to southeast Africa. It is sedentary in the north and migratory in the south, migrating south to breed. The species feeds on insects.

Habitat preference

The Australian Reed-warbler inhabits dense vegetation near water including thick reeds, rushes, and long grasses, tall crops, lantana and bamboo.

Results of fauna survey and likelihood of occurrence

Unlikely. The only sighting of this species was outside the Proposal area, adjacent to Lake Richmond. No suitable habitat occurs within the Proposal area.

Cattle egret (Ardea ibis)

Habitat preference

The Cattle Egret occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands. It has occasionally been seen in arid and semi-arid regions however this is extremely rare. High numbers have been observed in moist, low-lying poorly drained pastures with an abundance of high grass; it avoids low grass pastures.

It uses predominately shallow, open and fresh wetlands including meadows and swamps with low emergent vegetation and abundant aquatic flora. They have sometimes been observed in swamps with tall emergent vegetation.

The Cattle Egret often forages away from water on low lying grasslands, improved pastures and croplands. It is commonly found in cattle fields and other farm areas that contain livestock.

The Cattle Egret roosts in trees, or amongst ground vegetation in or near lakes and swamps. The species is not known to breed in southwest Western Australia.

Results of fauna survey and likelihood of occurrence

Unlikely. The only suitable habitat that exists in the Survey area was at Lake Richmond, which is located outside the Proposal area.

Fork-tailed swift (Apus pacificus)

Habitat preference

The Fork-tailed Swift is a summer migrant (October-April) to Australia, that has not been recorded breeding in Australia (ENV 2011a). This species is an aerial species, which forages high above the tree canopy and rarely lower so it is independent of terrestrial habitats in Australia (ENV 2011a).

Results of fauna survey and likelihood of occurrence

The Fork-tailed Swift was not recorded in the ENV fauna survey (2011a) but was listed by Birds Australia has potentially occurring within the Rockingham area. The Proposal area may support this species during its migratory route along the Western Australian coast high in the air space (ENV 2011a).

14.2.5 Insects

Graceful sun-moth (Synemon Gratiosa) – endangered

Synemon gratiosa (GSM) is an endangered day flying moth endemic to Western Australia between Beekeepers National Park (10 km North of Leeman) and Preston Beach (Bishop *et al.* 2010). GSM is associated with coastal heath on Quindalup dunes and Banksia woodland on Spearwood and Bassendean dunes; in both cases it is associated with its preferred host plants, *Lomandra maritima* or *Lomandra hermaphrodita* (Bishop *et al.* 2010). The adults lay their eggs on the base of the plants and when the larvae hatch they burrow into the leaf bases, growing tip and rhizomes where they pupate for the next eleven months. It is thought that males are sedentary and females disperse less than 1 km from their birth location and are unlikely to cross unsuitable habitat (CALM 2005).

The greatest threat to this species is through habitat loss, as this region is experiencing urban development. Other factors that make the species future uncertain are the ongoing threats of track maintenance, inappropriate fire regimes and damage to habitat from the recreational use of four wheel drive vehicles (Threatened Species Scientific Committee 2008).

Results of fauna survey and likelihood of occurrence

Because of the known presence of the GSM habitat with the Proposal area, a GSM survey was undertaken of the site in March 2010 and March 2011 by ENV (2011b) to determine the presence and abundance of the GSM in the Proposal area. The survey was carried out in accordance with the criteria set by the DEC in relation to GSM surveys (Bishop *et al.* 2010). A total of three individual GSM were recorded during the 2010 survey. One GSM was found within the Proposal area and two outside of this area (approximately 125 m and 500 m from the Proposal area boundary), indicating that the species is represented locally outside the Proposal area (Figure 107). No GSMs were observed or caught during the 2011 survey.

L. maritima densities were found to vary significantly across the Proposal area, with quadrats in close proximity to one another varying from 0 - 50% density. Indicative *Lomandra* density across the survey area is illustrated in Figure 108.

14.2.6 Mammals

Blue whale (Balaenoptera musculus) – endangered

Two subspecies of the Blue Whale are thought to exist in the Southern Hemisphere, including the Southern Blue Whale and the Pygmy Blue Whale. Pygmy Blue Whales are found north of 55ºS and are thought to be those found in Australian waters. Blue Whale sightings in Australia are widespread and they are believed to occur around the full extent of the continent.

Habitat preference

In Western Australia, Pygmy Blue Whales aggregate in deepwater habitat on the northern side of the Perth Canyon where the Leeuwin current causes eddies and downwelling and compensating upwelling as it passes over the canyon. Abundant zooplankton occurs in the cold water beneath the warm Leeuwin current and provides feeding opportunities for this species.

A resting point for the species occurs in the shallow waters of Geographe Bay.

Results of fauna survey and likelihood of occurrence

Based on Cannell (2004), the Blue Whale is unlikely to inhabit the Proposal area (K. Crawley pers comm. 2011).

Chuditch, western quoll (Dasyurus geoffroii) – vulnerable

Habitat preference

The Chuditch occurred on the Swan Coastal Plain until the 1930's in Western Australia, with the distribution of the species restricted to the southwest of Western Australia (Orell & Morris 1994). The major portions of remaining Chuditch populations occur in Jarrah forests with records also within drier woodland and mallee shrubland in the wheatbelt (Orell and Morris 1994).

Historical known habitat areas of the Chuditch suggest that the species utilised a wide variety of habitat, including woodland associations, dry sclerophyll forests, beach and deserts (Orell and Morris 1994). The Chuditch was also known to occupy areas of riparian vegetation and also in native vegetation along road reserves in the wheatbelt (Orell and Morris 1994).

Results of fauna survey and likelihood of occurrence

The ENV fauna survey (2011a) did not record this species during the survey and did not identify this species in either DEC or NatureMap database searches and previous fauna survey records within 10 km of the Proposal area. The Proposal area does not support potential Chuditch habitat as this species required logs as den sites which are not found within this area (ENV 2011a). The Chuditch has a large home range and there is no connectivity with surrounding bushland sufficient to support this species. It is highly unlikely that this species would occur within the Proposal area.

Southern right whale (Eubalaena australis) – Endangered

Southern Right Whales are seasonally present on the Australian coast between about May and November.

Southern Right Whales have been recorded in the coastal waters of all Australian states with the exception of the Northern Territory (Bannister *et al*. 1996 in DSEWPaC 2011c). Principally found around the southern coastline off southern Western Australia and far west South Australia, Southern Right Whales occur anywhere between Sydney and Perth, including off Tasmania (DSEWPaC 2011c).

Habitat preference

Habitat requirements of Southern Right Whales are not well understood. Early observations on calving grounds indicated a preference for water depth of less than 5 m and differential habitat use by calving females and unaccompanied whales has been documented. Their distribution has been associated with protected water, shallow sloping bathymetry, and a sedimentary. Females with calves occurred in shallower waters with a sandy bottom and closer to shore than those without calves.

The feeding habitat of the species is poorly known and there have been no dedicated studies in feeding areas. However, feeding areas are thought to be in deeper offshore waters ranging from sub-Antarctic areas to locations south of 60°S in areas probably associated with high productivity.

The species occasionally uses the SIMP during its annual winter migration to the south and west coasts of Western Australia (DEC 2007).

Results of fauna survey and likelihood of occurrence

The Southern Right whale is often seen in Perth coastal waters during its annual southwards migration from late autumn to early spring: this species may occasionally enter Cockburn Sound but is highly unlikely in the southern end of Cockburn Sound due to the restriction posed by the Causeway.

Humpback whale (Megaptera novaeangliae) – vulnerable

The Humpback Whale is a moderately large baleen whale which is known to occur along the coastlines of Western Australia, Queensland and New South Wales and may potentially occur off the coast of the Northern Territory and South Australia and Tasmania. There are two migratory populations of Humpback Whales in Australia, a west coast population and an east coast population. The species migrates annually between summer feeding grounds in Antarctica to tropical breeding grounds in winter.

Habitat preference

The Kimberley Region of Western Australia is an important breeding and calving ground for Humpback Whales while Exmouth Gulf and Shark Bay are known resting areas. The narrow coastal corridors formed along their migration path are important as whales are concentrated in these areas. In Western Australia, important areas are the Abrolhos Islands, Geraldton and Carnarvon to Point Cloates.

Humpback Whales feed primarily on krill during summer in Antarctic waters south of 55ºS. Most feeding on the west coast occurs between 70° E and 130° E.

Mangles Bay and Cockburn Sound is within a known Humpback Whale aggregation area frequented as a rest spot on their southward migration, from approximately mid September to mid-October each year.

Results of fauna survey and likelihood of occurrence

The Humpback whale is likely to occur offshore of Garden Island during its southward spring migration or northward autumn migration, but is unlikely to enter Cockburn Sound.

Australian sea-lion (Neophoca cinerea) – vulnerable

The Australian Sea-Lion is the only pinniped (fin-footed mammal) which is endemic to Australia. They are currently found from the Abrolhos Islands in Western Australia to the Pages Islands in South Australia. Australian Sea-Lions have large numbers of small, genetically isolated populations, low reproductive rates, high site fidelity and poor dispersal.

Australian Sea-Lions feed on a wide variety of prey including squids, fish, shark, rock lobsters and sea birds.

Habitat preference

Australian Sea-Lions typically breed and haul out on rocks and sandy beaches on the sheltered sides of islands, although there are several small colonies on the Australian mainland. Colony sites are characterised by shallow, protected pools in which pups congregate. The waters surrounding breeding sites provide important feeding areas.

The Shoalwater Islands are used by Australian Sea Lions to 'haul-out' or rest. These sites are predominantly used by juvenile and adult males during the non-breeding season, with Seal and Carnac islands being the primary sites in the Perth Metropolitan area.

There are no breeding colonies within the SIMP as females are mostly restricted to the breeding islands to the north near Jurien Bay, the Houtman Abrolhos and off the south coast. Australian Sea-Lions breed every 18 months. For six months out of every 18, the males migrate to the northern breeding islands to breed with the resident females, after which they return to the islands off the Metropolitan coast for approximately 12 months. This spatial separation may be due to the limited availability of food resources for females and pups. Metropolitan haul-out sites are therefore important to the survival of the west coast population.

Results of fauna survey and likelihood of occurrence

Given this species is known to occur within the SIMP, it is also likely to occur within the Proposal area.

Red tailed phascogale (Phascogale calura) – endangered

Habitat preference

The red-tailed phascogale inhabits Wandoo (*Eucalyptus wandoo*) and Sheoak (*Allocasuarina huegeliana*) woodland associations, with populations being most dense in the latter vegetation type. The species exhibits a preference for long unburnt habitat with a continuous canopy, as well as tree hollows (Kitchener 1981).

Results of fauna survey and likelihood of occurrence

The ENV fauna survey (2011a) did not record this species during the survey and did not identify this species in either DEC or NatureMap database searches and previous fauna survey records within 10 km of the Proposal area. The Proposal area does not support Red tailed phascogale habitat as the area is associated with coastal Quindalup Dune vegetation and is a highly fragmented area subject to many degrading influences. It is highly unlikely that this species occurs within and surrounding the Proposal area.

Quokka (Setonix brachyurus) – vulnerable

Habitat preference

The current distribution of the Quokka species includes two offshore islands, Rottnest Island and Bald Island and a number of sites in the south west of Western Australia (DSEWPaC 2011d). The Quokka inhabits a variety of habitats, with preferred habitat within dense streamside vegetation and heaths and shrublands on the mainland and offshore islands, to *Agonis linearifolia*-dominated swamps in the Jarrah Forest and regrowth areas of the Karri forests.

Results of fauna survey and likelihood of occurrence

The Quokka species was not recorded in the ENV fauna survey and was not identified is either DEC or NatureMap database searches and previous fauna survey records within 10 km of the survey area. Potential habitat for this species may exist within the Proposal area, however as the area is subject to various degrading influences such as weeds, littering and other anthropogenic influences the presence of this species is considered unlikely. The Quokka is considered to be locally extinct within the Perth Metropolitan area, occurring in small pockets within the south west of Western Australia on the mainland. It is highly unlikely for this species to occur within the Proposal area due to its current distribution within Western Australia.

14.2.7 Reptiles

Loggerhead turtle (Caretta caretta) – endangered

The Loggerhead Turtle occurs throughout the world in tropical, subtropical and temperate waters. In Australia, it occurs in the waters of coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia. Nesting is concentrated in southern Queensland and from Shark Bay to the North West Cape in Western Australia and foraging areas are more widely distributed.

In Western Australia nesting mainly occurs from Shark Bay to the North West Cape with major nesting at Dirk Hartog Island, Murion Island and the North West Cape.

Habitat preference

In Australia, Loggerhead Turtles nest on open sandy beaches where sand temperatures are in the range of 25–33 °C. Nesting sites must be free from light pollution to prevent disorientation, disturbance and to allow nesting females to come ashore.

Hatchlings and juvenile turtles enter the open ocean where they remain close to the sea surface and move with ocean currents. Large juveniles and adults occur in waters with both hard and soft substrates including rocky and coral reefs, muddy bays, sandflats, estuaries and seagrass meadows. Loggerhead turtles are carnivorous and feed largely on benthic invertebrates.

Results of fauna survey and likelihood of occurrence

Seagrass meadows occur within Cockburn Sound, including Mangles Bay and may provide suitable foraging habitat for this species. The 2009 State of Cockburn Sound Report (CSMC 2009) shows that seagrass health is acceptable for most of Cockburn Sound with the exception of Mangles Bay and Garden Island Settlement. Seagrasses in Mangles Bay are reported to be highly stressed due to restrictions in water circulation near the Garden Island causeway, which slows water movement and encourages sedimentary and detrital deposition, phytoplankton and epiphytic growth and reduces water quality. Seagrasses in Cockburn Sound do not naturally regenerate in areas where they have declined (CSMC 2009).

While it is possible for this species to occur within the Proposal area, marine turtles have not been identified as key species likely to be affected by the Proposal, as Mangles Bay is neither a nesting area nor a resident foraging area. This approach is consistent with other approved developments in Cockburn Sound, including James Point Port: Stage 1 (JPPL 2001) and the Port Rockingham Marina PER (RPS 2009), and with the SIMP Management Plan (DEC 2007; which notes that some species of marine turtles are occasional visitors to the park, but has no specific management objective for them).

Green turtle (Chelonia mydas) – vulnerable migratory

Habitat preference

Green turtles spend the first five to ten years on ocean currents, often found in association with driftlines and rafts of *Sargassum* (DSEWPaC 2011d). Once Green Turtles reach 30 to 40 cm curved carapace length, they settle in shallow benthic foraging habitats such as tropical tidal and sub-tidal coral and rocky reef habitat or inshore seagrass beds (DSEWPaC 2011d). The shallow foraging habitat of adults contains seagrass beds or algae mats on which Green Turtles mainly feed (DSEWPaC 2011d).

The distribution of the Green turtle species in Western Australia is mainly attributed to the tropical and subtropical climate. This species has been identified by the Department of Environment and Heritage (2005a) to occur within the following areas:

- Ashmore and Cartier Nature Reserves
- Ningaloo Marine Park
- Shark Bay World Heritage Area
- Dampier Archipelago Nature Reserve
- Thevenard Island Nature Reserve
- Barrow Island Nature Reserve
- Montebello Conservation Park
- Muiron Islands Nature Reserve.

Results of fauna survey and likelihood of occurrence

Green Turtles are unlikely to be present within the waters of Mangles Bay. The Proposal is within cooler waters mainly present within southern Western Australia and not within the subtropical to tropical waters, in which this species prefers to inhabit.

Leatherback turtle (Dermochelys coriacea) - endangered

Leatherback Turtles are the largest of all sea turtles. They are pelagic feeders, found in tropical, subtropical and temperate waters throughout the world. Their large body size, high metabolism, thick adipose tissue layer and regulation of blood flow allows them to utilise cold water foraging areas unlike other sea turtle species. As a result, this species is regularly found in the high latitudes of all oceans including the South Pacific Ocean in the waters offshore from NSW, Victoria, Tasmania and Western Australia.

It has been recorded feeding in the coastal waters of all Australian States. No major nesting has been recorded in Australia, although scattered isolated nesting occurs in southern Queensland and the Northern Territory.

The species is most commonly reported from coastal waters in central eastern Australia, southeast Australia and in south western Western Australia.

Habitat Preference

The Leatherback Turtle is a highly pelagic species, venturing close to shore mainly during the nesting season. They require sandy beaches to nest, with some evidence that coarser sand is more conducive to successful hatching than finer sand. Sand temperatures between 24–34 °C are required for successful incubation.

Nesting sites should be free from light pollution to prevent disorientation, disturbance and to allow nesting females to come ashore.

Results of fauna survey and likelihood of occurrence

While the species may occur within Mangles Bay and Cockburn Sound, it is unlikely to rely on the area for foraging or breeding.

14.2.8 Sharks

Grey nurse shark (Carcharias taurus [west coast population]) – vulnerable (migratory)

Two distinct populations of the Grey Nurse Shark occur in Australia. The east coast population is critically endangered and the west coast population is vulnerable.

Habitat preference

They have been observed just above the sea bed in or near deep sandy-bottomed gutters or rocky caves, in the vicinity of inshore rocky reefs and islands.

They have a broad inshore distribution, primarily in subtropical to cool temperate waters around the main continental landmasses. In Australia, grey nurse sharks have been regularly reported from Mooloolaba in southern Queensland, around most of the southern half of the continent (excluding the Great Australian Bight), and northward to Shark Bay in Western Australia. The grey nurse shark has been recorded as far north as Cairns in the east, the North West Shelf in the west and also in the Arafura Sea.

Results of fauna survey and likelihood of occurrence

Given their wide distribution around Australia, including around southern Australia, and northward along the west coast to as far as the North West Shelf, the Grey Nurse shark species are likely to be occasional visitors to Cockburn Sound

Great white shark (Carcharodon carcharias) – vulnerable (migratory)

The Great White Shark is widely distributed, and located throughout temperate and subtropical regions in the northern and southern hemispheres. It is primarily found in the coastal and offshore areas of the continental and insular shelves and offshore continental islands. They are uncommon in Australian waters however they tend to appear more frequently in waters near and around seal and sea lion colonies.

Habitat preference

Great White Sharks are normally found in inshore waters in the vicinity of rocky reefs and islands, and often near seal colonies. They have been caught at varying depths to 1 280m and although they are widely distributed, they appear to be far more common in some locations such as South Africa, Australia and United States of America than at others. They are uncommon in Australian waters but encounters are more frequent in waters in and around seal and sea lion colonies such as Neptune Islands, South Australia and larger solitary sharks in the waters around Dangerous Reef and from the Pages (near Kangaroo Island) to Nuyts Archipelago in the Great Australian Bight and the Recherche Archipelago in Western Australia (Environment Australia 2002).

Studies of Great White Sharks sighted at pinniped colonies indicate that the sharks appear to be largely transient, with a few longer-term residents. Individuals are known to return to feeding grounds annually on a seasonal basis (Environment Australia 2002).

Results of fauna survey and likelihood of occurrence

Great White Sharks have been recorded within the SIMP (DEC 2007). Given the presence of a resident Australian Sea-Lion population within the SIMP, the species is likely to be occasional visitors to Cockburn Sound.

Whale shark (Rhincodon typus) – vulnerable migratory

Habitat preference

The Whale Shark is an oceanic and coastal, tropical to warm-temperate pelagic shark and often seen far offshore, sometimes entering lagoons of coral atolls (DSEWPaC 2011d). The species is generally encountered close to or at the surface, as single individuals or occasionally in schools or aggregations of up to hundreds of sharks (Compagno 1984). Whale Sharks are generally found in areas where the surface temperature is 21–25 °C, preferably with cold water of 17 °C or less upwelling into it, and salinity of 34 to 34.5 parts per thousand (ppt) (Pogonoski *et al.* 2002). In Ningaloo Marine Park waters (Western Australia), sightings are most common in water temperatures around 27 °C (Department of Environment and Heritage 2005b).

Results of fauna survey and likelihood of occurrence

The Whale Shark is unlikely to be present within the waters of Mangles Bay associated and surrounding the Proposal area. As identified above, the species prefers the warm tropical waters off the Northern waters of Western Australia, in particular Ningaloo Reef. If species are to occur within the coastal areas of the Proposal area, they would be limited to deeper ocean waters off the Perth coastline, not shallow (2-3 m) waters of the Mangles Bay area.

14.2.9 Plants

Matted centrolepis (Centrolepis caespitosa) – endangered

Habitat preference

Centrolepis caespitosa occurs in winter-wet clay pans dominated by low shrubs and sedges (Gilfillan and Barrett 2004). The species generally occurs on swampy loam in low-lying winter depressions that are occasionally inundated with fresh (not saline) water and are dominated by low shrubs and sedges (Gilfillan and Barrett 2004).

Results of flora survey and likelihood of occurrence

Centrolepis caespitosa occurs in three (TECs in Western Australia. This species is known to occur within:

- the Merredin district part of the Mortlock River Salt Flats TEC
- the Blackwood district; occurring within the Shrublands on southern Swan Coastal Plain Ironstones TEC.
- herb rich shrublands in clay pans TEC.

A population of the threatened plant taxon, *Diuris micrantha*, also occurs at one location and two Priority species (*Triglochin stowardii* and *Wurmbea drummondii*) occur in the vicinity of *Centrolepis caespitosa* at Woodanilling (Gilfillan and Barrett 2004).

It is unlikely that this species will occur within the Proposal area, due to the lack of potential habitat within this area.

14.2.10 Migratory terrestrial species

14.2.11 Migratory marine species – mammals

Bryde's whale (Balaenoptera edeni)

Bryde's Whales occur in temperate to tropical waters from all Australian states except the Northern Territory. Their distribution is primarily assumed from incidental sightings, strandings and whaling data for all areas. Bryde's Whales have been recorded from all Australian states except the Northern Territory.

Habitat preference

Bryde's Whales are found year-round in waters between 40° S and 40° N, primarily in temperatures exceeding 16.3 °C. They appear to use the upper layers of the ocean and are therefore considered pelagic.

Insufficient information exists as to how Australian Bryde's Whales use their habitat, as no specific feeding or breeding grounds have been discovered off Australia.

Results of fauna survey and likelihood of occurrence

Based on Cannell (2004), the Bryde's Whale is unlikely to inhabit the Proposal area (K. Crawley pers comm. 2011).

Pygmy right whale (Caperea marginata)

The Pygmy Right Whale is the smallest and least known baleen whales. Pygmy Right Whale records in Australian waters are distributed between 32° S and 47° S, but are not uniformly spread around the coast.

The northern distribution of Pygmy Right Whales may be limited on the west and east coasts of Australia by the warm, south-flowing Leeuwin and East Australian currents. Western Australia has fewer records than comparative eastern Australian states, for this species.

Habitat preference

Pygmy Right Whales are primarily recorded in association with upwellings and areas of high productivity. They are thought to prefer waters between 5º C and 20ºC and they do not appear to be deep divers.

Results of fauna survey and likelihood of occurrence

Based on Cannell (2004), the Pygmy Right Whale is unlikely to inhabit the Proposal area (K. Crawley pers comm. 2011).

Dusky dolphin (Lagenorhynchus obscurus)

Dusky Dolphins occur throughout the southern hemisphere, primarily between 55º and 26ºS. They are primarily an inshore species although can be pelagic at times. The species is not well surveyed in Australia and is known in Australian waters from only thirteen (13) sightings.

Habitat preference

Dusky Dolphins occur in temperate and sub-Antarctic waters and primarily inhabit inshore waters. All sightings of the species in Australian waters have correlated with warmer than average water temperatures, in the order of 0.5ºC above normal temperatures. They are resident inshore for most of the year, but seek out colder water (below 18ºC) during summer, as inshore temperatures increase.

Results of fauna survey and likelihood of occurrence

Based on Cannell (2004), Dusky Dolphins are infrequently sighted within Perth Metropolitan waters (K. Crawley pers comm. 2011) and have low potential of occurring within the Proposal area.

Killer whale (Orcinus orca)

Killer Whales are the largest member of the dolphin family. In Australia, Killer Whales are recorded from all states, with numbers concentrated around Tasmania.

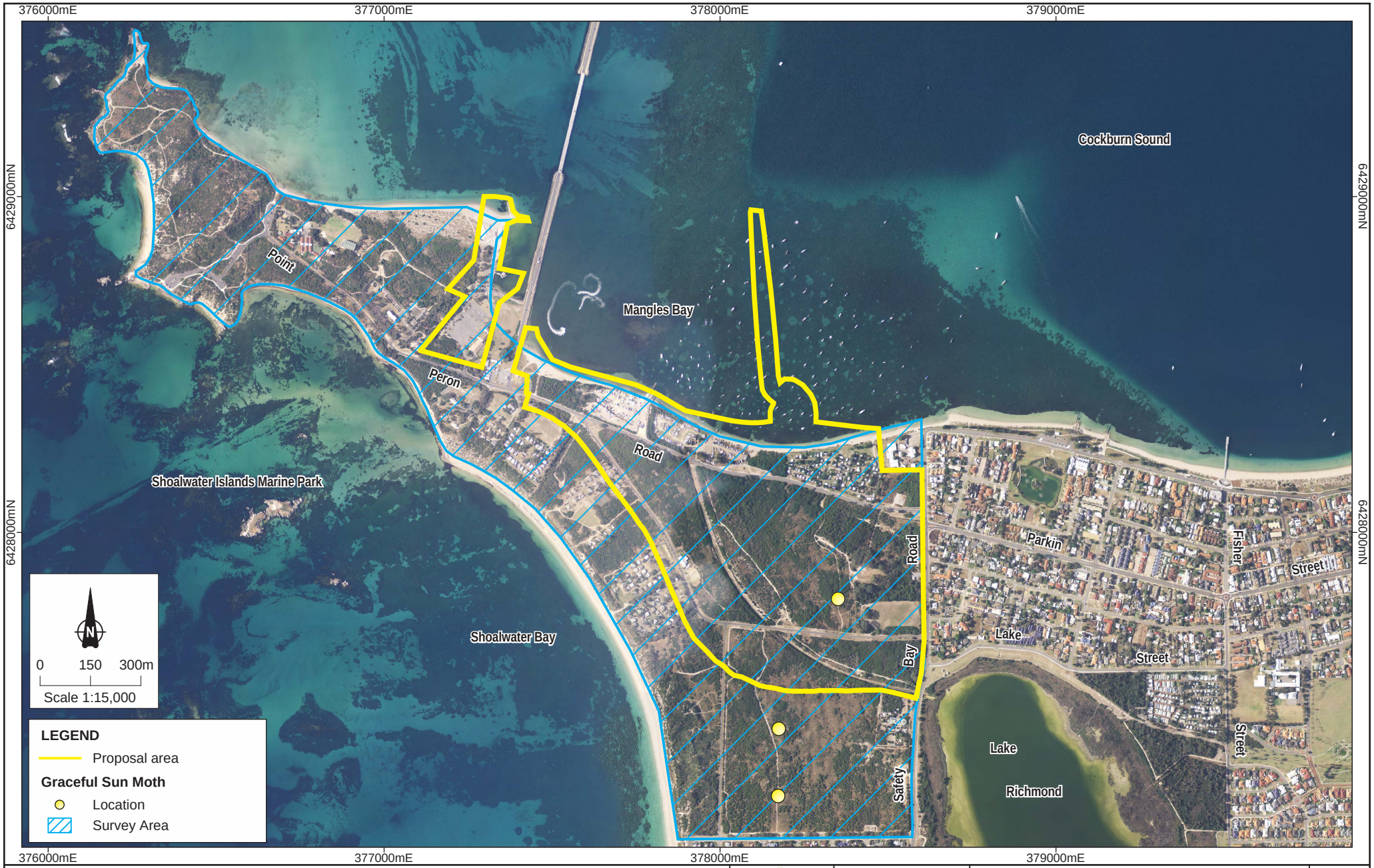
Habitat preference

Killer Whales inhabit oceanic, pelagic and neritic regions in warm and cold waters. In Australia they are most commonly seen off the continental slope and shelf, in particular near seal colonies.

Results of fauna survey and likelihood of occurrence

Given the species' tendency to inhabit waters near seal colonies and the proximity to a resident Australian Sea Lion population, it is possible that this species occurs in the Proposal area.

Based on Cannell (2004), Killer Whales have also been sighted off the western end of Rottnest Island (K. Crawley pers comm. 2011).



Source:
Imagery supplied by Landgate
Graceful Sun Moth Data supplied by ENV (2010)
Coordinate System: MGA94 Zone 50
Date: 9/2/2012

NB: Potential errors may occur in some areas

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Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F053.dgn

Recorded Graceful Sun Moth individuals

Figure No:
107

Source:
Cadastral Data supplied by Landgate
Lomandra Data supplied by ENV (2010)
Coordinate System: MGA94 Zone 50
Date: 9/2/2012
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F045.dgn

Lomandra maritima **density and locations recorded within Proposal area and surrounds**

Figure No: **108**

Source: Imagery supplied by Landgate (2010)
TEC Data supplied by DEC
Coordinate System: MGA94 Zone 50
Date: 9/2/2011
NB: Potential errors may occur in some areas

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Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F010.dgn

Location of Threatened Ecological Communities (TEC)

Figure No:
109

Source:
Imagery supplied by Geoscience Australia
RAMSAR Sites supplied by DoSEWPC
Coordinate System: MGA94 Zone 50
Date: 9/2/2012
NB: Potential errors may occur in some areas

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Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F013.dgn

Location of RAMSAR sites surrounding the Proposal area

Figure No:
110

14.3 Evaluation of options or alternatives to avoid or minimise impact

As the majority of the Proposal area will be cleared to allow for the marina and land development to proceed, he scope to consider alternative options for this Proposal to avoid or minimise impact are limited for impacts on Matters of NES.,. However, alternative marina design and construction techniques, outlined within the groundwater impact assessment Section 6, have reduced/minimised the impacts of dewatering to groundwater levels and surface water levels around and in Lake Richmond. These alternative design measures and construction techniques have reduced the impacts to groundwater levels and surface water levels hence reduced subsequent impacts to the Thrombolite TEC and the Sedgelands TEC.

14.4 Assessment of likely direct and indirect impacts

14.4.1 Potential sources of impact

The following aspects of the Proposal may affect Matters of NES:

- vegetation clearing for the development will result in clearing of fauna habitat
- construction of an inland marina may result in the inland migration of the saltwater interface and changes to water quality, which may potentially impact fauna habitat and TECs
- construction of the access channel and breakwater of the marina may result in the direct and indirect loss of marine habitat
- increased boat movements and berths may potentially impact fauna habitat and individual fauna species by increasing the risk of IMS, increasing fishing pressure and increasing the potential for boat strike of marine fauna
- increased recreational access may potentially impact fauna habitat through littering
- edge effects may potentially impact habitat at Lake Richmond.

Where species are likely to occur in the Proposal area, they are required to be assessed for direct and indirect impacts. The significant impact criteria were developed by DSWEPaC (DEWHA 2009) to assist in determining whether the impacts of a Proposed Action on Matters of NES are likely to be significant.

The general test for significance, according to the guidelines, is whether an impact is 'important, notable or of consequence, having regard to its context or intensity'. The significant impact criteria provide more distinctive tests and a Proposed Action must have a 'real[19] chance or possibility' of failing one or more of the criteria to be considered a controlled action under the EPBC Act.

There are separate significant impact criteria for determining the impact to species listed as Endangered, Vulnerable and Migratory species and TECs. The assessment of significance of impact for each Threatened and Migratory species has been undertaken against the relevant Significant Impact Criteria.

The Matters of NES that may be affected by the Proposal include:

- TEC: Sedgelands in Holocene dune swales of the southern Swan Coastal Plain (occurring around Lake Richmond) - endangered
- TEC: Thrombolite (microbial) community of coastal freshwater lakes of the Swan Coastal Plain (Lake Richmond) – endangered
- GSM (*Synemon gratiosa*) – endangered
- migratory birds.

[19] 'real' is also defined in the guidelines as 'not remote'

14.4.2 Vegetation clearing, edge effects and fragmentation

Vegetation will be cleared from the Proposal area as each stage of the Proposal is developed. Up to 40 ha of vegetation will be cleared for the Proposal. Maximum disturbance amounts for each habitat type of the EPBC listed species present within the Proposal area have been calculated be assessing the amount of each habitat that exists within the Proposal area (Table 63).

Table 63 Maximum direct disturbance of habitats as a result of the Proposal

Species	Habitat in survey area (ha)	Habitat within Proposal area		Habitat cleared for Proposal	
		(ha)	%	(ha)	%
GSM	76.9	37.8	49	32.6	40
High density lomandra	11.2	6.88	62	6.54	59
Medium density Lomandra	10.3	0.54	5	0.45	4
Low density Lomandra	55.3	30.4	55	23.7	43
Black cockatoos (woodland habitat)	19.3	5.75	30	1	5
Sedgeland TEC	25.1	0	0	0	0
Thrombolite TEC	3	0	0	0	0

Edge effects refer to the consequences of a boundary between vegetation/habitat and a disturbed area, which may result in increased weed invasion into habitat areas, and effect habitat quality adjacent to disturbance.

Habitat fragmentation effects can divide populations into isolated groups. Fragmentation may occur due to clearing where the continuity of habitat is reduced. The Proposal itself has the potential to fragment habitat by dividing the landscape.

In response to the DEC recommendations within the latest report findings (Bishop *et al.* 2010) the DSEWPaC significant impact guidelines developed for the Golden Sun moth (*Synemon plana*) will be applied together with the latest DEC conservation advice (DEC 2011b) in determining the significance of impact of vegetation clearing on the GSM.

The Proposal will result in GSM habitat loss through direct clearing of up to 32.6 ha of habitat as outlined in Table 63. The total clearing of habitat includes clearing of approximately 6.5 ha of high density habitat, 0.45 ha of medium density and 23.7 ha of low density of GSM habitat. The Proposal includes clearing of an area greater than 0.5 ha within a contiguous GSM habitat of greater than 10 ha. This is considered to represent a significant impact to the GSM (Bishop *et al.* 2010).

The potential habitat within the Proposal area is highly fragmented and cut off by unsuitable habitat which includes degraded and/or cleared areas, development and other anthropogenic influences. The Proposal are does not provide a linkage between GSM populations and as such, the possible community within the Proposal area is considered to be isolated habitat. The GSM has limited dispersal ability and sites greater than 200 m apart may be considered to be disjunct populations (Bishop *et al.* 2010).

The Proposal area and adjacent bushland represents small, isolated and degraded patches of habitat. The bushland within the Mangles Bay area is at least 3 km from the nearest large area of vegetation and is such is not likely to contribute to the overall ecological health of the species. The Proposal may introduce barriers to dispersal however is unlikely to significantly impact upon GSM population due to the existing habitat fragmentation.

Black cockatoos

Two black cockatoo species, the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) and Carnaby's Cockatoo (*Calyptorhynchus latirostris*) have been identified as to potentially occur within the Proposal area. The Proposal will result in the direct clearing of approximately 1 ha of woodland supporting tuarts identified by ENV (2011a The Proposal area does not contain foraging species such as Banksia, Marri or Jarrah trees and no suitable hollows were identified within the tuarts that are within the proposal area. Due to the lack of habitat available for these species, potential impacts from the Proposal from direct clearing will not result in a significant impact to the potential black cockatoo habitat or the population of black cockatoo species that may potential occur.

Indirect impacts may occur to the tuart species as a result of the hydrological changes incurred as a result of the inland marina. These potential impacts are addressed in Section 14.4.3.

Migratory birds

Assessment of the potential impacts to each of the 29 species identified as potentially occurring within the Proposal area are discussed below.

Southern Giant-Petrel (*Magronectes giganetus*) – Endangered

Southern Giant-Petrels cover a broad range of habitats and locations in Antarctic to subtropical waters. Their wintering areas include waters off South America, South Africa, Australia and New Zealand (Environment Australia 2001). There is no evidence that south western Australia is an important area for this bird, but it is considered likely to occur in the marine and coastal parts of the Proposal area as an infrequent visitor.

The Proposal area and surrounding areas, including Lake Richmond, is not considered to be critical habitat for this species (Environment Australia 2001) as the species mainly occurs in Antarctic waters and during summer and concentrating north of 50° S in winter. While this species may occur as an infrequent visitor to the area, the potential habitat within and surrounding the Proposal is highly unlikely to be critical to its survival.

The Proposal is considered highly unlikely to result in the introduction of invasive species or bird diseases within the marine or coastal zones or increase in trawler fishing that may impact upon this species.

As this species is a non-breeding visitor to Australia, breeding only on the Antarctic continent, Peninsula and islands and on sub-Antarctic islands and South America, the Proposal will not disrupt the breeding cycle of this species.

Northern Giant Petrel (*Macronectes giganteus)*

This species may occur in the Proposal are as an infrequent visitor. The Proposal is highly unlikely to result in the decrease in size of the population of these species due to their broad range of existence.

The Proposal will not significantly impact on the Northern Giant Petrel's range. The species occurs mainly in sub-Antarctic waters, but also regularly occurs in Antarctic waters of the south western Indian Ocean, the Drake Passage and west of the Antarctic Peninsula. The Northern Giant Petrel range extends into subtropical waters mainly between winter and spring. The home ranges of these species are very large, being estimated at 82,600,000 km^2 for the Northern Giant Petrel.

The Proposal does not support critical breeding or feeding habitat for this species and is unlikely to reduce the size of the population of this species and unlikely to fragment the important population of this species, causing the species to decline. The Northern Giant Petrel mainly occurs in sub-Antarctic and Antarctic waters which are outside of the Proposal area.

The species breeds on sub-Antarctic islands and South Georgia between 46º and 54º S, which are outside of the Proposal area. This Proposal will not disrupt the breeding cycle of this species.

The key threats to the Northern Giant-Petrel is longline fishing which causes the direct loss of seabirds as bycatch and predation by black rats, feral cats and habitat degradation by rabbits. Disease is not a known threat to this species and the Proposal is unlikely to introduce disease to the Proposal area.

The Proposal will not interfere with the recovery of the species. The species is likely to be an infrequent visitor to the area as its preferred breeding and feeding habitat occurs outside of the Proposal area. The Proposal is also unlikely to increase any of the key threatening process to this species.

Shy Albatross (*Thalassarche cauta cauta)*

The Proposal is unlikely to result in the decrease in size of the population, significantly impact on the range of the Shy Albatross or fragment the population due to their broad range of existence. The species occurs across all Australian coastal waters below 25º S and is most commonly found in south eastern Australia and Tasmania. The home range of this species is also very large, being estimated at 23,900,000 km^2 (BirdLife International 2011).

This species occurs across all Australian coastal waters below 25º S, with breeding of the species known to occur on Albatross Island, Bass Strait, Mewstone and Pedra Branca off southern Tasmania. As the breeding site outside of the Proposal area, the Proposal will not disrupt the breeding cycle of this species and is unlikely to impact habitat to the extent that the species is likely to decline.

This Proposal will not interfere with the recovery of this species as it preferred habitat is located outside of the Proposal area. In addition, the Proposal will not introduce any new or exacerbate any key threatening processes to this species.

White bellied Sea Eagle (*Haliaeetus leucogaster)*

The Proposal is unlikely to result in a significant impact to the White Bellied Sea Eagle as a result of clearing and edge effects associated with the Proposal. This species is known to inhabit coastal areas, with nests placed on high ground rock pinnacles and within wetland habitat of Lake Richmond (ENV 2011a).

The Proposal however, will not impact rocky coastal habitat, as only a small section of the Mangles Bay shore line will be cleared with rocky areas associated with Cape Peron and the SIMP not impacted by the Proposal. The Proposal will not clear potential foraging habitat at Lake Richmond, as clearing will be confined to the Proposal area itself, 200 m northwest of Lake Richmond.

Significant impact to this species will not occur as the potential habitat surrounding the Proposal area of the White bellied Sea Eagle will not be significantly impacted therefore not resulting in decline of the species or fragmentation of its potential habitat.

Rainbow Bee-eater (*Merops ornatus*)

The Proposal is unlikely to cause a significant impact to the Rainbow Bee-eater. The species was recorded at Lake Richmond, adjacent to the Proposal area. Lake Richmond provides the suitable wetland habitat for this species providing woodland and shrubland foraging habitat for this species. The Rainbow bee-eater is more likely to visit and forage at Lake Richmond, rather than the Proposal area.

The Proposal will not clear potential foraging habitat at Lake Richmond, as clearing will be confined to the Proposal area itself, 200 m northwest of Lake Richmond. The Proposal will not result in species decline or fragment habitat as there will be no impact to the foraging habitat of this species.

The Proposal may disrupt the lifecycle of some Rainbow Bee-eaters surrounding the Proposal area if clearing and earthmoving occurs during the September-October breeding season. These potential impacts however are restricted to the Proposal area itself with potential edge effects from construction managed through a CEMP.

Eastern Osprey (*Pandion cristatus)*

The Proposal is unlikely to result in a significant impact to the Eastern Osprey. A species nest was recorded within the rocky areas of the Shoalwater Bay, where the small islands and bays of the area provide suitable habitat for this species. The Proposal will not be impacting Shoalwater Bay (approximately 250 m south west of the Proposal area) as clearing will be restricted to the Proposal area.

Significant impact to this species will not occur as the potential habitat surrounding the Proposal area of the Eastern Osprey will not be impacted therefore not resulting in decline of the species or fragmentation of its potential habitat.

Migratory shorebirds

The following 19 migratory shorebirds have the potential to occur within the Proposal area:

1. *Actitis hypoleucos* (common sandpiper).
2. *Limosa limosa* (black-tailed godwit).
3. *Limosa lapponica* (bar-tailed godwit).
4. *Numenius phaeopus* (whimbrel).
5. *Numenius madagascariensis* (eastern curlew).
6. *Tringa stagnatilis* (marsh sandpiper).
7. *Tringa nebularia* (common greenshank).
8. *Tringa glareola* (wood sandpiper).
9. *Xenus cinereus* (terek sandpiper).
10. *Tringa brevipes* (grey-tailed tattler).
11. *Arenaria interpres* (ruddy turnstone).
12. *Calidris canutus* (red knot).
13. *Calidris tenuirostris* (great knot).
14. *Calidris alba* (sanderling).
15. *Calidris ruficollis* (red-necked stint).
16. *Pluvialis fulva* (pacific golden plover).
17. *Pluvialis squatarola* (grey plover).
18. *Charadrius mongolus* (lesser sand plover.
19. *Charadrius leschenaultii* (greater sand plover).

The Proposal is unlikely to result in a significant impact to the 19 species of migratory bird as a result of clearing and edge effects associated with the Proposal.

Important habitat for migratory shorebirds is defined in the Draft EPBC Act Policy Statement 3.21 Significant Impact Guidelines for 36 Migratory Shorebird Species (DSEWPaC 2009), as:

- an internationally important habitat for migratory bird species or
- supports at least 0.1% of the flyaway population of a single species or
- supports at least 2000 migratory shorebirds or
- supports at least 15 shorebird species.

The Proposal will therefore not result in a significant impact to this species as the Proposal area does not support important habitat for these migratory species. Whilst more than 15 shorebird species have been identified as occurring within the Proposal area (ENV 2011a) the Proposal will not result in a significant impact as:

- there is widespread shoreline habitat outside the Proposal area
- the small section of shoreline within the Proposal area is highly impacted by access (4WD and boating)
- important habitat (Lake Richmond) in close proximity to the Proposal area will not be impacted.

Fork-tailed Swift (Apus pacificus)

The Proposal is unlikely to result in a significant impact to the Fork-tailed Swift as the bird rarely lands and its' occurrence is likely to be spasmodic within the Proposal area.

Eastern Reef Egret (Ardea sacra)

The Proposal is unlikely to result in a significant impact to the species, as the Eastern Reef Egret is likely to only forage within the shoreline within the Proposal area and there is widespread habitat outside the Proposal area.

Glossy Ibis (Plegadis falcinellus)

The Proposal is unlikely to result in a significant impact to the species, as the Glossy Ibis is likely to only forage within the dry grassland areas within the Proposal area, and there is widespread habitat occurring outside the Proposal area.

Peregrine Falcon (Falco peregrinus)

The Proposal is unlikely to result in a significant impact to the species, as the Peregrine Falcon is likely to only forage within the shoreline within the Proposal area and there is widespread habitat outside the Proposal area.

14.4.3 Construction of inland marina

The proposed inland marina will result in the direct removal of land space and also alter the hydrological regime of the Proposal area. As outlined within Section **6** the Proposal will result in the lowering of water levels in Lake Richmond during construction of 0.032 mAHD and 0.038 mAHD during the operation of the Proposal. Salinity within Lake Richmond will decrease as a result of the Proposal.

Migratory species habitat

Migratory species known to occur or may potentially occur at Lake Richmond will not be significantly impacted by the hydrological changes to water levels at Lake Richmond. The foraging habitat of this species consists mainly of reeds, bulrushes and sedgelands surrounding the lake's perimeter.

Impact to the marine shoreline is limited in comparison to the available shoreline in the immediate and surrounding area. the marine shoreline impacted is also heavily utilised by boating and 4wd activities and therefore is likely to represent limited habitat value.

Black cockatoo habitat

Potential black cockatoo habitat is unlikely to be impacted by the Proposal. The Proposal does not propose to clear any tuart species and the Proposal is unlikely to indirectly impact Tuarts given the minimal changes to groundwater levels and given that the saltwater intrusion is of a very limited nature.

Threatened Ecological Communities

The Thrombolite and Sedgeland TECs will not be directly impacted by the Proposal. The Proposal will not result in clearing or the fragmentation of habitat, assist the introduction of invasive species, cause changes in species composition or interfere with the quality or recovery of the TECs.

Water levels

Groundwater modelling was undertaken to determine the impact of the Proposal upon Lake Richmond (Section 6.2.5). Groundwater in the Safety Bay Sand currently flows north from the lake to Mangles Bay in

winter, when water levels in the lake are higher than the Bay (Section 6.2.4). The flow direction reverses during the summer months as the water level in the lake drops (Section 6.2.4). This pattern will continue post-construction. It is this pattern that results in the chemical properties of the groundwater and lake water necessary to support the Thrombolite TEC (Section 7.4.3).

The Proposal will not alter the surface water quantity entering Lake Richmond. The Proposal area does not drain into Lake Richmond, and surface water from the Proposal will not enter Lake Richmond (Section 7.4.3).

As outlined in Section 7.4.3 water levels within Lake Richmond range from 0.2 mAHD to 1.2 mAHD (Figure 33). Low water levels may vary by more than 0.3 m between years (Figure 29). High water levels are similarly variable between years (Figure 29). The operational impacts of the marina on groundwater are greater than the construction impacts. A reduction of groundwater levels at the lake of 0.038 m is expected during operation (Section 6.3.5). In a worst case scenario, assuming a direct connection between the lake and groundwater, this would result in a 0.038 m reduction in groundwater levels at the lake.

The impacts to water levels in Lake Richmond associated with the Proposal are considered unlikely to impact upon ecological water requirements for the Sedgelands TEC or fauna present in the lake. The impact is comparatively small in terms of reduction in water levels (0.038 m) and is therefore considered highly unlikely to alter species composition by drawing water below the rooting level of local plants. This drop is also well within the 0.3 m inter-annual variation in low water levels and inter-annual variation in low water levels observed in the lake.

Water levels changes of 0.038 mAHD are not expected to result in a significant impact to the Thrombolite community. The changes in water levels are minor and can be considered to be within the range of the seasonal fluctuation of the lake's surface water levels, slightly exposing the thrombolites, already exposed during these months. Indirect impacts to this TEC as a result of a slight decrease in salinity are unlikely to occur as a decrease in salinity is not likely to significantly impact the TEC as would an increase in salinity (CALM 2003b).

The Proposal will not impact on the water quality experienced by the TECs or fauna in the lake. Stormwater from the Proposal area will not enter the lake or native vegetation (Section 7.4.3). Groundwater entering the lake will still pass through the Safety Bay sands, resulting in an alkaline groundwater high in calcium and carbonate/bicarbonate (Section 7.4.3). The change in the location of the saltwater wedge in groundwater is also not expected to impact upon the lake (Section 6.3.6).

It is therefore considered that the altered hydrological regime associated with the Proposal will not result in a significant impact to the Thrombolite or Sedgelands TEC due to changes in water quality or quantity.

14.4.4 Construction of access channel, breakwater and increased boat movements

Humpback whale

The species is known to occur along the coastlines of Western Australia, Queensland and New South Wales and may potentially occur off the coast of the Northern Territory and South Australia and Tasmania. The Kimberley region of Western Australia is an important breeding ground for this species and Mangles Bay and Cockburn Sound are within a known Humpback Whale aggregation area frequented during the southward migration. While the Proposal area is within this aggregation area, the proposed marine footprint is unlikely to impact on this species.

While this species is known to aggregate in waters near to the Proposal area, it is migratory and important feeding and breeding grounds are located outside of the Proposal area. In addition, the marine footprint is restricted to the shallow waters of Mangles Bay. This proposal is unlikely to affect habitat critical to the survival of this species.

Mangles Bay and Cockburn Sound are within a known Humpback Whale aggregation area frequented as a rest spot on their southward migration, from approximately mid September to mid-October each year. However the marine footprint is restricted to the shallow waters of Mangles Bay where whales are unlikely to occur and therefore the Proposal is unlikely to impact habitat to the extent that the species is likely to decline.

Key threats to the Humpback Whale include the resumption of commercial whaling, habitat degradation and predation. Invasive species are not a recognised threat to this species and the Proposal is unlikely to introduce an invasive species that may be harmful to this species. Disease is not a recognised threat to the Humpback Whale. The Proposal is unlikely to introduce disease that may cause the species to decline. This proposal will not interfere with the recovery of this species.

Australian Sea lion

This Proposal is unlikely to result in a decrease in the size of an important population of this species. The Australian Sea-Lion is currently found from the Abrolhos Islands in Western Australia to the Pages Islands in South Australia. The SIMP is used by juvenile and adult males during the non-breeding season to 'haul-out' and for foraging.

The Proposal area is outside of the SIMP and will not cause indirect impacts on the SIMP. It is therefore unlikely to impact on habitat critical to the survival of this species, fragment an important population or contribute to the decline of the species.

This Proposal is unlikely to disrupt the breeding cycle of an important population. No known breeding colonies for this species occur within the SIMP or the Proposal area. Females are mostly restricted to the breeding islands to the north near Jurien Bay, the Houtman Abrolhos and off the south coast. For six out of every 18 months, the males migrate to the northern breeding islands where they mate with the resident females, after which they return to the southern non-breeding male colonies.

Historically, the Australian Sea-Lion population declined due to commercial harvested. Habitat degradation and warming waters are now key threats to this species. Invasive species are not a known threat for the Australian Sea-Lion and this Proposal is unlikely to introduce an invasive species that may be harmful to this species.

Parasites and microbes which may cause disease to this species may become more prolific as waters warm due to climate change. This Proposal is unlikely to introduce new disease or to contribute to increasing water temperatures.

This proposal is unlikely to interfere with the recovery of the species as it is outside areas of known habitat and will not exacerbate or introduce any threats to the recovery of the species.

*Loggerhead Turtle (*Caretta caretta*) – Endangered*

The Proposal is unlikely to result in a long-term decrease in the size of a population. Loggerhead Turtles occur throughout the world in tropical, subtropical and temperate waters. In Australia, the species has a wide distribution, occurring in coastal waters throughout eastern, northern and western Australia. Nesting is concentrated in southern Queensland and from Shark Bay to the North West Cape in Western Australia

Loggerhead Turtles occur in coastal waters in association with coral and rocky reefs, seagrass beds and muddy bays around eastern, northern and Western Australia. While suitable habitat exists within Cockburn Sound, the marine footprint is relatively small and seagrass within Mangles Bay is degraded and unlikely to provide critical habitat for this species.

The species is migratory and has a wide distribution around eastern, northern and Western Australia. The small marine footprint of this Proposal will not fragment a population of Loggerhead Turtles.

The seagrass meadow within Mangles Bay is highly degraded and while it may provide some foraging potential, it is unlikely to be critical habitat for this species. Seagrass meadows within Cockburn Sound,

beyond Mangles Bay, provide seagrass habitat of a sound condition which is likely to be used preferentially by this species.

Known breeding areas in Australia include the southern Great Barrier Reef and adjacent mainland areas and in Western Australia near Murion Island and Shark Bay. This species is not known to breed in southwest Western Australia, near Mangles Bay.

Invasive predatory species including foxes and dogs are a known threat to Loggerhead Turtle nests in eastern Australia and are responsible for the destruction of a large proportion of clutches. Breeding of this species is not known to occur in southwest Western Australia, near Mangles Bay.

Disease is not a known threat to Loggerhead Turtles. Known threats include commercial and recreational fishing, coastal infrastructure and development, animal predation, Indigenous harvest, seismic surveys and climate change. This Proposal is unlikely to introduce a disease that may cause the species to decline.

While Loggerhead Turtles may occur in Mangles Bay, the area is unlikely to provide critical habitat for this species given the degraded state of seagrass meadows and the availability of sound seagrass habitat elsewhere in Cockburn Sound.

Leatherback Turtle (Dermochelys coriacea) – Endangered

Leatherback Turtles are pelagic feeders, found in tropical, subtropical and temperate waters throughout the world. This species is most commonly recorded from coastal waters in central eastern Australia, southeast Australia and in southwest Australia.

While this species is likely to occur within the Proposal area, given its wide distribution and migratory nature, the Proposal is unlikely to appreciably reduce the area of occupancy of the species.

Given the migratory nature of the species and its wide distribution in tropical, subtropical and temperate waters throughout the world, the Proposal is unlikely to fragment an existing population.

The Leatherback Turtle is widely distributed around Australia. It has been recorded feeding in the coastal waters of all Australian States however there are no major nesting sites in Australia. It is unlikely that the Proposal area contains habitat critical to the survival of this species.

No major nesting sites of this species have been recorded in Australia, although some scattered isolated nesting occurs in Southern Queensland and the Northern Territory.

The Leatherback Turtle is widely distributed around Australia. It has been recorded feeding in the coastal waters of all Australian States however there are no major nesting sites in Australia. It is unlikely that the Proposal area contains habitat critical to the survival of this species.

Invasive species are not a known threat to the Leatherback Turtle in Australia. It is unlikely that the Proposal will introduce an invasive species that will be harmful to the species.

Disease is not a known threat to the Leatherback Turtle. Known threats to the species in Australia include commercial and recreational fishing, coastal development, Indigenous harvest, seismic survey and climate change.

Leatherback Turtles are widely distributed around Australia however there are no major breeding sites in Australia. The Proposal is unlikely to interfere with the recovery of the species.

Southern Right Whale

Southern Right Whales are seasonally present on the Australian coast between about May and November.

Southern Right Whales have been recorded in the coastal waters of all Australian states with the exception of the Northern Territory (Bannister *et al*. 1996 in 2011c). Principally found around the southern coastline

off southern Western Australia and far west South Australia, Southern Right Whales occur anywhere between Sydney and Perth, including off Tasmania (2011c).

Habitat requirements of Southern Right Whales are not well understood. Early observations on calving grounds indicated a preference for water depth of less than 5 m and differential habitat use by calving females and unaccompanied whales has been documented. Their distribution has been associated with protected water with shallow sloping bathymetry. Females with calves occurred in shallower waters with a sandy bottom and closer to shore than those without calves.

The feeding habitat of the species is poorly known and there have been no dedicated studies in feeding areas. However, feeding areas are thought to be in deeper offshore waters ranging from sub-Antarctic areas to locations south of 60°S in areas probably associated with high productivity.

The species occasionally uses the SIMP during its annual winter migration to the south and west coasts of Western Australia (DEC 2007).

The Southern Right whale is often seen in Perth coastal waters during its annual southwards migration from late autumn to early spring: this species may occasionally enter Cockburn Sound but is highly unlikely in the southern end of Cockburn Sound due to the restriction posed by the Causeway.

The Proposal is unlikely to impact on Southern Right Whales.

Sharks

Grey Nurse Shark (*Carcharias taurus* [west coast population]) – vulnerable (migratory)

Two distinct populations of the Grey Nurse Shark occur in Australia. The east coast population is critically endangered and the west coast population is vulnerable.

They have been observed just above the sea bed in or near deep sandy-bottomed gutters or rocky caves, in the vicinity of inshore rocky reefs and islands.

They have a broad inshore distribution, primarily in subtropical to cool temperate waters around the main continental landmasses. In Australia, grey nurse sharks have been regularly reported from Mooloolaba in southern Queensland, around most of the southern half of the continent (excluding the Great Australian Bight), and northward to Shark Bay in Western Australia. The grey nurse shark has been recorded as far north as Cairns in the east, the North West Shelf in the west and also in the Arafura Sea.

Given their wide distribution around Australia, including around southern Australia, and northward along the west coast to as far as the North West Shelf, the Grey Nurse shark species are likely to be occasional visitors to Cockburn Sound

The Proposal is unlikely to impact on Grey Nurse Sharks.

Great White Shark (Carcharodon carcharias) – vulnerable (migratory)

The Great White Shark is widely distributed, and located throughout temperate and subtropical regions in the northern and southern hemispheres. It is primarily found in the coastal and offshore areas of the continental and insular shelves and offshore continental islands. They are uncommon in Australian waters however they tend to appear more frequently in waters near and around seal and sea lion colonies.

Great White Sharks are normally found in inshore waters in the vicinity of rocky reefs and islands, and often near seal colonies. They have been caught at varying depths to 1280m and although they are widely distributed, they appear to be far more common in some locations such as South Africa, Australia and United States of America than at others. They are uncommon in Australian waters but encounters are more frequent in waters in and around seal and sea lion colonies such as Neptune Islands, South Australia and larger solitary sharks in the waters around Dangerous Reef and from the Pages (near Kangaroo

Island) to Nuyts Archipelago in the Great Australian Bight and the Recherche Archipelago in Western Australia (Environment Australia 2002).

Studies of Great White Sharks sighted at pinniped colonies indicate that the sharks appear to be largely transient, with a few longer-term residents. Individuals are known to return to feeding grounds annually on a seasonal basis (Environment Australia 2002).

Great White Sharks have been recorded within the SIMP (DEC 2007). Given the presence of a resident Australian Sea-Lion population within the SIMP, the species is likely to be occasional visitors to Cockburn Sound.

The Proposal is unlikely to impact on Great White Sharks.

14.5 Potential for and nature of any cumulative impacts

The potential impact of the realignment of the SDOOL was modelled based on advice from Water Corporation regarding the dewatering requirements for the duplication (report provided in Appendix 5). The cumulative impact of the two proposals on Lake Richmond (and hence the TECs) is predominantly due to the construction of the SDOOL duplication (Section 6.3.1). Determining the acceptability of the impacts of the SDOOL duplication, and how these may be managed or mitigated, are not within the scope of this PER, but are a matter to be discussed between the Water Corporation and the relevant regulatory authorities.

14.6 Management measures and performance standards

Matters of NES may potentially be impacted by vegetation clearing, fire, noise and vibration, changes to groundwater levels, dredging activities, increased boat movements and berths, increased recreational access and edge effects. Management of these impacts will involve compliance with a wide range of management measures that are captured in the following management plans, identified within the Construction Environment Management Plan:

- dredge spoil management plan
- fire management plan
- GSM management plan
- noise and vibration management plan.

Key management measures implemented to minimise the impact of both the construction and operation phases the Proposal on Matters of NES. These management measures will include:

- not undertaking clearing outside authorised areas
- conducting clearing in stages to allow for the movement of any remaining fauna
- planting and/or seeding disturbed areas with local provenance species where appropriate
- consolidating and formalising walking tracks in sensitive areas to reduce disturbance to vegetation
- limiting noise and vibration that may disturb fauna during construction
- restricting the time and length excavated trenches are opened/exposed
- preventing vehicle access outside authorised areas during construction, and limiting vehicle speeds inside the construction area
- fencing where required to protect vegetation
- establish a monitoring program to evaluate the rehabilitation performance.
- providing suitable areas as conservation offsets
- conduct rehabilitation of habitat areas in the vicinity of the Proposal area

- landscape the median strips of Memorial Drive and verges of Safety Bay Road.
- dewatering to be undertaken in a manner that minimises impact of saltwater intrusion and drawdown on native vegetation, as described in Section 6
- Development of a groundwater, surface water and vegetation monitoring program prior to submitting licenses to take groundwater for dewatering being submitted to the DoW. The Dewatering Management Plan will outline the process for dewatering, monitoring, reporting and any trigger levels that may apply with regards to dewatering.
- designing the Proposal in a water sensitive manner.
- a strategic weed control program with the aim of a net decrease in weeds in the area.

14.7 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

With the application of management and mitigation measures described in Section 14.6, the Proposal is expected to result in the following outcomes in relation to matters of national environmental significance:

1. Reduction in area of available GSM habitat, offset by an improvement in local, adjacent habitat.
2. No significant impact to Migratory species as the Proposal area does not support important habitat for migratory species and the Proposal is not having a significant impact on Lake Richmond.
3. No direct or indirect impact to the black cockatoo (Carnaby's and Forest Red-Tailed) habitat.
4. No significant impacts to marine migratory species.

Overall, there are likely to be some local reductions in fauna populations within the Proposal boundary; but the Proposal is unlikely to significantly affect the regional diversity or abundance as the habitats are well distributed locally and regionally.

With management and offsets, it is considered that the Proposal can meet EPA objectives, as well as other applicable policy and guidelines objectives.

15. Aboriginal and European heritage impact assessment

15.1 Relevant environmental objectives, policies, guidelines, standards and procedures

15.1.1 EPA objectives

The EPA applies the following objective to the assessment of proposals that may affect heritage:

To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.

15.1.2 Legislation, policy and guidance

State legislation

The Minister for Indigenous Affairs is responsible for the administration of the *Aboriginal Heritage Act 1972* (AH Act). Under section 17 of the AH Act, it is an offence to disturb any Aboriginal site without consent under section 18 of that Act. The Minister considers recommendations from the Aboriginal Cultural Material Committee (ACMC) and the general interests of the community when making a decision on disturbance to a site and may also impose conditions on the approval.

The Registrar of Aboriginal Sites is responsible for maintaining the Register of Places and Objects. The Department of Indigenous Affairs (DIA) has a database of all recorded sites.

Native title

Native title, or Indigenous land rights, is a concept in the law of Australia that recognises the continued ownership of land by local Australian Aborigines or Torres Strait Islanders. The colonisation of Australia was conducted under the false assumption that the land was unoccupied (*terra nullius*) and could therefore be claimed for the Crown and distributed to colonists by the Government. The legal concept of Native Title as it applies in Australia was recognised by the judicial system in 1992, and the Keating Government later enacted the *Native Title Act 1993* (Commonwealth) to clarify the legal position of landholders and the processes that must be followed for Native Title to be claimed, protected and recognised through the courts.

EPA Guidance Statement No. 41

EPA Guidance Statement No. 41, "*Assessment of Aboriginal Heritage*" (EPA 2004d), provides guidance on the process for the assessment of Aboriginal heritage as an environmental factor. In its assessment of proposals the EPA will expect proponents to:

- report on the likelihood of the presence of matters of heritage significance to Aboriginal people
- analyse if the proposed biophysical changes will result in an impact on matters of heritage significance to Aboriginal people.

Based on this information, the EPA will make a determination on whether Aboriginal heritage is a relevant environmental factor. Where it is determined to be a relevant environmental factor, the EPA will expect the proponent to properly consider how to minimise any adverse impact of the proposal on heritage values.

This guidance statement also details those actions that may be pertinent to the factor of Aboriginal heritage, including:

- consultation with DIA staff and desktop review of sites
- undertaking an Aboriginal heritage and/or archaeological survey in consultation with relevant Aboriginal representatives
- inform relevant Aboriginal people of the proposal and conduct appropriate consultation
- demonstrate that any concerns raised by Aboriginal people have been considered in the environmental management of the factor and that this is made known to the relevant Aboriginal people.

City of Rockingham - Heritage and conservation and development policy 3.1.7

Places with cultural heritage significance located within the City of Rockingham are listed on the Heritage List which has been established under *Town Planning Scheme No.2. Planning Policy 3.1.7 – Heritage Conservation and Development Policy* (Planning Policy 3.1.7) has been prepared by the City of Rockingham to provide development and design guidance for development of or relating to places listed on the Heritage List.

The objectives of the policy are:

- to conserve and protect places of cultural heritage significance within the City of Rockingham
- to ensure that development does not adversely affect the significance of heritage places
- to ensure that heritage significance is given due weight in decision making for applications for planning approval
- to provide greater certainty to landowners and the community about the planning processes for heritage identification and protection in the City of Rockingham.

The following impact assessment has been made in accordance with Planning Policy 3.1.7, including consideration of the following key Policy Statements:

1. Relevant Considerations for Development Assessment, including:
   - whether the proposed development will adversely affect the significance of any heritage place
   - measures to conserve the heritage significance of a place and its setting.
2. Development Control Principles for:
   - alterations, extensions or change of use affecting a heritage place
   - demolition of a heritage place (including a place within a heritage area).
3. Levels of Significance.

15.2 Findings of surveys and investigations

15.2.1 Aboriginal Heritage

Significant sites in the vicinity of the Proposal area

A search of the DIA 'Aboriginal Heritage Enquiry System' (DIA 2011) identified three 'Registered' sites located within and adjacent to the Proposal area. Also identified in the vicinity of the Proposal area were six 'Other Heritage' Aboriginal sites that have been lodged with the DIA and are recorded as 'stored data' or awaiting an assessment decision by the ACMC to decide if they will be registered sites or not. The 'Registered' and 'Other Heritage' Aboriginal sites are outlined in (Table 64). The locations of key heritage sites within and adjacent to the Proposal area are shown in Figure 111.

Table 64 'Registered' and 'Other Heritage' Aboriginal sites in the vicinity of the Proposal area

Site Name	Heritage Status^	Location (refer to Figure 111)	Reason for Significance
Lake Richmond	Registered Aboriginal Site (Site ID 15974)	Adjacent to the Proposal area	Ceremonial and spiritual site (camping by Traditional Aboriginal family groups).
Rotary Park	Registered Aboriginal Site (Site ID 3471)	Within and outside Proposal area	Mythological site
Indian Ocean	Registered Aboriginal Site (Site ID 3776)	Outside Proposal area	Mythological site
Lake Richmond	Other Heritage Site (Site ID 352): Stored Data*	Outside Proposal area	Man-Made Structure, Fish Trap
Fisherman's Head	Other Heritage Site (Site ID 20293): Lodged#	Outside Proposal area	Artefacts / Scatter site
Point John	Other Heritage Site (Site ID 20294): Lodged#	Outside Proposal area	Artefacts / Scatter site
Mooribirdup Ceremonial Grounds	Other Heritage Site (Site ID 22888): Information Assessed†	Inside Proposal area	Ceremonial site
Mooribirdup Burial Site	Other Heritage Site (Site ID 22889): Lodged#	Outside Proposal area	Burial site
Mooribirdup Hunting and Fishing Areas	Other Heritage Site (Site ID 22890): Lodged#	Outside Proposal area	Camping and hunting grounds

^ Heritage Status: assessment status on the DIA Aboriginal Sites Database.

* Stored Data: Sites deemed by the ACMC not to fulfil any of the criteria under section 5 of the AH Act are entered in the Stored data index. This is also the case for those places which the ACMC finds do not have any Aboriginal association.

Lodged: Lodged data comprises information reported to the Registrar of Aboriginal Sites about places and objects which have not yet been assessed under section 5 of the AH Act. The provisions of the AH Act apply to these places until they are assessed as places to which the AH Act does not apply

† Information Assessed: information provided to the ACMC has been assessed and the final assessment and decision is pending.

Aboriginal heritage studies and assessments

Two Aboriginal heritage assessments were undertaken for the Proposal area, considering that the Proposal will impact upon the Aboriginal heritage value of Cockburn Sound and its surrounds:

- McDonald Hale & Associates (1997)
- Brad Goode & Associates (2011).

These assessments identified that nine sites of Aboriginal cultural significance, as registered by the DIA, lie within or in the vicinity of the Proposal area. Collectively, these sites were found to have mythological, ceremonial and artefact significance.

During consultation for this assessment, the Aboriginal spokespeople indicated that although there were mythological associations with the area, the area was not a sacred site and the Dreaming associated with this area is *mootch* – dead or finished (McDonald Hale & Associates 1997).

In September 2010 Brad Goode & Associates were engaged to complete an updated Aboriginal survey for the Proposal. As a result of archival research it had been determined that one registered Aboriginal heritage site (Rotary Park 3471) and one other heritage place (Mooribirdup Ceremonial Ground 22888) are within the Proposal Area. After consultation with 22 Nyungah representatives, no new sites of ethnographic significance (as defined by section 5 of the Aboriginal Heritage Act (1972)) were identified within the Proposal area. There was one historic site (Sister Kate's former orphanage holiday camp) adjacent to the Proposal area. The report recommended the site be registered with DIA under section 5a and 5c of the AHC Act.

Subsequent to the studies conducted for the Proposal, several Aboriginal heritage areas have been identified through past and ongoing stakeholder consultation (Table 65).

Rotary Park – Site ID 3471

The Rotary Park site has been classified as a 'Registered' site, due to its mythological significance and links to the Nyungar creation narrative about the spiritual landscape in the area. There are two versions of mythology attached to the site, as provided by informants during Aboriginal heritage assessments of the area. One story indicates that the Rotary Park site forms part of a mythological songline about the Waugal, a creation spirit in Aboriginal mythology. Other informants have indicated that the mythology of the site is the story of a crocodile moving across the sea and landscape, losing body parts in a battle with a shark. The lost body parts are believed to have formed the landscape, with lakes at Rotary Park being formed when the crocodile rested following the battle.

Mooribirdup Ceremonial Grounds – Site ID 22888

This site has been reported as a ceremonial ground, with informants indicating songs of 'Thanking' were sung at the location. In addition the site has been described as a repository of cultural resources, being rich in bush foods and medicines. The site is currently listed as an 'Other Heritage' site, with information provided regarding the site being assessed and considered by the DIA. The reported values for the site cannot be historically verified and are inconsistent with views of the majority of the Nyungah community consulted, and the site itself is inaccurately defined, spatially (Brad Goode & Associates 2011).

Sister Kate's Children's Home

Informants consulted during the assessment for the Proposal indicated that the site of the Sister Kate's Children's Home was a former traditional camping area, containing spring fed water sources, including a well which is still *in situ.* The home also holds significance in terms of Western Australian history, as a location where a number of children from the 'stolen generation' were taken for summer holidays and where family members could camp nearby to visit their children. The site of Sister Kate's is recommended to be designated as a 'Registered' site under section 5a and 5 c of the AH Act (Brad Goode& Associates 2011).

Some of the anecdotal evidence for this site may have arisen from confusion between the presence of an earlier establishment, the Sisters of Notre Dame des Missions convent school, which was located at the site of a former turtle factory, now occupied by the Cruising Yacht Club of WA (Section 15.2.2). Evidence indicates that Sister Kate's is likely to have established around 1962, with an official lease signed in 1972.

Although located outside of the Proposal area, the Proponent has been asked to investigate whether the site can be leased to the Nyungah community for cultural and educational purposes.

Table 65 Aboriginal consultation schedule

Date	Key Stakeholders	Description
1989	N/A (name of informants withheld from report).	McDonald, Hales & Associates (1989a and 1989b) conducted the original Aboriginal Heritage survey of the Proposal area on behalf of the Department of Marine and Harbours. The site was surveyed for archaeological sites and an ethnographic survey was undertaken. The 'Indian Ocean' (Site ID 3776) mythological site covering the sea, coastline and other features was recorded.
1997	N/A (name of informants withheld from report).	McDonald, Hales & Associates (1997) conducted an Aboriginal heritage assessment of concept plans for an inshore marina on behalf of LandCorp. The ethnographic research involved representatives of two key groups associated with the survey area. The report suggested that 'Rotary Park' and the 'Indian Ocean' site (Site ID 3776) should ideally be listed as a single site. The assessment also recorded Lake Richmond (Site ID 15974). Both 'Rotary Park' and 'Lake Richmond' are on the permanent register. Consultations indicated the key informants did not oppose the proposed development subject to the Proponent funding commemorative and interpretative items including plaques and information displays.
May 2005	• Mr. Ken Colbung (Bibbulmun Tribal Group) • Mr. Joe Walley (the Walley family) • Mr. Cedric Jacobs (the Jacobs family) • Mr. Fred Collard (the Collard family) • Mr. Pat Hume (Independent Environmental Nyungahs) • Mr. Corrie Bodney (Ballaruk Aboriginal Corporation) • Mr. Trevor Walley (Naramya Aboriginal Corporation) • Mr. Joe Northover (Gnaala Karla Booja Native Title Claimant Group) • South West Aboriginal Land and Sea Council (SWALSC).	Key stakeholders were advised of the proposed development and further comments regarding Aboriginal heritage matters in addition to that provided in the 1997 assessment were sought by the Proponent.
July 2005	• Mr. Ken Colbung • Mr. Joe Walley • Mr. Trevor Walley • Mr. Cedric Jacobs.	The project team met with representatives of the Naramya Aboriginal Corporation and Indigenous Business Australia. Mr. Walley outlined Aboriginal associations with the area and proposed a number of considerations for the concept plan, such as: • A ceremonial ground behind the RSL hall; • A meeting ground at Sister Kates (the former leasehold site facing Shoalwater Bay), that were subsequently included in the concept plan.

Date	Key Stakeholders	Description
2011	Gnaala Karla Booja WC 98/58 Native Title Claim representatives as nominated by SWALSC • Mr. Harry Nannup Snr • Mr. Kieran Ugle Snr • Mr. Clarence Walley • Ms Catherine Coomer • Mr. Jack Walley • Mr. Franklin Nannup Jnr • Mrs. Janet Hayden • Ms Charne Hayden • Mrs. Lorna Little • Mrs. Louise Hansen Named DIA site informants Mooribirdup Ceremonial Grounds (Site ID 22888) • Mr. Fred Pickett • Mr. Lindsay Pickett • Mr. Russell Nellie • Mr. Trevor Walley Named DIA site informants for Rotary Park(Site ID 3471) and Lake Richmond (Site 15974) • Ms Rebecca Hume • Ms Esandra Colbung • Mr. Patrick Hume • Mr. Joe Northover • Mr. Greg Winmar • Ms Dorothy Winmar Other informants • Mr. Phillip Prosser • Mr. Troy Hume • Ms Gladis Yarran	Brad Goode & Associates Pty Ltd (Consulting Anthropologists) has undertaken five group ethnographic consultations to provide further advice on Aboriginal heritage items that relate to the development proposal. The project team provided a detailed briefing to the working party of the Gnaala Karla Booja WC 98/58 Native Title Claim group at SWALSC and had further discussions with Mr. Trevor Walley of the Naramya Aboriginal Corporation. The consultations established a survey process and identified appropriate DIA informants and native title claimants to speak for the area. Archival research determined that the Mooribirdup Ceremonial Grounds (Site ID 22888) are located within the Proposal area. This site had not been reported to the DIA at the time of Aboriginal Heritage Assessment in the 1990's (McDonald Hale & Associates 1997). As the status of the site has not been determined, consultations were undertaken to ascertain if there is material evidence of the site's ritual use. Ministerial consent to undertake works will be made with an application pursuant to section 18 of the AH Act to use land that may contain Aboriginal heritage sites. The majority of Nyungah community members consulted, supported the section 18 application on the basis of conditions.

15.2.2 European heritage

The first European exploration of the Rockingham area occurred in the early 1800's by French explorer Commodore Nicolas Baudin. Baudin named several features along the coast including Cape Peron (CoR 2008). Farmers first settled the eastern parts of Rockingham in the 1830's and a port was established to the east of Mangles Bay for the shipment of timber in the 1870's. However, the port ceased to exist in the early 1900's due to the appeal of Bunbury port (CoR 2008).

HMAS Stirling Naval Base was commissioned on Garden Island in 1978 (Royal Australian Navy 2000) and gun emplacements built on Cape Peron in 1942. The Cape Peron Battery Complex is currently listed on the Register of the National Estate (Place ID No. 18515, DSEWPaC 2011c) and the Rockingham Municipal Heritage Inventory (CoR 2008). The Battery Complex is located at the end of Point Peron Road outside the Proposal area (Figure 111).

Other buildings within the Cape Peron area that are listed by the Rockingham Municipal Heritage Inventory (CoR 2008) for their heritage significance include:

- the Point Peron Recreation Camp buildings. The recreational camp site is located outside the Proposal area to the west of the Garden Island Causeway and is the last property on Point Peron Road (Figure 111). These buildings were constructed in 1942 for use as military barracks and are currently leased to the Department of Education and Training for education purposes
- the 'Turtle Factory' building. It was constructed in 1923 initially to farm turtles for food production. This venture was unsuccessful and the building was later used to operate a boarding facility and then used by the Sisters of Notre Dame des Missions as a convent school (CoR 2008). The building is located within the Proposal area on the Mangles Bay foreshore and is now used by the Cruising Yacht Club (Figure 111).

Source:
Imagery supplied by Landgate
Aboriginal Heritage Data supplied by DIA
European Heritage supplied by City of Rockingham
Coordinate System: MGA94 Zone 50

Date: 8/2/2012
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F014.dgn

Aboriginal and European heritage sites within and surrounding the Proposal area

Figure No:
111

15.3 Evaluation of options or alternatives to avoid or minimise impact

Consideration will be given to relocating the 'Turtle Factory' building rather than demolishing it, however, this may not be plausible given the building is constructed of asbestos material. The Proponent will consult with the relevant government heritage agencies, community groups and the City of Rockingham to determine the best outcome for this building.

The area at the corner of Memorial Drive and Safety Bay Road will remain uncleared as part of the development to avoid any disturbance of the Lake Richmond Heritage site where it overlaps the Proposal area boundary.

15.4 Assessment of likely direct and indirect impacts

The primary aspects of the proposal that may potentially affect the Aboriginal and European heritage values of the Proposal area are:

- physical disturbance of the land surface during clearing and construction including removal of topsoil and overburden, and landform modification has the potential to disturb heritage sites and affect ethnographic values
- presence of construction and operational personnel has the potential to disturb heritage sites, disrupt cultural association meetings and gatherings, and affect ethnographic values.

15.4.1 Disturbance to Aboriginal heritage sites

The Rotary Park site (Figure 111), does encompass features including the sea, seabed and onshore manifestations. The construction of sea and land based infrastructure for the proposed development will affect all of these features through:

- dredging activities
- sea based infrastructure (e.g. breakwaters)
- land based infrastructure
- creation of artificial inland canals.

The site 'Mooribirdup Ceremonial Grounds' (Figure 111) is currently defined by informants as existing within the Proposal area but a recent survey by Brad Goode & Associates (2011) did not identify this site as occurring at this location. As the site was unable to be verified during the 2011 investigations, and the majority of the consulted Nyungar informants did not support the existence of such a site, it is recommended that the site be placed into the DIA stored data system (Brad Goode & Associates 2011). Although this site lies wholly within the Proposal area, there is no strong opposition to the Proponent applying for a section 18 approval to disturb this site.

Disturbance of Rotary Park and Mooribirdup Ceremonial Grounds for the Proposal is unavoidable. The sites were discussed in consultation with the site informants and the Native Title Claimants for the area in April 2011 (Brad Goode & Associates 2011) (Table 65). Of the five Nyungar representative groups consulted in April, three indicated that provided appropriate conditions were set, they would not be opposed to the Proponent applying for section 18 approval to disturb the sites present within the Proposal area. The recommended conditions and actions discussed during this consultation are outlined in Section 15.5.1.

Two groups consulted to date have indicated that the Proposal will not be supported due to the potential disturbance of the spiritual values of the area, including the breakage of the 'Waugal songline' and the mingling of salt-water and fresh-water spirits (Brad Goode & Associates 2011). The Proponent will continue discussions with these groups to ensure that their concerns are considered and that appropriate mitigation and management measures can be developed prior.

15.4.2 Disturbance to European heritage sites

The Battery Complex is located outside of the Proposal area and will not be affected by the proposed development and mitigation measures are likely to enhance values associated with this site.

Both the Turtle Factory and Point Peron Recreation Camp buildings are listed under Management Category 'D' of the Rockingham Municipal Heritage Inventory (CoR 2008) which is defined as '*significant, but not essential to an understanding of the history of the district'* (CoR 2008). The Point Peron Recreation Camp buildings will not be disturbed by the Proposal but the Turtle Factory will require removal as part of the development.

15.5 Management measures and performance standards

15.5.1 Aboriginal heritage

Section 17 of the AH Act makes it an offence to excavate, destroy or damage conceal or otherwise alter an Aboriginal site unless authorized to do so by the Registrar of Sites under section 16, or the Minister for Indigenous Affairs under section 18. Where a Proponent may impact on any Aboriginal site, they must seek the consent of the Minister for Indigenous Affairs under section 18 of the AH Act.

Once the section 18 application is lodged with the DIA, it is considered by the ACMC. The ACMC is an appointed body that provides advice to the Minister for Indigenous Affairs on and matters related to objects and purposes of the AH Act. The ACMC will consider the extent and adequacy of consultation with affected Aboriginal people, endeavouring to ensure that all Aboriginal people with an interest or who assert an interest in the land in question have been notified of the proposed use and have had an opportunity to comment on it. The ACMC relies on its own research and evidence presented in heritage reports accompanying the section 18 application to establish that adequate consultation has occurred.

Upon receipt of the recommendation from the ACMC, the Minister may grant or decline consent, or may grant subject to conditions. In considering whether to give consent, the Minister is required to take into account the interests of the general community.

The Proponent will continue consultation and discussions with heritage site informants and the Native Title Claimants for the area throughout the planning, development and implementation stages of the Proposal. Consultation will also occur prior to the application for a section 18 consent notice under the AH Act to commence ground disturbing work in the proximity of the heritage sites.

In consultation conducted to-date as part of the heritage assessments of the Proposal area, Aboriginal representatives have outlined a number of recommendations with regard to the heritage sites located within and adjacent to the Proposal area. The aim of these recommendations is to preserve the heritage values of the area and ensure that Cape Peron can continue to be used by Aboriginal persons as a meeting and learning place for the continued teaching of their customs and to serve as an Aboriginal heritage educational site for the wider community. These recommendations are summarised in Figure 85, and will likely form the conditions for the section 18 approval to disturb.

Table 66 Recommendations for conditions to manage the Aboriginal heritage values of the Proposal area

Recommendation	Aboriginal / Nyungar Representative/s
Interpretation and presentation of the cultural and historical values held for the area by means of public art displays and signage. This will require close consultation with the Nyungar community to determine the form and content of this interpretation, to ensure that no sensitive cultural material is revealed inappropriately.	• Principal Informants for Site ID 2288 'Mooribirdup Ceremonial Grounds' • SWALSC Female Nominees • Hume and colbung groups • SWALSC Nominees
The Nyungar community is given the opportunity to conduct appropriate proprietary rituals prior to ground disturbance associated with the sites mentioned above, in order to mitigate any associated spiritual consequences associated with these areas.	• Principal Informants for Site ID 2288 'Mooribirdup Ceremonial Grounds'
Rehabilitation is conducted nearby, utilising any indigenous seeds and plants are salvaged from the Proposal area prior to works commencing and utilised in rehabilitation.	• Principal Informants for Site ID 2288 'Mooribirdup Ceremonial Grounds'
Employment opportunities for Nyungar people are provided where possible throughout the construction phase of the Proposal.	• SWALSC Female Nominees • SWALSC Nominees
The Proponent to investigate the option for the former Sister Kate's Children's Home site to be leased to the Nyungar community. The site should also be registered with the DIA under the AH Act.	• Principal Informants for Site ID 2288 'Mooribirdup Ceremonial Grounds' • SWALSC Female Nominees • Hume and Colbung groups • SWALSC Nominees
All clearing of land to be monitored by a qualified archaeologist and two Nyungah community members.	• To be determined

Where required these conditions and related management actions will be implemented through the CEMP (Appendix 1). In addition to conditions set by the section 18 approval and management actions in the CEMP, all clearing and initial disturbance activities will be monitored by a qualified archaeologist and two Nyungar community members.

15.5.2 European Heritage

The Turtle Factory will require removal as part of the proposed development. As this site is of cultural significance, consideration will be given to relocating the building, however, this may not be feasible given the building is constructed of asbestos material. The project developers will consult with the relevant government heritage agencies, community groups and the City of Rockingham to determine the best outcome for this building.

15.6 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

The Proposal will potentially affect some of the cultural heritage values associated with the Cape Peron area, including the two Aboriginal heritage sites (Rotary Park and Mooribirdup Ceremonial Grounds) and a European heritage site (the Turtle Factory). Approval will be sought to disturb the Aboriginal heritage sites under section 18 of the AH Act. The proposed development may also reduce the opportunity for local Aboriginal people to meet for cultural and learning purposes on the Mangles Bay foreshore, as is done presently.

In consultation with the local Aboriginal community, an appropriate 'interpretative site' will be established to recognise the Aboriginal heritage values of the area whilst providing a meeting place for the local Aboriginal community as a meeting place. There are also other opportunities to recognise the Aboriginal connections with Cape Peron within the development (e.g. public art, information). The project developers will also consult with the relevant Government heritage agencies, community groups and the City of Rockingham to determine the best outcome for the Turtle Factory building.

16. Recreation and public access impact assessment

16.1 Relevant environmental objectives, policies, guidelines, standards and procedures

16.1.1 EPA objectives

The EPA applied the following objective in assessing proposals that may affect recreation values and public access:

To ensure that existing and planned recreational uses are not compromised.

16.1.2 Legislation, policy and guidance

Perth's Coastal Waters

The EPA Perth's Coastal Waters position paper (EPA 2000b) outlines the EPA's position on protecting the recreation and aesthetics of the environment which include the sporting and leisure activities with either frequent or infrequent body contact with the water. Six EQOs or management goals were developed to protect the identified environmental values. Relevant to recreation, aesthetics and public use are four EQOs, being:

- maintenance of primary contact recreation values (water safe for swimming)
- maintenance of secondary contact recreation values (waters safe for boating)
- maintenance of aesthetic values (pleasant, attractive environment)
- maintenance of industrial water supply values (water suitable for industry use).

Draft Perth Coastal Planning Strategy

The Draft Perth Coastal Planning Strategy (DPI and WAPC 2008) aims to guide future sustainable planning for conservation, recreation, infrastructure and development of Perth's coast (DPI and WAPC 2008). The objective of the strategy is to outline coastal management along the coast to guide the location, size, scale and density of developments along the coastal strip of the Perth Metropolitan area over the next 10 to 15 years.

The Strategy identifies precincts along the coast and desirable use outcomes for each precinct. Different precincts have different objectives in terms of meeting social needs, including recreation.

The Proposal is located in the Rockingham Activity Centre Precinct (Precinct 43) and the Point Peron Precinct (44) (DPI and WAPC 2008). The Rockingham Activity Centre Precinct is recognised as an area adjacent to the Rockingham town centre with the potential for tourist and recreational uses.

The draft Perth Coastal Planning Strategy will be considered in this PER to addressing the recreational and public access opportunities and challenges identified by the community. However, the planning considerations associated with each of the precinct considerations and recommendations for precinct character will be addressed through the rezoning and LSP preparation process.

Rockingham Lakes Regional Park Management Plan

The RLRP Management Plan (DEC 2010a) provides the guiding principles for the management and conservation of the environmental, cultural heritage, recreation values of the RLRP. The plan is used to inform the assessment of development proposals on lands within and adjoining RLRP to ensure that proposed land use is compatible and to limit impacts upon the nature conservation and social values of the RLRP.

Specifically, the RLRP management plan provides guiding principles for managing recreation values within the regional park addressing:

- visitor use
- recreation sites and facilities
- park access and circulation
- visitor safety.

The RLRP Management Plan recognises the Proposal areas as subject to detailed planning (DEC 2010a). The plan identifies that should the Proposal proceed, land associated with the Proposal area would be excised from the Regional Park.

The RLRP Management Plan intends that the current uses and facilities of this area will be maintained pending the outcomes of this Proposal. The Proposal will address the potential impacts of the Proposal on the recreational values of the Regional Park and mitigation and offset measures will seek to maintain the current level of use and facility. Planning for the recreational aspects of the Proposal will consider the recreational guiding principles of the RLRP Management Plan, to provide consistency with and improving the access (including bicycle and pedestrian access), parking and boat launching facilities within the adjacent Regional Park.

City of Rockingham Strategic Plan – 2006 – 2011

The City of Rockingham has developed a 20 year strategic plan, which aims to have a forward looking approach to development and planning. The Strategic Plan (CoR 2007) outlines a number of development goals relating to land use and the environment, including:

4. Responsive planning that reflects community needs and achieves:
    - sustainable economic, social and cultural development
    - protecting the natural environment
    - a choice of living environments and lifestyles
    - attractive, liveable neighbourhoods
    - improved appearance of the built environment
    - sustainable use of land
    - improved community safety and crime prevention
    - community interaction and vibrancy which reflects cultural identity.
5. Environmental planning and management which achieves:
    - community awareness and involvement in preservation of the natural environment
    - opportunities for eco tourism
    - sustainable waste management
    - protection of our bio-diversity, including coastal reserves
    - reduced greenhouse gas emissions
    - sustainable energy efficiencies
    - risk management.

6. An integrated transport system which:
   - addresses economic, environmental, social and cultural development priorities
   - provides equitable access to community facilities and services
   - enables the Strategic Regional Centre to reach its potential.
7. Infrastructure appropriate to community needs including: encouraging developers to integrate community development and infrastructure into the planning of residential estates.

16.2 Findings of surveys and investigations

16.2.1 Mangles Bay foreshore

The Mangles Bay foreshore comprises sandy beaches backed by low sand dunes. A large proportion of this foreshore is presently occupied by the local yacht club, fishing club (with associated jetty and boat ramp) and chalet accommodation. The use of the land by these facilities currently restricts public access to these foreshore areas, although access along the beach is unimpeded.

Offshore, from the Proposal area to the Causeway, the waters are extremely shallow and have dense seagrass meadows that grow to the intertidal mark. The beach is thus not a popular swimming area, and beach-based recreation is more focussed on walking, and the launching of boats.

The recreational use of the beach within the Proposal area includes walking (most of the Mangles Bay foreshore is a designated dog beach), yachting and fishing. Mangles Bay waters to the east of the Causeway are popular for boat fishing and crabbing, with waters to the west of the Causeway utilised less often. An area directly to the east of the Garden Island Causeway is also designated a power water craft and water ski area.

The Cape Peron area to the west of the Causeway (which is outside the development footprint of the Proposal) has day-use car parks for accessing beaches and lookouts, and a public boat ramp directly to the west of the Garden Island Causeway. This area is the focus for many recreational activities, including:

- water-based activities: boating, swimming, snorkelling, fishing and crabbing
- land-based activities: walking, fishing and nature appreciation.

16.2.2 Beach and marine recreational uses

The water based recreational activities at Cape Peron include:

- boating (including sailing)
- jet ski and water ski activities within the gazetted area (adjacent to the Proposal Area)
- swimming
- fishing.

The Cruising Yacht Club currently utilises the former Turtle Factory building, which will require removal from the Proposal area.

Boating

The Perth Recreational Boating Facilities Study (DPI 2009) examined the recreational boating facility needs of the Perth Metropolitan area to 2025, and was first presented in draft form to the community in May 2007. The study area was defined as being the navigable waters and shores of the Perth Metropolitan area including the near-shore waters of the Indian Ocean from Two Rocks in the north to Singleton in the south, together with the Swan River up to the Whiteman Bridge and the Canning River up to the Kent Street weir (DPI 2009). The study concluded that Perth's recreational boating facilities are

presently under heavy demand pressure. Perth's boat registration statistics in combination with published population projections indicate that recreational boat numbers in Perth will continue to increase from 48 468 in 2007 to a projected 84 857 in 2025 (DPI 2009).

Within the south metropolitan area the Perth Recreational Boating Facility Study identified the Woodman Point recreational boating precinct as a highly important site, and expansion of its facilities was identified as a key short-term initiative (to 2012) to address recreational boating needs. In December 2008, the Woodman Point boating precinct was upgraded with the construction of four new public boat ramps, bringing the total to eight public boat ramps, and making it the largest boat launching facility in Western Australia. In May 2010 an additional 300 car and boat trailer bays were also added. The Mangles Bay marina was identified as a medium-term initiative (to 2018) for consideration to address recreational boating needs (DPI 2009).

Predicted increases in boat ownership for suburbs adjacent to the waters of Cockburn Sound and Warnbro Sound are shown in Table 67. The data are for boats with motors (this includes jet skis, but does not include yachts, canoes or surf skis) and the DPI (2009) medium growth scenario for Perth's population growth and growing level of boat ownership (reflecting the increasing affluence of Perth's population). For example, within the entire Perth Metropolitan area the level of boat ownership per 1,000 people is:

- 29.0 in 2010 and predicted to be 37.1 in 2025 for boats <7.5 m in length ('trailerable' boats)
- 3.2 in 2010 and predicted to be 4.2 in 2025 for boats >7.5 m (boats requiring a pen or moorings).

The data shown in Table 67 are the total for areas defined in DPI (2009) as:

- 'Cockburn', with Cockburn 50% covering the southern portion, which includes Coogee and Henderson (access Woodman Point boat ramp and Challenger Beach boat ramp)
- 'Kwinana'
- 'Rockingham', which extends from Rockingham to Singleton, and which contributes two thirds of the boats in Table 67. Compared to the entire Perth Metropolitan area, the Rockingham area has a level of boat ownership that is much higher for trailerable boats (~45.5/1000 population), but lower for boats requiring a pen or mooring (~2.0 /1000 population).

Boat ownership in suburbs adjacent to Cockburn Sound and Warnbro Sound is predicted to increase by about 18% from 2012 to 2025 (the medium-term), and by about 45% from 2012 to 2025 (the long-term) (Table 67).

Table 67 Predicted levels of recreational boat ownership in the 'Cockburn' (50%), 'Kwinana 'and 'Rockingham' regions, medium growth scenario (source: DPI 2009)

Year	Boats <7.5 m ('trailerable')	Boats >7.5 m (require moorings or pens)	Total boats
2012	8 097	459	8 556
2018	9 491	571	10 062
2025	11 750	717	12 467

Recreational boating use (and fishing) is heaviest during summer (DPI 2009), and to a lesser extent autumn. The yachting season also covers a similar period, and typically runs from October to April inclusive.

There are eight public boat ramps that service trailerable boats (< 7.5 m in length) in the Cockburn Sound/Warnbro Sound region. The Department of Transport (DoT) undertakes routine annual surveys of Perth's public boat ramp use at peak holiday times in December and January, targeting the long weekends around Boxing Day, New Year's Day and Australia Day (DPI 2009). Survey times vary from year to year, but indicate peak numbers at around 10-11 AM, except in 2009/2010 at the two major boat ramps (Cape Peron and Woodman Point) where the peak was in the afternoon. As shown in Figure 112, available data indicates about 240-305 boats are typically launched by peak times in the Warnbro Sound/Shoalwater region (including ~100-175 at the Point Peron boat ramp), and about 330-530 boats are launched in

Cockburn Sound (depending on whether 2009/10 data are considered more representative, or other years). The total launched in the Warnbro Sound/Shoalwater region and Cockburn Sound at peak times was 570–845.

DPI (2009) also notes that the private boat ramps of the Cockburn Power Boat Association record a similar volume of boat launching to the intensely used Woodman Point boat ramp immediately adjacent (i.e. 200-400 boats launched at peak times), taking the overall to 770-1045, which represents at least 10% of the total number of registered boats in this category (Table 67). The Woodman Point boating precinct development involves the addition of more boat ramps to accommodate predicted increases in recreational boat use in the region. The inclusion of the Cockburn Power Boat Association private boat ramps results in a greater level of peak usage than the 5% used by the DPI (2009) for public boat ramps alone. There are no data for other private boat ramps in Cockburn Sound, including the yacht club and fishing club in Mangles Bay.

The extent to which the number of boats launched up to 10-11 AM represents the total number of boats launched each day can be gauged by City of Rockingham data from a traffic counter installed at the Point Peron boat ramp from 02 December 2009 to 31 January 2010. The data indicate the total number of boats each day ranged from 11 (30 December 2009) to 224 (19 December 2009), with an average of 80. These data also indicate that the number of cars with trailers present in the boat ramp car park at 11.00 AM (assuming the majority of boats launched up till then are still present) represents around half to two thirds of all boats launched that day (Figure 113). If these data are viewed as representative of other boat ramps, at peak holiday times around 15-20% of trailerable boats in the region are launched each day, and this drops to <2% in non-peak times in the summer period (Figure 113).

Non-trailerable boats (>7.5 m in length) are not as well serviced as trailerable boats. Regular audits undertaken by the DPI of existing facilities within the Perth Metropolitan area of all available marina pens and swing moorings identified that all were taken up by the end of 2006 (DPI 2009). Boat registration figures indicate that from year end 2006 to year end 2007 there were approximately 450 new large boats registered. By contrast, over the same period there were very few new pens developed in Perth; these craft were either trailerable or were moored outside of Metropolitan Perth or took up moorings being used by small boats that could revert to trailers. This situation highlights the current shortage of pens in Perth (DPI 2009).

Mangles Bay is heavily used as a mooring area. The Rockingham Mangles Bay Mooring Control Area was proclaimed in 2007 and is administered by the Department of Transport pursuant to the Shipping and Pilotage (Mooring Control Areas) Regulations 1983. The Mooring Control Area (MCA) contains two separate Mooring Zones with approximately 600 (legal and illegal) moorings. On 1 October 2010, DoT announced that all existing owners of unauthorised moorings in the MCA had until 1 January 2011 to formally register their moorings in accordance with the Shipping and Pilotage (Mooring Control Areas) Regulations 1983, or risk the mooring being removed without compensation.

In recognition of the environmental impact some types of moorings have on the local seagrass areas, and as a pre-condition of establishing the MCA and permitting moorings to remain in Mangles Bay, it was a key requirement that all registered moorings be of an environmentally acceptable design. As a condition of registration, owners of existing unauthorised moorings that are not considered by DoT to be of an environmentally acceptable design will be required to upgrade their mooring to an approved design within their inaugural 24 month registration period or not have their registration renewed.

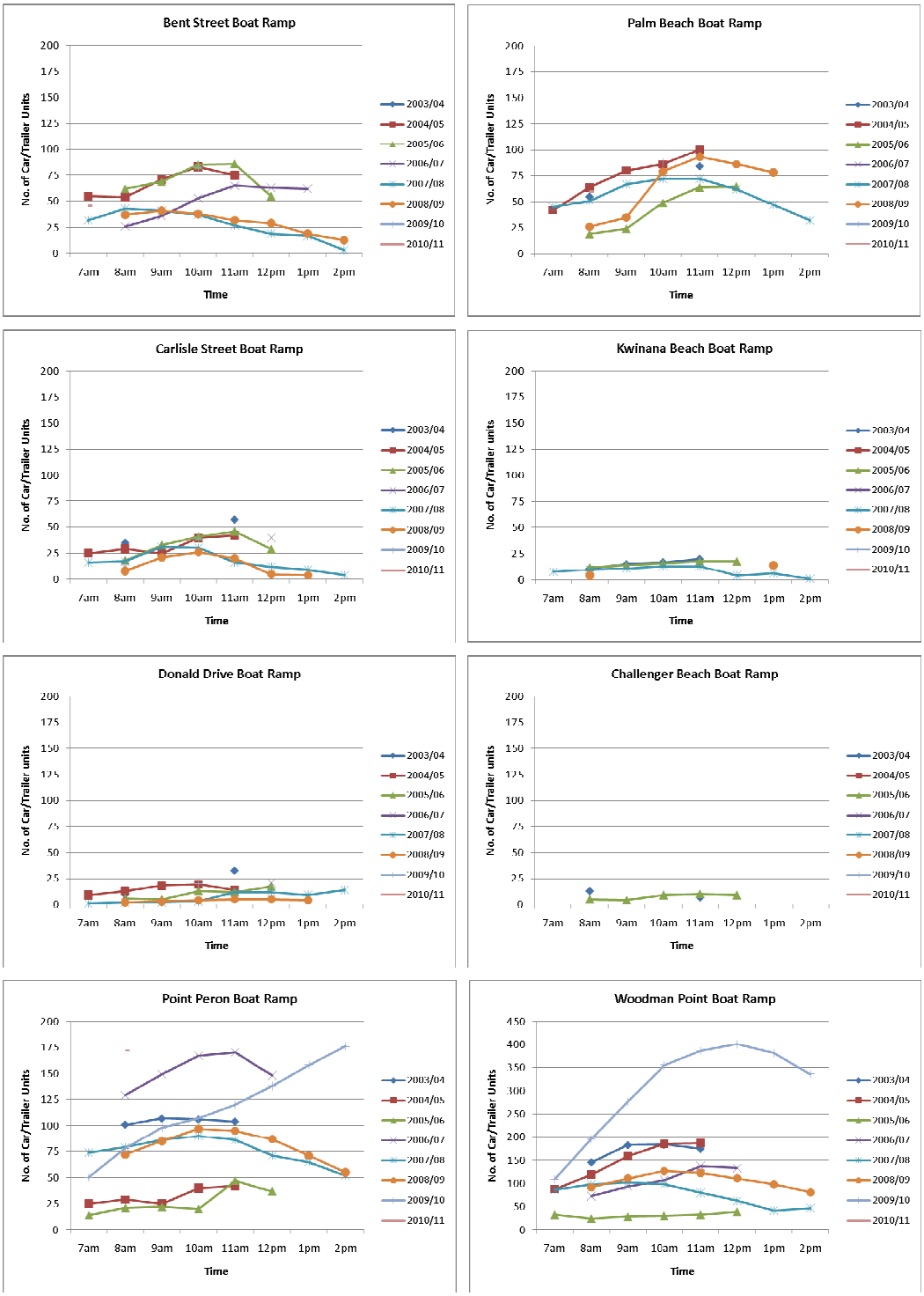


Figure 112 Public boat ramp use in Dec/Jan (source: DoT unpublished data), note scale change at Woodman Point

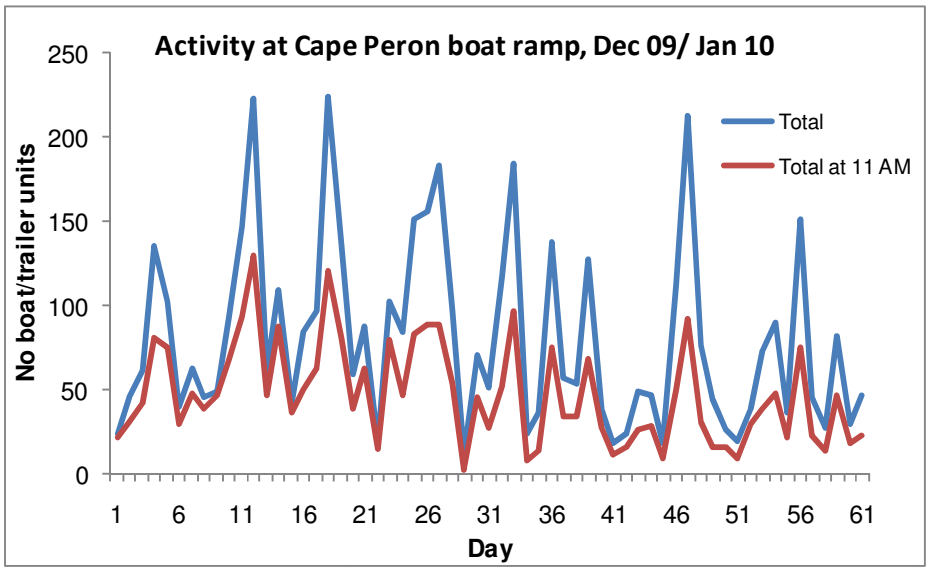


Figure 113 Metered data for public boat ramp use at Cape Peron in Dec 2009/Jan 2010 (DoT unpublished data)

Boating movement within Cockburn Sound and Warnbro Sound can be gauged to a large extent from DoF recreational boating data (see section on Fishing below), as fishing is a major recreational activity (Sumner et al 2008; DPI 2009): for example Sumner et al (2008) found that 82% of 15,999 boat crews interviewed at public boat ramps in the west coast bioregion in 2005/06 had been undertaking some sort of fishing. Recreational fishing data indicate high boat usage in Mangles Bay, Southern Flats, the waters adjacent to Garden Island (east and west) and the waters from Woodman Point to Carnac Island. The waters east of the Causeway (Mangles Bay and Southern Flats) are particularly popular with families/small boats due to their sheltered nature. Recreational boaters undertaking other activities such as diving, sea-lion and dolphin watching and sightseeing are more likely to focus on the more scenic islands and reefs of the SIMP, the western side of Garden Island, and around Carnac Island. Sailing occurs in the deeper waters of southern Cockburn Sound (Figure 114).

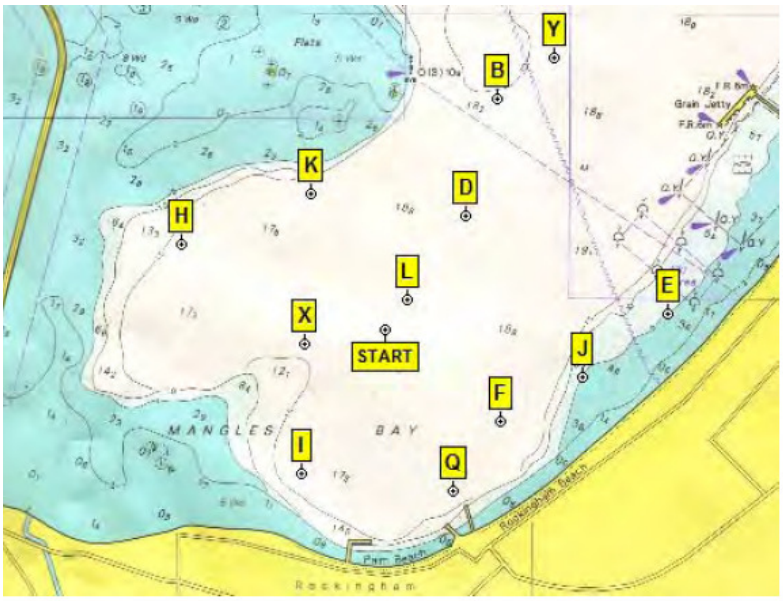


Figure 114 Cruising Yacht Club race course for 2001-2012 (Cruising Yacht Club 2011)

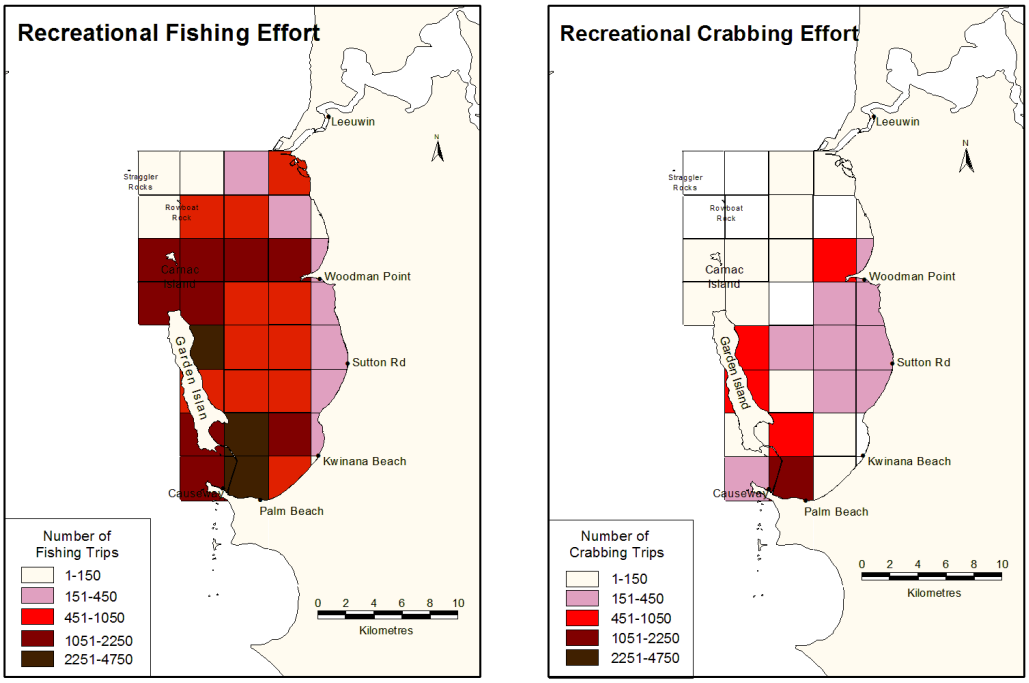
Jet skiing and water skiing

The Mangles Bay foreshore area is currently gazetted water ski area and jet ski area (Figure 116). These areas are currently in use for high speed boating activities associated with jet skiing and water skiing activities. The Mangles Bay water ski areas encompasses all waters of Mangles Bay within a line commencing on the foreshore 100 m west of the prolongation of Weld Street, Rockingham, then to the East of Cardinal Navigation Mark at Southern Flats and then to the northern end of the underpass of the Navy Causeway, excluding Naval Waters and the marked personnel water craft (PWC) area (DoT 2011a). The designated take-off and landing area is situated 100 m south west of the prolongation of Weld Street and extending 400 m south west along the shore (DoT 2011a).

Fishing

Cockburn Sound and the SIMP are very popular for recreational fishing. The main fish species targeted are Australian herring, King George whiting, skipjack trevally, pink snapper tailor and garfish. The most targeted marine invertebrate in Cockburn Sound and the SIMP is the blue swimmer crab. Additional species caught and retained less frequently include whiting, flounder, tarwhine, snook and mullet (L. Battagello MBFC pers. comm.; Sumner *et al*. 2008), octopus and southern calamari squid. A number of fish species are caught and discarded, e.g. western striped grunter, brownspot wrasse and weeping toadfish.

In a relative sense, the level of boat-based fishing effort is about two orders of magnitude higher in Cockburn Sound and on the eastern side of Garden Island (e.g. 10,000–100,000 fisher hours in 2005/06; refer Figure 115) than in the SIMP (100–1,000 fishers hours in 2005/06; refer Figure 115). The most popular recreational fishing areas are Mangles Bay, Southern Flats, the waters adjacent to Garden Island (east and west) and the waters from Woodman Point to Carnac Island (Figure 115). The most popular crabbing areas are Mangles Bay, Southern Flats, the eastern side of Garden Island, and Woodman Point (Figure 115). Fishing and crabbing are particularly popular in Mangles Bay (Figure 115), with fishers operating from boats on moorings, boats at anchor, boats at drift and from the beach both during the week and on weekends (Dybdahl 1979; L. Battagello MBFC pers. comm.).



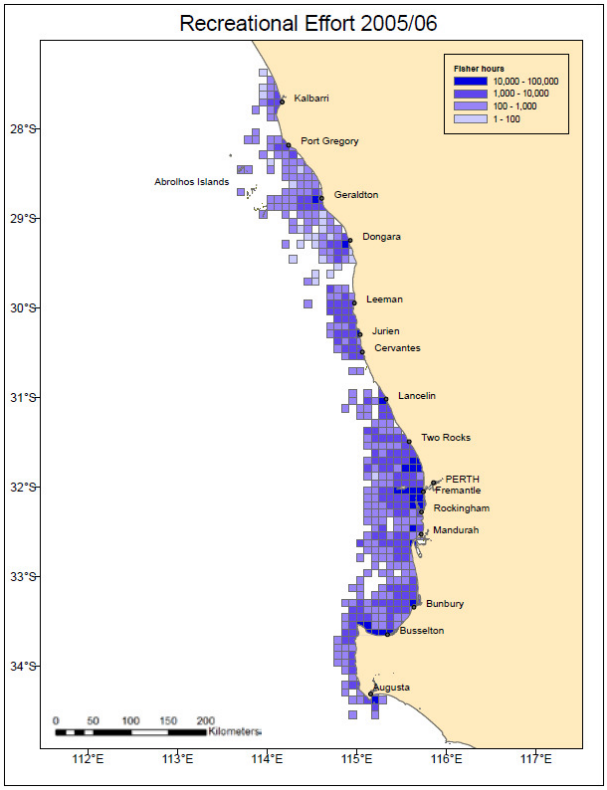


Figure 115 Recreational fishing and crabbing effort in Cockburn Sound and surrounds in 2000/2001 (top) and west coast region for 2005/2005 (bottom)

Swimming

The Mangles Bay area, including Palm Beach, is not a popular swimming beach as it is very shallow and full of seagrass. Swimming is also prohibited within 20 m of the Palm Beach boat ramps (DoT 2011a).

16.2.3 Land based recreation and accommodation

Cape Peron is notable for the breadth of coastal recreation opportunities it offers and for its scenic views. The majority of visitors to Cape Peron are locals, with some visitors from the Perth Metropolitan area and few tourists (DEC 2010a). The Cape's accessibility and high scenic value make it a popular sightseeing destination, while it is also popular for activities including fishing, walking, exercising dogs, diving, swimming, picnicking and windsurfing (DEC 2010a). Public facilities provided at Cape Peron include dual use paths and limestone tracks, lookout points, seating and four car parks (Figure 117). A boat ramp is situated on the north side of the Cape, west of the Garden Island Causeway.

In 2005 a Recreational Survey was conducted across RLRP and it estimated that over 2,000 people/week, or 111 600 people/year, visited Cape Peron and the number of visitors on weekdays versus the weekend days was similar (CALM 2005). This is a large increase in visitor numbers compared to the 2001 recreational survey results where 800 visitors/week to Cape Peron were estimated. The survey identified that the main purpose of visiting Cape Peron was for fishing/surfing/diving (27% or interviewees) followed by walking (16%) and exercising the dog (15%) (CALM 2005).

The DEC has identified three main users of the RLRP (including Cape Peron):

1. Natural Environment use – conservation areas and retained/rehabilitated bushland.
2. Recreational use – facilities designed to enhance use and access of area without detracting from natural or cultural values of the RLRP.
3. Special use – areas managed for purposes other than recreation or conservation (Water Corporation).

The DEC has issued a number of leases for properties within the RLRP (DEC 2010a), including:

- private recreation camps
- Apex Holiday Camp Inc
- Australian Post-Tel Institute (WA) Inc
- L & S Recreation Centre Inc
- Point Peron Aquatic Youth and Family Association
- RSL Rockingham
- Maritime Union of Australia (two leases held)
- Colin Ross Bullock – Blinded Soldiers of St Dunstan's WA.
- DoE's School Camp at Cape Peron
- Rockingham Volunteer Sea Rescue Group
- DoT boat shed
- Naval Association of Australia, Rockingham Subsection
- Naragebup Rockingham Regional Environment Centre Inc
- Rockingham Golf Course
- Lakeside Deli.

As outlined in the RLRP Management Plan, the DEC does not plan on issuing any new leases for recreation camps or private accommodation, once sites are vacated. DEC intends to rehabilitate the vacated areas so as to facilitate public access (DEC 2010a).

Other than the camps listed above, there are no accommodation facilities at Cape Peron. The DEC is investigating options for low-key public accommodation facilities, including chalets and a camping area.

Visitors access Cape Peron through regional roads; however these roads are not currently suited to high volumes/speeds of traffic (Section 19). There is also limited signage to indicate the location of facilities and attractions. In addition, bicycle and pedestrian access is limited, with few pathways and trails within and between the recreational facilities (DEC 2010a). The RLRP Master Plan outlines the proposal to connect Cape Peron and the rest of the RLRP to the Bikewest Perth Bicycle Network, in consultation with Main Roads WA, Bikewest and the City of Rockingham. In addition to this, the Master Plan proposes to establish walk trails through the RLRP.

Due to the isolated bushland areas within the RLRP and at Cape Peron, there are issues with vandalism and anti-social behaviour.

The key components of the RLRP Recreation Master Plan are shown in Figure 117.

Lake Richmond

Lake Richmond is an attractive expanse of water in an urban setting and is used for walking, bird watching and nature observation (DEC 2010a). Public facilities provided at Cape Peron include public dining facilities (picnic tables and barbecue), lookout points and an extensive walk trail. The Naragebup Rockingham Regional Environment Centre, located adjacent to Lake Richmond on Safety Bay Road, plays an important role in providing visitors with educational and scientific information on the RLRP.

The foremost recreation management issue at Lake Richmond is ensuring that visitor use of facilities does not adversely affect the TEC of thrombolites. This is particularly relevant given that the number of nearby residents living in close proximity to the lake will increase as a result of the Proposal and it is expected that use of the lake as a recreation resource will also increase.

Source:
Imagery supplied by Landgate
Recreational Area supplied by DoT (2010)
Coordinate System: MGA94 Zone 50
Date: 2/8/2012

NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn:
CAD Resources

CAD Resources File No:
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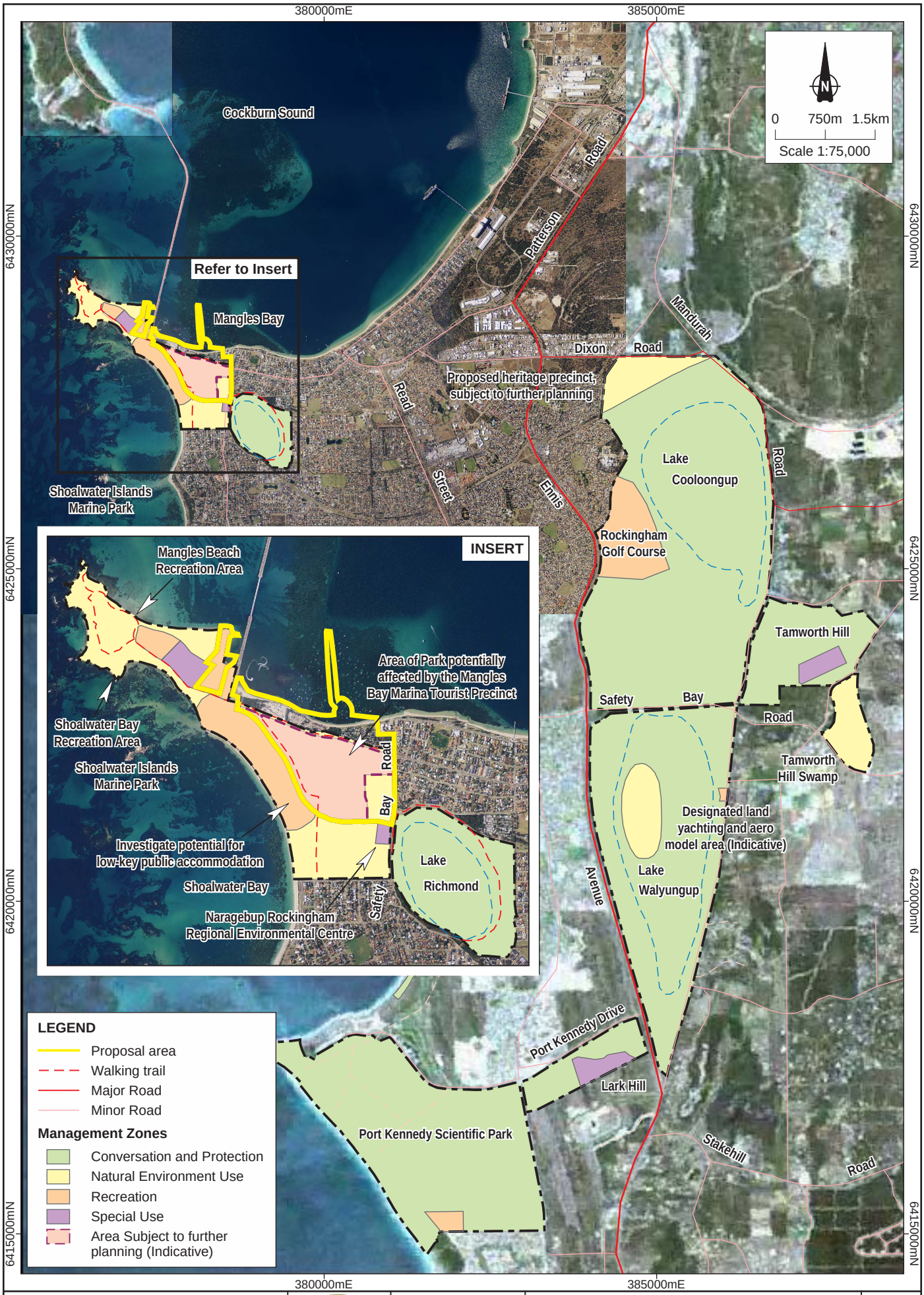
Recreational water restrictions

Figure No:
116



Source:
Aerial Photography supplied by Landgate (2010)
Recreational Management Zones supplied by DEC & CoR
Coordinate System: MGA94 Zone 50
Date: 8/2/2012
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F027.dgn

Rockingham Lakes Regional Park Recreation Master Plan (DEC 2010a)

Figure No: **117**

16.3 Evaluation of options or alternatives to avoid or minimise impact

16.3.1 Short-term impact minimisation options

During construction stages, the Proposal is predicted to have only a minimal impact on the recreational values and public access in the area. Access to the beach will be restricted during the dredging, dewatering and excavation stages of the Proposal due to safety requirements.

16.3.2 Long-term impact minimisation options

The Proposal has considered alternatives in design and layout of the marina and the associated development to avoid and minimise impact the recreational values of the Cape Peron area, whilst also positively contributing to the recreational values in the area. The Proposal will provide:

- a range of public recreation and tourist facilities to enhance Cape Peron as a destination for local and international visitors
- improved public access to Shoalwater Bay and Mangles Bay and pedestrian and cycle linkages between Rockingham Beach to Cape Peron
- a secure marina area specifically designed for commercial and recreational boating and yachting clubs
- increased facilities for management and regulation of boating activity with associated improvements in public safety
- increased management presence, lighting and increased public use of Cape Peron will help discourage anti-social behaviour
- low cost, family holiday accommodation for a wide cross section of the community.

In addition, the Proposal will also provide new recreation facilities and funds for on-going management. The recreation facilities will include lighting, parking, walk trails, a lookout, cycle path and fishing platform.

16.4 Assessment of likely direct and indirect impacts

Aspects or activities of the Proposal that have the potential to affect recreation values and public access, not considering mitigation efforts, include:

- dredge movements may cause temporary disruption to yachting and recreational fishing activities
- construction noise and increased turbidity from dredging may temporarily affect recreational amenity
- increased turbidity from dredging may temporarily affect local fish and crab behaviour and recreational swimming
- direct removal of a small amount of beach due to the construction of the access channel and breakwaters to allow access to the marina
- interruption of pedestrian traffic flow along the beach due to the access channel and breakwaters
- increased traffic and use of both land and water based recreation areas
- interruption of adjacent gazetted water-ski area and power craft area
- construction of marina will reduce public access to the beach.

16.4.1 Interruption of beach and marine based recreation

Beach access and direct removal of beach

Restricted public beach access will result during the construction stages of the Proposal. It is expected that construction will be undertaken within an 18 month period where beach access will be limited.

Areas of the beach will be directly removed from the Mangles Bay area to allow for the construction of breakwaters and the channel entrance to the Proposal's marina. Approximately 0.4 ha of beach will be removed as part of this Proposal, therefore removing potential areas where swimming and other activities currently occur (Table 68).

Table 68 Estimated beach loss areas

Component of Proposal	Area of beach to be removed (m^2)
Dredge channel	370
Breakwater	770
Land Reclamation	2930
Total	4070

There is potential for the Proposal to generate noise and pollution emissions during the construction phase. The mitigation and management of these emissions is discussed in Section 21.

Channel dredging

Dredging the marina access channel will be undertaken progressively over approximately three months during the construction stage of the Proposal. Dredging will be undertaken during the winter period, to minimise the potential impacts of turbidity on both seagrass and marina fauna.

Some impacts to recreational activities in the area may potentially occur, particularly to boating activities and recreational fishing, but these are expected to be minimal due to the short duration of dredging, and its proposed timing in winter (when recreational boating activity and fishing are lowest). Boat users and fishers will still be able to use Mangles Bay whilst dredging is occurring (turbidity is expected to be minimal; refer Section 10), but will need to avoid the dredge.

There will be no impact on yachting, as the dredging will occur outside the sailing season (refer Section 16.2.2). Gazetted power craft and water ski areas (Figure 116) are expected to experience temporary impacts during the dredging phase of the Proposal, but these are also expected to be minimal given the proposed timing of dredging in winter.

There will also be temporary impacts on the amenity of the area due to the noise and turbidity associated with dredging, but these are expected to be minimal and will also be managed (refer Section 10).

Channel final design

Following the completion of construction, the final marina layout will not impact the gazetted PWC area or Mangles Nay water ski area as the channel will extend out approximately 500 m into Mangles Bay Figure 116.

16.4.2 Interruption of land based recreation activities

Pedestrian traffic flow will be interrupted along the beach and current walking tracks within the Proposal area removed from the area. Pedestrian access along the beach shoreline will be interrupted with the introduction of the marina access channel and breakwaters, interfering with the continuous shoreline of Mangles Bay.

The building utilised by the Cruising Yacht Club (former Turtle Factory building) will be removed as part of the Proposal. The yacht club will have premises made available to them within the Proposal area, and have been included in the consultation process (refer to Section 4).

As discussed in Section 19, the Proposal will result in increased traffic during both the construction and operational phases. The upgrade to Memorial Drive will interrupt traffic access to Cape Peron temporarily; however detours will be established and sign-posted. Once completed the upgrade to Memorial Drive will improve the current access to Cape Peron.

The Proposal has made provision for a dual lane road within the service corridor to accommodate increased traffic movements to and from Garden Island.

16.4.3 Increased recreational boating use

Boat ownership in areas adjacent to Cockburn Sound and Warnbro Sound is predicted to increase by about 30% in the next 10 years, and by about 45% in the next 15 years. Recreational use of the marine environment will increase accordingly. The proposed marina development is intended to help manage this increased recreational demand on the region.

Increased boat ownership in the region

The level of boat ownership associated with the marina has been estimated as follows:

- of the marina's 500 pens/berths, half will be for the new club facility, with the remaining pens/berths for public use and marina residents
- there will be 1500-2000 new residents within the development and approximately 10% more for short stay accommodation. Assuming 2000 residents and a level of ownership for trailerable boats that is similar to the Rockingham area (~45.5/1000 population), this equates to 91 trailerable boats (Note: as many residents will have non-trailerable boats, this number may be an overestimate).

DoT predictions are that the number of trailerable boats using the waters of Cockburn Sound and the SIMP will increase by 1506-3911 over the medium-term (2018) to long-term (2025), and about three quarters of this increase will be in the Rockingham region (refer Section 16.2.2 and Table 67). The trailerable boats of marina residents thus represent a minor proportion (approximately 0.8-1.0%) of predicted increases over the medium-term to long-term, and less than 1% of the trailerable boats using the waters of Cockburn Sound and the SIMP. DoT predictions also indicate that the number of non-trailerable boats using the waters of Cockburn Sound and the SIMP will increase by 112-258 vessels over the medium-term (2018) to long-term (2025), and about two thirds of this increase will be in the Rockingham region (refer Section 16.2.2 and Table 67). As the marina provides for 240 additional vessels, it will meet predicted demand and also allow for an increase in boats > 7.5 m in length in excess of those predicted by the DoT in the medium-term, but will be insufficient to meet the demand in the long-term.

The predicted effect of the marina on levels of recreational boat ownership in areas adjacent to Cockburn Sound and the SIMP are shown in Table 69. The marina will allow for 128 more boats than the predicted increases of 1,506 boats the medium-term (2018), due to berths available for boats >7.5 m in length. The marina will not affect predicted boat numbers in the long-term (2025), because the current facilities are insufficient to meet predicted demand. The estimated 91 trailerable boats of marina residents and 500 berthed boats will represent about 5.8% of registered boats in suburbs adjacent to Cockburn Sound and the SIMP in the medium-term (2018), and about 4.7% of boats in the long-term (2025).

Table 69 Predicted levels of recreational boat ownership in the 'Cockburn' (50%), 'Kwinana 'and 'Rockingham' regions, medium growth scenario (source: DPI 2009), with and without the Mangles Bay Marina

Year	Boats <7.5 m ('trailerable')		Boats >7.5 m (require moorings or pens)		Total	
	Without marina	With marina	Without marina	With marina	Without marina	With marina
2012	8,097	No change	459	No change	8,556	No change
2018	9,491	No change	571	699	10,062	10,190
2025	11,750	No change	717	No change	12,467	No change

The cumulative increase in recreational boating pressure in the region due to both the proposed Mangles Bay marina and the approved Port Rockingham Marina is shown in Table 70. The predictions assume that all 500 pens in the Port Rockingham Marina will be boats > 7.5 m in length. Both marinas will potentially result in about a two -fold increase increases in boats > 7.5 m in length in the medium-term to long-term, but minor increases in total boat numbers as these remain largely driven by increases in trailerable boats due to regional population increases.

Table 70 Predicted levels of recreational boat ownership in the 'Cockburn' (50%), 'Kwinana 'and 'Rockingham' regions, medium growth scenario (source: DPI 2007), with and without the Mangles Bay marina and Port Rockingham marina

Year	Boats <7.5 m ('trailerable')		Boats >7.5 m (require moorings or pens)		Total	
	Without marina	With marina	Without marina	With marina	Without marina	With marina
2012	8,097	No change	459	No change	8,556	No change
2018	9,491	No change	571	1199	10,062	10,690
2025	11,750	No change	717	1199	12,467	12,949

Increased recreational boating pressure in Cockburn Sound and the Shoalwater islands Marine Park

The DoT's data for trailerable boat usage indicate approx. 20% of registered boats are launched each day during peak holiday times in summer (refer Section 16.2.2). If the assumption is made that this level of usage also occurs for boats > 7.5 m in length, the DoT's predicted increases in boat ownership indicate that – without the marina - recreational boat traffic (trailerable and non-trailerable boats) on the waters of Cockburn Sound and Warnbro Sound during peak holiday times will increase from about 1,711 boats/day (in 2012) to 2 012–2 590 boats/day in the medium-term (2018) to long-term (2025). Without the marina, the boat traffic due to non-trailerable vessels will increase from 92 boats/day to 114–143 boats/day during peak times in summer.

The marina will not result in any further increases in trailerable boats other than those due to the regional population growth predicted by the DoT, but will potentially result in an additional 128 non-trailerable boats in the medium-term (by 2018) (see above). In the medium-term (by 2018), the marina will thus increase recreational boat traffic – over and above that due to the regional population growth - by approximately 26 boats/day during peak times in summer, all due to large vessels. This would represent about 1% of total recreational boat traffic in Cockburn Sound and Warnbro Sound, but 19% of traffic due to non-trailerable vessels in the medium-term. The marina will have no effect on regional levels of boat traffic in the long-term (2025).

Should both the Mangles Bay marina and the proposed Port Rockingham Marina proceed, the combined increase in recreational boat traffic in the medium-term to long-term would be approximately 96–126 boats/day during peak times in summer, all due to large vessels. This would represent about 4-5% of total recreational boat traffic in Cockburn Sound and Warnbro Sound, but around half of traffic due to non-trailerable vessels.

Increased recreational boating pressure in the shallow waters of Mangles Bay

At present, recreational boating pressure within the shallow waters of Mangles Bay is largely due to the boats associated with the 650 registered moorings in the Bay (fishing occurs from moored boats, refer Section 16.2.2), boats launched from the private boat ramps of the yacht club and the fishing club in Mangles Bay, and boats launched at Cape Peron public boat ramp and Palm Beach public boat ramp (the two public boat ramps closest to Mangles Bay) (Figure 112).

The marina is likely to cause a small increase in recreational boat pressure within the shallow waters of Mangles Bay due to the ownership of trailerable boats by marina residents. The non-trailerable boats in the marina are not expected to add to recreational boating pressure in the shallow waters of Mangles Bay (other than along the access channel) as mooring congestion to the east of the access channel will discourage movements, and their keel clearance will prohibit movement into waters west of the access channel. The non-trailerable boats in the marina are expected to head out the marina access channel to Southern Flats, to the SIMP via the northern Causeway entrance, or to eastern side of Garden Island. Non-trailerable boats will thus contribute to recreational boating pressure within the broader region of Cockburn Sound and the SIMP (see above), rather than the shallow waters of Mangles Bay.

The above information is summarised in Table 71, and indicates that although the marina will cause a small increase in recreational boating pressure within the shallow waters of Mangles Bay, it will not constitute the major source of recreational pressure.

Table 71 Potential sources of recreational boat pressure within the shallow waters of Mangles Bay at present, and in the medium-term (2018) to long-term (2025)

Source of recreational boating pressure	Potential boat numbers during peak times, at present	Potential boat numbers at peak times with marina in the medium-term to long-term
Registered moorings in Mangles Bay	600 moorings, a large proportion with boats.	600 moorings, a large proportion with boats. Level of usage continues.
Cruising Yacht Club ramp	unknown	Level of usage continues – club members use marina boat ramp
Mangles Bay Fishing Club ramp	unknown	Level of usage continues – club members use marina boat ramp
Cape Peron public boat ramp	100-175 boats launched at peak times. Proportion entering Mangles Bay unknown, but area popular for trailerable boats.	118–254 boats[1] launched at peak times. Proportion entering Mangles Bay unknown, but area popular for trailerable boats.
Palm Beach public boat ramp	100 boats launched at peak times. Proportion entering Mangles Bay unknown, but area popular for trailerable boats.	118–145 boats[1] launched at peak times. Proportion entering Mangles Bay unknown, but area popular for trailerable boats.
Mangles Bay marina – resident's trailerable boats	Not applicable	9 boats[2] during peak times in summer, and also assumes they all stay in Mangles Bay

1. Based on predicted increases in recreational boat ownership of 18–45% in the medium-term (2018) to long-term (2025)

2. Assumes 10% of boats are launched during peak times. This is higher than the 5% typically used by the DPI (2009), but has been used as a conservative estimate of the higher level of boat usage of marina residents.

Should both the Mangles Bay marina and the proposed Port Rockingham Marina proceed, the latter is not expected to contribute to recreational boating pressure in the shallow waters of Mangles Bay (all boats expected to be non-trailerable size), but will contribute to recreational boating pressure within the broader region of Cockburn Sound and the SIMP (see above).

The yachts of The Cruising Yacht Club are not included in the above assessment, as the sailing course is in the deep waters of southern Cockburn Sound (refer Figure 113). Should the marina development proceed, The Cruising Yacht Club will continue to launch craft from Mangles Bay, but most will be via the marina boat ramp, and only junior sailors will launch from the beach.

The estimated 91 trailerable boats and additional 220 berthed boats associated with the marina will potentially introduce an additional 31-62 boat movements/day into Mangles Bay at peak times in summer, and this will need to be managed to reduce potential conflict with other recreational users. Adherence to the marina access channel should minimise potential conflict to a large extent.

16.5 Management measures and performance standards

The proposed marina development is primarily a public boating and tourist facility proposed to cope with the high demand for boating facilities in the City of Rockingham area. Within the Cape Peron and Lake Richmond area of the RLRP, it is proposed to:

- improve recreational opportunities by providing hard walking and cycling paths without creating additional disturbance to the natural environment
- formalise beach access points, provide parking and remove unnecessary paths to minimise dune erosion
- recognise cultural heritage (Aboriginal and European) links with the area (e.g. providing interpretive signage at sites of significance and contributing to the maintenance of these sites)
- contribute to research and educational opportunities through the provision of facilities within the marina and interpretative walk trails/signage.

16.5.1 Beach and marine recreational management measures

The Proposal will offer opportunities for decreased stress on the marine ecosystem by supporting better management of impacts due to tourist, recreational use and boating activity. This will be achieved through:

- promoting/display information about natural and cultural values and appropriate behaviour in the marine environment, including sustainable fishing practices; appropriate boat speeds to minimise boat strike on penguins, dolphins and sea lions; no interference with marine life (including feeding dolphins); and no littering
- provide a base for surveillance, monitoring and research in the marine environment, including the impacts of recreational use and management activities.
- provision of refuelling and sullage pump out facilities at the yacht club
- provision of signage to minimise conflict between recreational boat users (water-skis, jet-skis, yachts and power boats).

16.5.2 Land based recreational management measures

The Proposal will provide new recreation facilities and funds to positively contribute to the management of the RLRP as an offset measure (refer to Section 17). In order to enhance the passive recreational enjoyment of the Cape Peron area and maintain public access, the following management measures will be implemented:

- installation of recreation facilities such as lighting, parking, walk trails, cycle path and fishing platform
- installation of signage, rubbish facilities and brush fencing of sensitive dunal areas within and surrounding the Proposal area
- provision of a range of accommodation options to service this area of Rockingham, including affordable family holiday accommodation, hotel and mixed use areas adjacent to the marina and Mangles Bay.

Further details of the accommodation numbers and provision of these facilities will be determined in during the Local Structure Planning preparation process of the Proposal.

The Proposal has undertaken a traffic study (see Section 19) to determine the likely impacts to the road system as a result of the marina. Road access to the marina, the land development and surrounding area will be improved through upgrading of surrounding roads, in particular, Memorial Drive to ensure access is retained to the coastal foreshore area for recreational purposes. Details of mitigation measures of traffic are included in Section 19.

16.6 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

Overall the Proposal will provide positive outcomes increasing the recreation and tourism values for the Mangles Bay area and the wider Rockingham Region. The Proposal will be developed in accordance with the targets and vision of the City of Rockingham's Strategic Plan (CoR 2007) and the RLRP Management Plan (DEC 2010a).

Once operational, the Proposal should not restrict recreational fishing and yachting activities within Mangles Bay. During construction there may be some temporary disruption of recreational fishing due to dredge movements, and the turbidity and noise associated with dredging (although these are expected to be minimal). There will also be some temporary disruption of other recreational activities (land-based and water-based) due to restricted site access, and some temporary effects on the amenity of the area due to noise and turbidity.

17. Conservation areas impact assessment

17.1 Relevant environmental objectives, policies, guidelines, standards and procedures

17.1.1 EPA objectives

The EPA applies the following objective in assessing proposals that may affect conservation areas and areas of natural heritage:

To protect the environmental values of areas identified as having significant environmental attributes.

To maintain the integrity, functions and environmental values.

To maintain the integrity, ecological functions and environmental values of the seabed and coast.

17.1.2 Legislation, policy and guidance

The following policies are relevant to the identification and protection of areas of conservation significance.

National Strategy for Ecologically Sustainable Development

This document sets out the broad strategic and policy framework under which governments will cooperatively make decisions and take actions to pursue environmentally sustainable development in Australia. It will be used by governments to guide policy and decision making, particularly in those key industry sectors which rely on the utilisation of natural resources.

Australia' s Biodiversity conservation Strategy

The Australia's Biodiversity Conservation Strategy 2010-2030 was prepared by the National Biodiversity Strategy Review Task Group to provide a guiding framework for conserving Australian biodiversity.

EPA Guidance Statement No 10

EPA Guidance Statement No. 10 (EPA 2006a), *Level of assessment for proposals affecting natural areas within the System 6 region and Swan Coastal Plain portion of the System 1 Region*, outlines the EPA's approach to environmental assessment of proposals involving the clearing of natural vegetation within these areas.

Bush Forever

Bush Forever is a non-statutory regional policy endorsed by the Government of Western Australia. The policy identifies 51 200 ha of regionally significant bushland (and any associated wetlands) on the Swan Coastal Plain within the Perth Metropolitan Region for protection and management across 287 Bush Forever sites. The majority of bushland areas are within Government ownership, with about 9% owned by private landowners. Areas of bushland outside Bush Forever sites may have regional values, but were not identified for protection and management in Bush Forever because of wider social and economic considerations.

Bush Forever is used as a basis for decision making and an agreed framework for the protection and management of Bush Forever sites.

Bushland Policy for the Perth Metropolitan Region, Statement of Planning Policy 2.8

Statement of Planning Policy (SPP) 2.8 addresses the protection and management of regionally significant bushland identified for protection in Bush Forever (WAPC 2005a). This SPP provides the policy and implementation framework for Bush Forever Protection sites; these measures combined give statutory planning effect to Bush Forever.

The SPP requires that proposals impacting on bush forever sites should, amongst others, ensure that all reasonable steps have been taken to avoid, minimise or mitigate any likely adverse impacts (direct or indirect) on regionally significant bushland, consistent with the SPP. Requirements of the SPP include:

- focus development within cleared, degraded and less intact areas of bushland and where possible avoid fragmentation of the bushland area and provide for ecological linkages
- protect bushland with the highest conservation value
- seek to avoid unacceptable losses, which includes a general presumption against clearing regionally significant bushland containing:
- Threatened Ecological Communities
- threatened and poorly reserved plant communities
- Declared Rare Flora
- Specially Protected Fauna
- Environmental Protection Policy wetlands
- vegetation complexes where less than 10% of the original extent currently remains on the Swan Coastal Plain
- wetland dependent vegetation fringing creeks, rivers and estuaries.

Details of long term protection, management and measures to minimise impact must be provided in a Statement of Environmental Effects and Environment Management Plan with any planning proposal.

Regional Parks

In 1997, the State Government announced a commitment to introduce legislation to give regional parks legal standing. Regional parks are vested in the Conservation Commission of Western Australia. The coordination and management of the eight Metropolitan regional parks is to be progressively transferred to CALM (now DEC), the Government's primary agency for conservation and recreation land management.

The current land tenure arrangements within defined regional park areas are complex with a number of different landholders of both Crown land and private land. The WAPC has proceeded to, and will continue to, acquire the land that is required to consolidate the parks.

Rockingham Lakes Regional Park, Proposed Final Management Plan

The key environmental and social objectives from this plan (DEC 2010a) that are relevant to the Proposal include:

Environmental objectives:

- maintain and improve the ecological condition of the coast adjoining the RLRP
- protect and enhance wetland environments
- protect, conserve, rehabilitate and restore locally and regionally significant flora and vegetation communities
- maintain and improve the overall condition of the Threatened Ecological Communities
- maintain the diversity of the indigenous fauna species in the RLRP and if possible reintroduce species lost from the RLRP

- minimise the impact of environmental weeds on biodiversity within the RLRP using methods compatible with the conservation of the natural environment
- restore degraded areas of the RLRP to a condition resembling the natural environment
- minimise the environmental and social impact of pets and domestic animals in the RLRP
- encourage appropriate management of corridors and linkages between the RLRP and other conservation or recreation areas.

Social objectives:

- maintain and enhance the natural and cultural landscape qualities
- identify, protect and appropriately manage sites with Aboriginal and non-Aboriginal cultural heritage value
- ensure that the level of visitor use and behaviour is sustainable and minimises conflict with other Park visitors and values
- provide and manage a range of quality recreation sites, facilities and uses that allow for a diversity of recreation opportunities without conflicting other Park values
- provide safe, convenient and structured access to and within the RLRP.

Development proposal objective:

- ensure that developments do not adversely affect values of the RLRP.

Shoalwater Island Marine Park Management Plan 2007-2017

The SIMP Management Plan 2007–2017 was formally approved by the Minister for the Environment in August 2007. The plan sets out, among other things, a zoning scheme and a 'best practice' model for managing the identified ecological and social values of the SIMP. The zoning scheme proposes that the areas to the north of Cape Peron (to the west of the Causeway) be within a General Use Zone. Shoalwater Bay (on the southern side of Cape Peron) is a recommended Special Purpose Zone for wildlife conservation, and further south are two sanctuary zones (at Second Rock, and Becher Point), and a Special Purpose Zone for scientific reference at Murray Reef.

State Environmental (Cockburn Sound) Policy

The State Environmental (Cockburn Sound) Policy (SEP) recognises that Cockburn Sound, situated within Perth's coastal waters, is highly valued by the community for its ecological, economic and recreational attributes (Government of Western Australia 2005b). The SEP broadly aims to:

- establish environmental values, environmental quality
- objectives and environmental quality criteria for the waters of Cockburn Sound
- identify a program to protect the environmental values
- integrate environmental planning and management of the land and marine environment
- establish an Environmental Management Plan (EMP) to coordinate management
- provide a mechanism for the Management Council to coordinate environmental management efforts
- provide for regular reporting on progress against established water quality criteria.

17.2 Findings of surveys and investigations

The flora, vegetation and fauna studies that have been undertaken within the Proposal area and surrounds are described in Section 8 (Flora and Vegetation) and Section 9 (Terrestrial Fauna). The Conservation areas surrounding and within the Proposal area are shown in Figure 118.

Source:
Bush Forever Sites supplied by Department of Planning
Coordinate System: MGA94 Zone 50
Date: 8/2/2012
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F016.dgn

Conservation areas within and surrounding the Proposal area

Figure No:
118

17.3 Evaluation of options or alternatives to avoid or minimise impact

Cape Peron is a popular holiday and day-use recreation destination. Cape Peron is popular for water and land based activities such as boating, swimming, snorkelling, walking and scenic driving, and for nature-based appreciation and study. Increasing population in Perth and surrounds, and the increase of *per capita* boat ownership has seen the use of Cape Peron escalate rapidly in recent years.

Infrastructure available to support the increased use of Cape Peron has, however, not kept pace with the increased use of this area (Strategen 2006). Evidence of the imbalance between use and facilities/management that currently exists in the Cape Peron area can be seen in the number of informal paths and tracks through the vegetation, anchor drag scars in the seagrass of Mangles bay, anecdotal evidence of sullage dumping and informal re-fuelling in Mangles Bay, and the common anti-social behaviour, including vandalism and car break-ins that occur on Cape Peron.

The Proposals primary aim is to meet the high demand for boating facilities in the Rockingham area. Currently, boats unable to fit on non-commercial trailers are confined to moorings in Mangles Bay, which provides little protection to vessels from winter storms which approach from the northwest.

In 2005, a review of the costs, benefits and constraints of Mangles Bay and other potential sites along the City of Rockingham coastline was prepared for the City of Rockingham by NS Projects (2005). The review concluded that for a marina based development, when assessed against the Proposal sustainability objectives (now the Proposal's design objectives included within Appendix 2), Mangles Bay presented the least constraints and most opportunities when compared with the other sections of the coastline in the City of Rockingham.

Alternative design concepts have been considered in consultation with key stakeholders, the community during the 2005 and 2006 process and the development of the current proposed action. All options involved an inland marina; however, each differed with respect to layout and the extent of the footprint.

An offshore marina option in Mangles Bay was not considered likely to provide the benefits of a mixed use tourism precinct. It would have involved the loss of a substantial proportion of seagrass in Mangles Bay and would not be likely to be found environmentally acceptable even with planned rehabilitation of seagrass (EPA 1998). The minimisation of potential adverse environmental impacts from the development was one of the aims of the Proposal. The details of the 2005/6 process and community and stakeholder involvement in developing the concept and Proposal objectives are provided in Appendix 4 as part of the SER.

The development footprint has been reduced from the original design(s) presented in 1998 and 2006 to the EPA. This reduction serves to limit the amount of native vegetation clearing, to minimise disturbance to the TEC (FCT 30a: *Calitris preissii* forest and woodlands). Changes to Marina design (footprint) and construction techniques have been undertaken to reduce the risk to Lake Richmond, TEC FCT 19 Sedgelands on Holocene dune swales and other adjacent vegetation communities. A summary of how mitigation has been incorporated into the Proposal is described in Table 72.

Table 72 Mitigation sequence

Mitigation	Consideration in the Proposal
Avoid - avoiding the adverse environmental impacts altogether	The marina has been moved to the west and north (of the 2006 options presented) to avoid potential impacts on Lake Richmond. The configuration of the marina has been designed to avoid areas where stagnant water may be produced.
Minimise - limiting the degree or magnitude of the adverse impact	The Proposal includes an inland marina to minimise the marine footprint and potential seagrass loss in Mangles Bay. The terrestrial footprint of the Proposal has been reduced to minimise clearing of vegetation generally and clearing of a TEC. The construction of the marina has been amended from dry excavation to a wet excavation technique on the basis of groundwater modelling which showed an impact to groundwater at Lake Richmond that was considered to be potentially significant. Dredging will be undertaken using best practice cutter suction dredge techniques to minimise impacts to water quality.
Rectify - repairing, rehabilitating or restoring the site as soon as possible	The Proposal footprint will be permanent so rectification is not applicable.
Reduce - gradually eliminating the adverse impact over time by preservation and maintenance operations during the life of the action	Indirect effects of construction, such as groundwater drawdown and turbidity from dredging, will reduce over time and, following the completion of construction activities, these are expected to return to pre-construction conditions. This process will be monitored and if conditions fail to return to pre-construction conditions as expected, contingencies would be implemented.
Offset - undertaking such activities that counterbalance an adverse residual environmental impact	Transplantation of seagrass to offset direct and indirect losses of seagrass associated with the Proposal. Rehabilitation of vegetation within the Cape Peron area. Provision of infrastructure for passive recreation within the Cape Peron area.

17.4 Assessment of likely direct and indirect impacts

The following aspects of the proposal may affect the conservation areas in, or adjacent to, the Proposal area:

- decrease in the representation of regionally significant bushland in the Swan Coastal Plain portion of the Perth Metropolitan Region as a result of clearing and earthworks associated with the development
- fragmentation of bushland as a result of clearing for the development which may disrupt recreational activities and the movement of terrestrial fauna
- potential increase in recreational activity and opportunity to better manage recreation
- potential loss of visual amenity associated with the natural coastal environment through the development; however, visual amenity may also be enhanced through rehabilitation measures.

The potential impacts on vegetation, flora, and fauna values have been described in Section 8 and Section 9, respectively. In summary, the development will result in the clearing of approximately 40 ha within the Bush Forever site 355, and 37 ha in the RLRP or less than 1% of the total area of the RLRP, which covers an area of 4270 ha.

The site supports the Quindalup Vegetation Complex of which 48% of the pre-European settlement extent of this complex remains. Approximately 20% of this complex is designated as Bush Forever, exceeding the 10% retention objective of this policy.

17.4.1 Bush Forever Site 355 – Cape Peron

All land within the proposal area south of Point Peron Road is within Bush Forever Site 355 (Government of Western Australia 2000) and within the RLRP (Figure 117 and Figure 118). The purpose of the Bush Forever site is to protect regionally significant vegetation within the site.

The total area of Bush Forever Site 355 is 174.5 ha of which 106.1 ha is vegetated (Bennett 2005). The remaining 68.4 ha consists predominantly of holiday cottages, the Water Corporation waste water treatment plant and recreational camps (Bennett 2005).

The Proposal area does not support any populations of flora of significance. The site's vegetation ranges from Very Good to Good to Degraded. The Proposal area supports the Quindalup Vegetation Complex. On the Swan Coastal Plain, within the Perth Metropolitan Region, 48% of the pre-European settlement extent of the Quindalup Complex remains (ENV 2010), of which 20% of this complex is designated as Bush Forever, exceeding the 10% retention objective of the Bush Forever policy.

The Proposal area supports two FCTs that are listed as Priority 3 PECs (Figure 44). FCT SCP30b Quindalup *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands and FCT SCP29b *Acacia* shrublands on taller dunes. The Proposal area overlaps with FCT 30b, however this area of vegetation will not be disturbed and is included in the rehabilitation plan. The Proposal will impact upon FCT 29b. This vegetation community type is dominant in the area identified for rehabilitation/restoration effort and is in Good to Degraded condition in this area.

The TEC, *Callitris preissii* (or *Melaleuca lanceolata*) forest and woodlands occurs in three locations within Bush Forever Site 355. This FCT is listed as vulnerable by the State but is not listed by the Commonwealth (ENV 2010). This TEC is located around the small grassed area on the corner of Memorial Drive and Safety Bay Road and has been subject to various degrading influences such as weeds and human activity (ENV 2010).

The Bush Forever site 355 supports a range of fauna habitat types, providing shelter and foraging opportunities for a range of fauna. One reptile of conservation significance, *Lerista lineata* (Perth Lined Skink), was recorded in the area. *L. lineata* is listed as Priority 3 by the DEC (ENV 2011a). This species was recorded at all six sites within the survey area (ENV 2011a). No conservation significant mammals have been recorded within the area however the Quenda, Water Rat, Chuditch, Red-tailed Phascogale and the Quokka may potentially occur within this area. The GSM has also been recorded within Bush Forever site 355 with potential habitat for this species known to occur across this area (see Sections on terrestrial fauna Section 9 and Matters of NES Section 14 on fauna species within the area).

The provisions of EPA Guidance Statement No. 10 (EPA 2006a) were applied to assess the likely direct and indirect impacts to the significance of this site as a result of the Proposal. The Proposal area's representation of ecological communities, diversity, rarity, ecological processes/natural systems, scientific/evolutionary importance are outlined below.

Clearing and edge effects

The Proposal will require 54.18 ha to be excised from of the Bush Forever Site 355. Of this 40 ha of vegetated areas will be cleared as a result of the Proposal. The clearing is required to facilitate the construction of the development including the inland marina and the service corridor. The exact location of the individual elements of the Proposal (e.g. land development location, recreational use areas etc) is still to be finalised as part of the detailed LSP. However, all land development uses will be contained to within the Proposal component areas as indicated in Figure 7 and vegetation disturbance will not exceed those values indicated above.

Clearing of vegetation will directly reduce the extent of vegetation communities; however, all of the vegetation complexes impacted by clearing are well represented at Cape Peron outside the Proposal area and clearing required for the Proposal would not result in any vegetation complexes being cleared to less

than 10% of the original extent and not impact on the regional significance of flora and vegetation of the Bush Forever site 355.

Clearing will impact 1.93 ha of TEC *Callitris preissii* (or *Melaleuca lanceolata*) forest and woodlands communities within the Proposal area. However, there is the potential for edge effects to occur to the TEC surrounding the small grassed area on the corner of Memorial Drive and Safety Bay Road. Degrading influences such as general construction activities during the construction phase of the Proposal, recreational walking, littering and domestic pets may potentially affect this TEC. These potential edge effects however, would only be minor and not impact on the regional significance of this TEC as it is represented within Bush Forever Site 355.

Hydrological changes

Indirect impacts from changes to the hydrological regime of the marina are unlikely to affect the flora and vegetation communities. A description and assessment of changes to water levels and salinity are addressed within Section 8. This section addresses the potential impact of the hydrological changes on the regional significance of this Bush Forever site.

The identified groundwater level and salinity changes are as a result of the construction of the inland marina are assessed as not impacting the remaining vegetation contained within Bush Forever site 355 (Section 8). As identified in Section 6, drawdown will be to a maximum of 0.032m (3.2 cm) during the construction phase of the Proposal and 0.038m (3.8cm) during the operational stage of the marina. Salinity changes are expected to occur across the Proposal area with the creation of new saltwater interface (Figure 52), however, the extent of saline intrusion is confined and will not impact on adjacent vegetation. The assessment of impacts to the TEC *Callitris preissii* (Section 8), flora and vegetation (Section 8) and fauna habitat (Section 9) indicate that the Proposal will not have a significant impact to this community and therefore the regional significance of this Bush Forever site, with localised potential effects appropriately managed.

Disturbance to heritage sites

The Proposal will directly impact heritage sites within the Bush Forever site 355. The Aboriginal Heritage site Rotary Park (Site ID 3471) and Mooribirdup Ceremonial Grounds (Site ID 22888) and the European Heritage site 'Turtle Factory' will be removed and/or disturbed as a result of the Proposal. The removal of these Aboriginal sites will be addressed through the AH Act process with the Turtle Factory considered for relocation through the planning process. Further details are outlined in Section 15.

Disturbance to potential acid sulfate soils

The soils of the Proposal area are mapped as having a low or no risk of actual acid sulfate soils (AASS) and PASS at less than 3 m from the surface. As highlighted in Section 20 (contaminated sites impact assessment), the soils of the Proposal area do not contain AASS or PASS. The soils of the area also exhibit good buffering capacity die to the highly calcareous nature of the soils within this area which would neutralise any AASS that may be exposed during the construction and operational phases of the Proposal as a result of the dewatering of the marina.

17.4.2 Bush Forever Site 358 – Lake Richmond

Bush Forever site 358 Lake Richmond is located adjacent to the Proposal area and within the RLRP (Figure 118). The assessment of Lake Richmond's regional significance values addressed in this section within the context of its Bush Forever status as it encompasses the lake itself and its surrounding floristic, fauna and ecological values, its listing as an EPP lake and Conservation Category Wetland and its geological significance due Lake Richmond's marine origin. The total area of Bush Forever Site 358 is 28.7 ha which does not include the open water of the lake.

The Bush Forever site is located on the Quindalup Vegetation Complex consisting of uplands, shrublands and wetland units. The lake is bordered by flats devoid of permanent vegetation surrounded by sedges at

the base of surrounding coastal dunes. The sedgeland is several metres wide and is underlain by peaty soil. The area is dominated by *Baumea juncea*, *Scirpus validus* and clumps of bulrush *Typha orientalis* (ENV 2011a).

The wetland within the Bush Forever site 358 provides shelter and foraging opportunities for a number of different species including wetland waders and ducks on the fringes of the lake to small ground dwelling reptiles and mammals in the associated fringing vegetation (ENV 2011a). The fauna survey undertaken by ENV (ENV 2011a) recorded migratory bird species foraging and hunting over head at the lake. Frog species were also recorded during the survey utilising the freshwater habitat.

The site supports two TECs which include the Thrombolite (microbial) community of coastal freshwater lakes of the Swan Coastal Plain (Lake Richmond) and Sedgelands in Holocene dune swales of the southern Swan Coastal Plain both listed as endangered by the Australian Government and listed as critically endangered by the State. The potential impacts to these TECs have been addressed individually in detail within the Surface Water (Section 7), Flora and Vegetation (Section 8) and Matters of NES sections (Section 14).

The provisions of EPA Guidance Statement No. 10 (EPA 2006a) were applied to assess the likely direct and indirect impacts to the significance of this site as a result of the Proposal. The Proposal area's representation of ecological communities, diversity, rarity, ecological processes/natural systems, scientific/evolutionary importance are outlined below.

Clearing and edge effects

Direct impacts to flora, vegetation and fauna habitats within the Bush Forever Site will not occur from clearing as it is located outside the Proposal area. Edge effects to the site are also not expected to occur as a result of the Proposal. The site is adjacent to an altered environment consisting of urban development (towards the eastern side), infrastructure and roads with portions of the site adjacent to the lake with grassed areas used by locals for walking and jogging. Edge effects of the Proposal on the Bush Forever site are therefore not significant as the distance and nature of these separating factors preclude it from these potential impacts.

Hydrological changes

Indirect impacts from changes to the hydrological regime from dewatering of the marina are to Lake Richmond are addressed within Section 6.1. This section addresses the potential impacts of the hydrological changes on the regional significance of this Bush Forever site.

The identified groundwater levels changes and changes in water levels in Lake Richmond are not expected to impact the regional significance of this Bush Forever Site. As identified in Section 6 drawdown will be to a maximum of 0.032 m during construction program of the marina, with a maximum of 0.038 m during the operation of the marina (Figure 25). The assessment of impacts to the TECs, Surface Water (Section 7), flora and vegetation (Section 8), wetland habitat (Section 9) indicate that the Proposal will not have a significant impact to the regional significance of this Bush Forever Site.

Disturbance to heritage sites

Lake Richmond is a registered Aboriginal Heritage site and listed on the Register of the National Estate (site 17279). There are two registered Aboriginal Heritage sites at Lake Richmond, Site 154974 a ceremonial site and de-registered Site 352 a man-made structure (fish trap). The Proposal will not impact these sites and the significance of the saltwater/freshwater mythological significance of the area as a result of the Proposal. Further details are provided in Section 15.

Disturbance to potential acid sulfate soils

The low lying areas around the lake are mapped as having a high risk of (AASS) and PASS at less than 3m from the surface. As highlighted in Section 20 the soils of Lake Richmond have a buffering capacity

(ENV 2005) which would neutralise any AASS that may be exposed during the construction and operational phases of the Proposal as a result of dewatering of the marina.

17.4.3 Rockingham Lakes Regional Park

All of the Proposal area south of Point Peron Road is within the RLRP. Regional parks are areas of regional open space that have been identified through planning processes as having regionally significant conservation, landscape and recreation values (CALM 2003a). RLRP is one of eight regional parks in the Perth Metropolitan Area. A draft management plan has been developed for the park to provide broad direction for the protection and enhancement of the conservation, recreation and landscape values of the park (DEC 2010a). The following sections describe the values and the likely direct or indirect impacts to these values.

Natural environment

The RLRP has significant conservation value owing to its geomorphic features, the presence of diverse wetland types, habitat, flora and fauna. The location of the park in relation to other conservation reserves also enhances its value in a regional context.

Potential impacts of the proposed development on flora and vegetation and fauna are described in Section 8 and Section 9, respectively. The proposal will result in 37 ha, being excised from the Regional Park which equates to approximately less than 1% of the total area (4720 ha) of the RLRP.

Recreation

The RLRP provides for a range of active and passive recreation opportunities. Most visitors to the eastern part of the park are local residents, whilst Cape Peron and Lake Richmond have a greater profile and attract visitors from across the Perth Metropolitan Area.

Construction of the proposed development may temporarily impact on users of the area. Activities such as walking, snorkelling, boat launching and other recreational activities may be limited; however, opportunities for these activities will increase with the development. The development will also enable better management of these activities in the park and adjoining marine areas.

Cultural and European heritage

Traditionally, Aboriginal family groups travelled the Rockingham area throughout the seasons. Wetlands and woodlands would hold high cultural significance due to their importance in providing food and shelter. Various aspects of European heritage are linked to the RLRP, for example, the Second World War gun batteries on Cape Peron.

The proposed development may impact on heritage values within the park including an ethnographic site (S02169, Cockburn Sound) and the Turtle Factory building (now The Cruising Yacht Club).

Approval will be sought to disturb the Aboriginal heritage site under section 18 of the AH Act. The proposed development may reduce the opportunity for local people to meet for cultural and learning purposes on the Mangles Bay foreshore, as is presently done.

The Proponent will engage with the relevant Government heritage agencies, community groups and the City of Rockingham during the Local Structure Planning process, to consider potential sites to relocate the Turtle Factory.

Landscape

The diverse landscapes of the RLRP, including wetlands, woodlands and coastal areas, contribute to its scenic values.

The Proposal will result in a change in the landscape of the Mangles Bay area; however, the proposed development is designed to ensure that it is complimentary to the natural landscape and will include rehabilitation of the wider Cape Peron bushland. It will also provide additional passive recreation facilities such as walkways and information displays.

Research and education

The unique and diverse environmental features of the RLRP provide many educational opportunities.

The proposed development is expected to contribute positively to education opportunities in the Mangles Bay area through the establishment of information displays highlighting both the environmental and heritage values of the area.

17.4.4 Shoalwater Islands Marine Park

The SIMP covers an area of approximately 6,658 ha and contains the chain of islands that run parallel to the coast between Cape Peron, Becher Point, the waters of Shoalwater Bay, Warnbro Sound and a part of Cockburn Sound off Cape Peron (Figure 118). The SIMP borders Mangles Bay at the Garden Island causeway (Figure 118). The Shoalwater islands are an important refuge for a variety of native wildlife, particularly the Little Penguin (refer to Marine Fauna Section 13 for details), sea birds and the Australian Sea-lion (Section 13). The islands also make a significant contribution to the conservation value of Western Australia's islands estate.

The SIMP is vested to the MPRA and managed by the DEC. Recreational fishing in the SIMP is managed by the DoF in close cooperation with DEC. The Shoalwater Islands (i.e. the terrestrial portion) are managed under the 1992 Shoalwater Islands Management Plan.

The Proposal is located to the east of the Garden Island Causeway and therefore will not impact directly on the SIMP (see Figure 118). However, scarring and loss of seagrass between the western side of the Garden Island Causeway and Cape Peron may be exacerbated by an increase in recreational boating use (see Section 16).

17.5 Management measures and performance standards

Management measures will be implemented to minimise, mitigate and offset the impacts on conservation areas. These management measures are described in the following three sections.

Given the intersecting values requiring mitigation and offsetting, the package is described below to address the residual impacts to Bush Forever Site 355 and RLRP.

The Proposal proposes to impact upon 37 ha of native vegetation within the RLRP and Bush Forever Site 355. The area represents less than 1% of the RLRP which covers an area of 4 270 ha (RLRP Management Plan, DEC, 2010).

The Proposal seeks that the environmental mitigation and offset package be used to directly benefit the RLRP and offset the impacts to Bush Forever Site 355.

In describing the types of environmental offsets, Environmental Protection Bulletin No. 1 provides the following guidance, "Offsets activities are usually undertaken outside the area where the impact occurs (i.e. offsite) and may consist of beneficial environmental activities including restoration and rehabilitation of degraded but valuable environments. In some circumstances, these activities may not be feasible and other types of offsets may be needed. For example, securing land for conservation or enhancing its protection could be options".

The offset package proposed supports the use of restoration and rehabilitation of degraded adjacent and nearby areas within the RLRP. These initiatives are both feasible and consistent with the objectives of the RLRP Management Plan.

There is no legal stipulation to the ratio of land affected to land replaced or restored as part of an environmental offset. The Statement of Planning Policy 2.8 does, however, establish environmental offset ratios applicable to Bush Forever sites.

SPP 2.8 establishes an equivalent gain environmental offset ratio of 1:1 for an area of medium conservation significance which is cleared and a net gain ratio of 1.5 for an area of high conservation significance. SPP 2.8 notes that gains can include active improvements of quality and/or avoiding potential losses of quality by agreement to forego permitted uses

The Proposal area is considered to support an area of "medium" conservation significance. The presence of GSM habitat and the location of one individual is of conservation significance. The density of GSM recorded onsite and adjacent sites is low (DEC, Pers comm. 2011) and therefore the significance of the isolated, small population which may be considered to be unviable in the long-term, requires consideration in the context of more extensive habitat and potential population in the RLRP (Strategen 2011).

The Proposal is committed to providing an environmental offset ratio of approximately 1.5:1 to rehabilitate the balance area within Cape Peron. Agreement of the offset package would ensure the Proposal rehabilitates 56 ha of the Cape to improve the biodiversity of the area, consistent with the objectives of the RLRP. The area to be rehabilitated includes similar vegetation units and an area of GSM habitat.

Proposed, Park management, vegetation and flora mitigation measures, address the impact on the Bush Forever Site is consistent with the management objectives of the RLRP and include the protection and rehabilitation of the remnant vegetation of Cape Peron to enhance the conservation values and ecological linkage with Lake Richmond. The rehabilitation would be carried out by undertaking:

- a strategic weed control program with the aim of a net decrease in weeds in the area
- collection of seed and any other available material from the site to be cleared for use in rehabilitation efforts
- planting and/or seeding disturbed areas with local provenance species where appropriate
- use of habitat logs and woody debris to create a variety of fauna habitat throughout the site
- establishment of a Mangles Bay Heritage trail with informative signs and displays illustrating the heritage values of the area
- installation of interpretive signage
- encouraging any existing links to community bush care groups and programs such as Healthy Parks Healthy People which may be in operation in the Regional Park
- fencing or installation of tree guards where required to protect vegetation
- rabbit baiting to reduce predation, should this pest be noted on site
- stabilisation of disturbed dune areas
- provision of funding to the DEC for ongoing management of the area
- investigation of the possibility of links with the scientific community to study the success factors involved in this rehabilitation project, which may increase the success of this or future projects
- establish a monitoring program to evaluate the rehabilitation performance.

This program will be achieved in partnership with the DEC Regional Park land managers and has the potential to create a large and easily measurable improvement in vegetation condition and ecological diversity in the Proposal site.

Restoration of degraded bushland requires funding for consecutive years at an appropriate level to achieve the goal of establishing an integrated, self supporting and diverse suite of vegetation. Additional benefits of this kind of program include a reduction in fire risk due to reduction in weeds such as introduced grasses; increased aesthetic values for the wider community; and a reduction of degrading factors to a wider area of land in connection to the Proposal site. Projects of this scale are often beyond the reach of state or local agencies and therefore represent real value to the community and scientific community at large.

Management measures will be undertaken to monitor the potential impacts to the hydrological regime (as outlined in Section 6. A further offset is proposed through securing a parcel of land that is currently not protected, with similar or greater conservation value. The rehabilitation and possible land acquisition offsets will be determined in consultation with the DEC and OPEA.

17.6 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

17.6.1 Bush Forever Site 355 – Cape Peron

The Proposal is not expected to impact the regional significance of the Cape Peron Bush Forever site 355. The Proposal will not significantly impact the TECs, the diversity of flora and fauna however, will disturb the heritage values of the area. The changes to the hydrological regime (see Section 6 (groundwater) and Section 6.1 (surface water) are considered acceptable. The offset measures of the Bush Forever site 355 will also mitigate the localised impacts to this Bush Forever site. The offsets package is also designed to meet the requirements of Statement of Planning Policy (SPP) 2.8, which addresses the protection and management of regionally significant bushland.

17.6.2 Bush Forever Site 358 – Lake Richmond

The Proposal is expected not to impact on the regional significance of the Lake Richmond Bush Forever site 358. The Proposal will not be significantly impact the TECs, fish species within the lake, the diversity of flora and fauna or disturb the heritage values of the area. The changes to the hydrological regime (see Section 6 (groundwater) and Section 6.1 (surface water) are considered acceptable as the changes are within the seasonal variations experienced at Lake Richmond, with the key environmental values of the lake not significantly affected.

17.6.3 Rockingham Lakes Regional Park

The area represents less than 1% of the RLRP which covers an area of 4,270 ha (RLRP Management Plan, DEC, 2010).

The Proposal is committed to providing an environmental offset ratio of approximately 1.5:1 to rehabilitate the balance area within Cape Peron. Agreement of the offset package would ensure the Proposal rehabilitates 54 ha of the Cape to improve the biodiversity of the area, consistent with the objectives of the RLRP.

The area where rehabilitation/restoration effort should be focussed will be selected in consultation with the DEC and other stakeholders.

This program will be achieved in partnership with the Regional Park land managers and has the potential to create a large and easily measurable improvement in vegetation condition and ecological diversity in the Proposal area.

17.6.4 Shoalwater Islands Marine Park

The Proposal is located to the east of the Garden Island Causeway and therefore will not impact directly on the SIMP.

18. Visual amenity impact assessment

18.1 Relevant environmental objectives, policies, guidelines, standards and procedures

18.1.1 EPA objectives

The EPA applies the following objective in its assessment of Proposals that may affect visual amenity, landscape and landforms:

To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable

To maintain the integrity, ecological functions and environmental values of landscapes and landforms.

18.1.2 Legislation, policy and guidance

EPA Guidance Statement No. 33

EPA Guidance Statement No. 33 (EPA 2008a) provides guidance on land use planning and development processes to achieve environmentally sound outcomes. Part B of the Guidance Statement ('*Biophysical factors*') provides advice in relation to 'landscape and landforms' and Part D ('*Social surrounds*') provides advice in relation to 'visual amenity'. The Guidance Statement provides checklists for considering both of these factors during local area planning. Checklist criteria relevant to the Proposal are as follows:

Landscape and landforms

- consider any guidance and principles that have been developed for the broader area
- carry out studies to describe and evaluate the existing landscape, landforms and visual resource
- describe the potential impacts that a proposed development may have with respect to landscape and landforms and their associated values
- consult with stakeholders and demonstrate how this has been incorporated into the Proposal
- employ sound design measures and propose management measures that mitigate as far as possible the potential adverse impacts of the development on the landscape
- consider whether the location, design and management measures proposed are consistent with relevant objectives and pursue improvements where possible
- ensure implementation of approved design and management measures.

Visual amenity

- retain natural landforms and vegetation in visually prominent places, as well as other parts of a site, in order to maintain local landscape character
- avoid locating development where it would be visually obtrusive
- adopt appropriate building design
- rehabilitate disturbed natural areas
- carry out landscaping works to meet completion criteria.

Visual Landscape Planning in Western Australia

The WAPC has developed the Visual Landscape Planning in Western Australia manual to provide advice on incorporating visual landscape planning into the planning system. Planning should aim to

accommodate change while maintaining, and where possible, enhancing the quality of landscapes (WAPC 2007).

Blending, according to WAPC (2007), refers to development that is visible (or possibly prominent); however, its appearance remains compatible with the surrounding landscape setting. Blending has been identified as particularly relevant to valued natural landscapes that are subject to pressures for change (WAPC 2007). Blending, as a specific visual management objective within the broader objective of protection and maintenance of visual landscape character, would be the most appropriate objective for the proposed development area.

State Planning Policy No. 2: Environment and Natural Resource Policy

WAPC's State Planning Policy No. 2 (WAPC 2003) discusses the importance of protecting and improving landscapes during the planning and decision making stages of a development proposal. Protection and improvement of landscapes is to occur by way of:

- identification and protection of landscapes with high natural resource values
- encouragement of restoration of degraded landscapes
- consideration of the capacity of landscapes to absorb development
- planning, designing, and siting new development in a way which is sensitive to the character of the landscape
- consideration of the need for a landscape or visual impact assessment for development proposals that may impact upon sensitive landscapes.

18.2 Findings of surveys and investigations

Place Laboratory (2010) assessed the landscape values of the scheme amendment area and the potential impacts of the associated development concept. The results of this study are summarised below.

Visual analysis

A visual analysis was undertaken of the area which identified sites of historical and cultural significance and vantage points, as well as evaluating the visual impact to the existing landscape character and scenic quality (Figure 119).

The vantage points of the proposed development were classified into three zones for assessment including:

- zone 1 – perimeter, defined by the boundaries of the Proposal area to determine landscape character, road typologies and spatial quality of existing conditions
- zone 2 – coastline, the coastline from the east of Garden Island Causeway to Rotary Park to identify scenic quality, available views, contextual landmarks and landscape character
- zone 3 – vantage points, surrounding vantage points to identify key vantages points to enable assessment of visual impact of development to views from the surrounding area.

The surrounding vantage points were chosen based on their elevation, depth of view and access, specifically focusing on existing lookout and ridges that are regularly used by the general public. Two primary vantage points were located, including Battery Hill within Cape Peron (Figure 123) and the dunal ridge along Shoalwater Bay (Figure 119). Both locations have 360 degree views that include the Proposal area. The Proposal area will not be visible from John Point in Cape Peron (Figure 119) which is used frequently by the public.

Further visual analysis will be undertaken as part of the local structure planning process once the likely building mass and heights are confirmed to determine their visibility from the key zones. The final design will take into consideration further studies to ameliorate the impact through location, orientation and materiality.

18.3 Evaluation of options or alternatives to avoid or minimise impact

Alternative design concepts have been considered in consultation with key stakeholders and the community during the 2005 and 2006 process and the development of the current proposed action. The development footprint has been reduced from the original design(s) presented in 1998 and 2006 to reduce the amount of native vegetation clearing and to allow a greater buffer distance between the development and Lake Richmond and to reduce impacts on SIMP.

18.4 Assessment of likely direct and indirect impacts

Activities or aspects of the Proposal that may potentially affect landscape values and visual amenity include:

- clearing vegetation will alter the appearance of the natural environment which may be visible from identified significant sites
- physical attributes of significant infrastructure that may obstruct or change views of existing natural features considered aesthetically significant. The infrastructure may, in itself, be aesthetically displeasing.

The Proposal area will impact the foreshore of Mangles Bay, east of the Garden Island Causeway (Figure 120, Figure 121 and Figure 122). The proposed breakwaters at the entry to the marina will also obstruct views along the coastline both west to Cape Peron and east along the Esplanade.

However the existing views from the aforementioned locations are already interrupted by both industrial and residential areas, including the BP Oil Refinery and Kwinana Power Station (Figure 120). Furthermore, the coastline near the Garden Island Causeway, is already disturbed by four wheel drive access to the beach. Therefore the impact to visual amenity is not considered significant given the already disturbed nature of the landscape.

The Proposal area will be visible from several of the views surrounding the proposed development, including Battery Hill and RLRP (Figure 123 and Figure 124). Existing views from these locations are already disturbed by both industrial, residential and associated infrastructure such as roads and tracks, therefore the visual impact to this area is not considered significant given the already disturbed nature of the landscape.

Further visual analysis will be undertaken as part of the planning process once the likely building mass and heights is confirmed to determine their visibility from the key zones. The final design development will take into consideration further studies to ameliorate the impact through location, orientation and materiality.

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Mangles Bay Marina Based Tourist Precinct

Visual analysis of Proposal area and surrounds (Source: Place Laboratory 2010)

Figure 119

strategen
Oct-2011

18.6 Management measures and performance standards

Existing visual amenity values within, and surrounding the Proposal area will be maintained as far as practicable through the implementation of the following measures:

- retaining vegetation associated with area of POS
- the shore disturbance required for the Proposal is concentrated in the area of existing yacht club activity
- aligning roads on existing contours where practicable
- avoiding interruption of the natural ridgeline
- contributing to rehabilitation and management works in adjacent RLRP
- connecting the new development with the existing residential and commercial areas through legible pedestrian access ways
- guiding building height and distribution to provide diversity, permeability and limit mass
- developing design guidelines that specify architectural designs, colours and materials that blends well with the natural landscape and are visually sensitive to the area
- developing a LSP that maintains key view corridors
- maintaining a landscape buffer around Proposal area that minimizes visual impact on the area.
- maintaining a landscape buffer along the coastline.

Figure 120 Garden Island causeway

Figure 121 Boat club coastline

Figure 122 Esplanade coastline

Figure 123 Battery Hill, Cape Peron

Figure 124 Rockingham Lakes Regional Park

18.7 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

Place Laboratory (2010) performed an initial visual analysis of the site identifying the potential impact of development to visual amenity. Visual amenity of the coastline and surrounding views is an aesthetic value that may be compromised following the implementation of Proposal, though the view sheds are currently broken by the existing infrastructure, industry and residential housing. This impact may be managed through using landscape location, orientation, materiality and height.

Further visual analysis will be undertaken as part of the LSP preparation process, following confirmation of the likely building mass and heights to determine their visibility from the key zones. The outcomes of further studies will inform the design development.

19. Road traffic impact assessment

19.1 Relevant environmental objectives, policies, guidelines, standards and procedures

The following management objective is considered relevant to the Proposal:

To ensure that the increase in traffic resulting from the Proposal does not adversely impact on the amenity of social surroundings or increase the risk to local public safety.

19.1.1 Main Roads Western Australia (MRWA) Road Hierarchy Criteria

To promote effective and efficient traffic management, Main Roads Western Australia (MRWA) developed a Road Hierarchy in the early 1990s which is applied to all Western Australian roads. The Road Hierarchy categories outline the responsibility for management of roads and provide a classification to allow planners to determine the traffic management structures required to meet anticipated traffic flows. The primary criteria used in Road Hierarchy classification (MRWA 2011) are outlined in Table 73.

Table 73 Primary criteria for Road Hierarchy classifications (MRWA 2011)

Criteria	Location	Responsibility	Degree of Connectivity	Predominant Purpose	Indicative Traffic Volume
Primary Distributor	All of WA incl. built up areas	MRWA	High. Connects to other Primary and Distributor roads.	Movement of inter regional and/or cross town/city traffic.	-
District Distributor A	Built up areas	Local Government	High. Connects to Primary and/or other Distributor roads.	High capacity traffic movements between industrial, commercial and residential areas.	> 8000 vehicles per day (vpd).
District Distributor B	Built up areas	Local Government	High. Connects to primary and/or other distributor roads.	Reduced capacity but high traffic volumes travelling between industrial, commercial and residential areas.	> 6000 vpd.
Regional Distributor	Non Built up areas	Local Government	High. Connects to primary and/or other distributor roads.	Roads linking significant destinations and designed for efficient movement of people and goods between and within regions.	> 100 vpd.
Local Distributor	All of WA incl. built up areas	Local Government	Medium. Minor network role connects to distributors and access roads.	Movement of traffic within local areas and connect access roads to higher order Distributors.	Built up area – Max 6000 vpd. Non built up Area – up to 100 vpd.
Access Road	All of WA incl. built up areas	Local Government	Low. Provides mainly for property access.	Provision of vehicle access to abutting properties.	Built up Area – Maximum 3000 vpd. Non built up Area – up to 75 vpd.

19.1.2 Heavy vehicle road use

Heavy vehicles are defined as a motor vehicle with a gross vehicle mass greater than 4.5 tonnes but not greater than 8 tonnes, or that seats more than 12 adults (including the driver) and has a gross vehicle mass no greater than 8 tonnes (DoT 2011b). During construction the Proposal is estimated to generate around 100 – 120 truck movements per day in to and from the construction site (Transcore 2011).

MRWA manages the activities of heavy vehicles through the issue of permits for Western Australian Restricted Access Vehicles Network (RAV Network). Restricted Access Vehicle permits are required if the load exceeds the following specifications:

- 2.5 metres wide
- 4.3 metres high
- 19 metres long
- 42.5 tonne gross combination mass
- a permit is also required when towing more than one trailer.

The Proponent has considered the MRWA RAV Network in order to plan appropriate construction traffic routes. There are ten RAV networks corresponding to different truck/trailer combinations and/or load weights in Western Australia. On the basis that standard prime-mover and semi-trailer vehicles will be utilised to transport material to the construction site, two RAV networks have been considered as appropriate for use in construction traffic route planning (Transcore 2011):

- RAV network 1 – defined by exception; all public roads with the exception of those specified as unsuitable
- RAV network 2 – all roads within this network can be assumed to be appropriate for construction traffic.

The consideration of routes for construction traffic is discussed further in Section 19.4.2.

19.1.3 Rockingham City Council

The City of Rockingham is responsible for the approval and maintenance of roads within and surrounding the Proposal area. As indicated in Table 73, the regulation of road design for a majority of roads is regulated by Local Government. The modification and development of roads and related structures for the Proposal will be done in accordance with the City of Rockingham infrastructure guidelines.

19.2 Findings of surveys and investigations

Riley Consulting 2005

A traffic assessment was conducted by Riley Consulting (2005) for the preparation of the 2006 SER. Riley Consulting used the Saturn traffic model to estimate the future traffic flows along key roads within and in proximity to the Proposal area as a result of the proposed development (Strategen 2006). Riley Consulting provided the existing and future traffic volumes around the Proposal area. Traffic estimates were based on the previous Proposal area outlines and therefore may not be appropriate for the current Proposal layout.

Transcore 2011

To supplement the Riley Consulting (2005) study, a traffic report was undertaken by Transcore (2011). The objectives of this study were to identify the following:

- existing traffic conditions for the network connecting to the Proposal
- outline of suitable routes for construction vehicles
- details of requirements to upgrade Memorial Drive.

Transcore 2011 identified eight key roads (Figure 125) which make up the road network connected with the Proposal area. The road network within and around the Proposal area consists of local access, local distributor and distributor roads that service the area. These existing roads provide access to Garden Island and direct access to residential, retail, commercial and recreational areas. A summary of the existing road network as described by Transcore is included in Table 74.

Table 74 Key roads connected to the Proposal area (Transcore 2011)

Road	MRWA Road Hierarchy	Current Traffic (vpd)	Peak times	Details
Cape Peron Road	Local access road	4450	0700 – 0800 1600 – 1700	Provides access to the Garden Island Causeway.
Naval access road	-	2700 – 3 000	0630 – 0730	Restricted access only.
Memorial Drive	Local access road	~ < 1000	-	Narrow road, unsealed shoulders and no footpaths.
Lease Road	Local access road	~ < 1000	-	Narrow road, unsealed shoulders and no footpaths.
Boundary Road	Local distributor	-	-	Residential dwellings on southern side with direct access to road.
Parkin Street	District distributor B	7770	0700 – 0800 1500 – 1600	Direct access to residential, retail and commercial properties on both sides. Bus route. Traffic demand in excess of capacity.
Rae Road	District distributor A	4900	1100 – 1200 1600 – 1700	Direct access to residential, retail and commercial properties on both sides. 40 kph speed zone adjacent to Safety Bay Primary School. Two roundabouts.
Safety Bay Road	District distributor A	9300	-	~3% of vehicles are heavy vehicles. Extra width for cycle lane on each side of the road. Direct access to residential, retail and commercial properties on both sides. Bus route. Five roundabouts.

Transcore identified and undertook an assessment of the likely direct and indirect impacts of the Proposal to the surrounding traffic network. The results of the study are outlined in detail in Section 19.2.

Source:
Aerial Photography supplied by Landgate (2010)
Road Data supplied by Landgate
Coordinate System: MGA94 Zone 50
Date: 8/2/2012

NB: Potential errors may occur in some areas

STRATEGEN
environmental consultants

Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F023.dgn

Road Network surrounding the Proposal Area

Figure No:
125

19.3 Evaluation of options or alternatives to avoid or minimise impact

The options to avoid or minimise impact on road traffic of this Proposal is limited, as the Proposal will increase traffic to the area during both the construction and operational phases of the Proposal. However, there is flexibility in the design and location of the roads within and surrounding the Proposal area to mitigate both the short and long-term impacts of the Proposal of the surrounding Rockingham area.

The key management strategy to limit the impact of road traffic on the Rockingham area, in particular Cape Peron, is the design of the road infrastructure system internally and surrounding the Proposal area. This PER identifies those roads that will be impacted by increases in traffic flows, with a commitment to implement the appropriate measures during the LSP preparation and subdivision approval of the Proposal.

19.4 Assessment of likely direct and indirect impacts

19.4.1 Potential sources of impact

The proposed development would increase the volume of traffic flow along roads in its proximity. The increase in traffic may impact on residents and users of the area with regard to:

- public safety issues (e.g. road traffic and pedestrian safety)
- reduction in amenity (e.g. increase in noise emissions from vehicles).

19.4.2 Traffic generated by the Proposal

Traffic demand for the road network surrounding the Proposal area will be comprised of three components:

- naval base traffic – predicted to increase over time
- construction traffic – both light and heavy vehicles accessing the Proposal area during the construction phase
- operational traffic – vehicle movements accessing the marina and tourism precinct following the completion of construction.

Naval base traffic

HMAS Stirling Naval Base is located on Garden Island and a causeway links Cape Peron to the island for naval personnel access requirements. Access to Garden Island via the causeway is restricted and is not available to the general public. Point Peron Road connects the causeway with the surrounding road network.

The daily recorded traffic on the naval access road (supplied by the naval base) is 2700 – 3000 vpd, which is predicted to grow to 4000 vpd by 2018. During the morning peak hour period of 0630 hours and 0730 hours on weekdays, approximately 1200 vehicle movements are recorded, although this increases substantially when a naval fleet arrives at Garden Island (Transcore 2011). Although the traffic loads in the area are within the design limitations for an entire day, significant problems do occur due to car stacking on local distributor roads during the peak morning and afternoon periods resulting in existing community concern about the amount of traffic on these roads.

Construction traffic

During construction, the Proposal is estimated to generate around 100 – 120 truck movements per day in to, and from the construction site (Transcore 2011). Site access points will be designed once the final layout of the Proposal and associated works has been confirmed. Immediate access to the site will likely be via a haul road located within the site boundary, with access to either Safety Bay Road or Memorial Drive. If the local road network is to be utilised for site access, Point Peron Road and Memorial Drive are the optimal roads for direct access due to proximity to the site (Transcore 2011).

As outlined in Section 19.1.2, the use of MRWA RAV networks has been considered in planning the potential routes for construction traffic. These routes were be selected on the basis that standard prime-mover and semi-trailer vehicles will be utilised to transport material to the construction site (Transcore 2011).

Ennis Avenue has been identified as the primary road through which site access would be routed, as it is part of the RAV network and is ideal for long distance truck movements (Transcore 2011). Three potential routes to Ennis Avenue from the construction site have been identified: Parkin Street/Patterson Road, Safety Bay Road/Rae Road and Safety Bay Road (Table 75). Based on an assessment of these routes, Safety Bay Road is considered to be the preferred option for construction traffic as this would avoid the 40 km/hour school zone on Rae Road, the town centre and busy traffic of Parkin Street (Transcore 2011).

Table 75 Potential freight routes to Ennis Avenue (Transcore 2011)

Freight route	Advantages	Disadvantages
Parkin Street/Patterson Road	Shorter than alternative options.	High levels of traffic on Parkin St, including a busy town centre. Frequent property access movements.
Safety Bay Road/Rae Road	Shorter link to Ennis Ave than Safety Bay Rd. Less roundabout intersections to negotiate (2 as opposed to 5 for Safety Bay Road). Control of access after the Garden Highway roundabout (no direct property access).	Rae Rd between Safety Bay Rd and Garden Island Hwy is a residential suburban street with direct property access to residences on both sides of the road. A 40 kph speed restriction applies between 7:30am and 9:00am and between 2:30pm and 4:00pm within the school zone on Rae Rd. The speed restriction may apply around schools from 7.30am to 5pm in the future under a new proposal to be considered by the Road Safety Council.
Safety Bay Road	A higher traffic environment which means less potential impact on residents. Avoids passing through the school speed zone on Rae Rd. Direct residential property access is only on the northern side for a large portion of the road. Control of access after the Read St roundabout (no direct property access).	A longer link to Ennis Avenue than Safety Bay Rd. More roundabout intersections to negotiate (5 as opposed to 2 for Rae Rd). Rae Rd has control of access for a greater proportion of its length.

Operational traffic

As the final design of the marina and components has not been confirmed, only a preliminary estimate of traffic volumes has been made. The Proposal is estimated to generate approximately 7000 daily trips, with peak hour traffic of approximately 700 trips (Transcore 2011). Peak hour for access to the marina is expected to fall between 0800 – 0900 in the morning and 1700 –1800 in the evening.

Combined traffic peak

The naval base traffic is likely to present the most significant peak period for traffic movements on Cape Peron Road and the network surrounding the Proposal. It is assumed that the demand generated by operational traffic will be 70% of the 0800 - 0900 naval peak hour. Estimates suggest that 70% of the operational traffic will utilise Memorial Drive to travel to and from the marina and tourism Precinct. During the morning peak period, Memorial Drive is expected to carry approximately 450 vph (vehicles per hour) eastbound and 1100 vph westbound once the Proposal is completed. As part of the Proposal, this road will be redesigned to cater for the increased volume of traffic (Section 19.4.3 below).

19.4.3 Upgrades to Memorial Drive

Memorial Drive is a local access road according to the MRWA road hierarchy (Transcore 2011), with a typical daily traffic flow of less than 1000 vpd. Connecting Point Peron Road with Lease Road and Safety Bay Road, Memorial Drive is considered to be the primary road that will potentially be bearing the increase in traffic generated by the Proposal. The key characteristics of the existing road include:

- a two-lane single carriageway
- limited lane marking
- narrow width (~5.5 m across)
- unsealed shoulders
- no footpaths
- limited property access
- intersections with Lease Road and Safety Bay Road.

The anticipated peak traffic flows (450 vph eastbound and 1 000 vph westbound) can be accommodated on a two-lane single carriageway road, including appropriate intersection treatments where required. The initial carriageway will be 7 m wide with one lane in each direction.

Potential future expansion of the naval base at Garden Island is anticipated to increase the traffic volume on Memorial Drive and surrounding roads. In the event of this increase in demand, a second 7 m carriageway will be added, upgrading Memorial Drive to two lanes each way.

As outlined in Section 19.1.3, the road will be designed according to City of Rockingham standards.

19.5 Management measures and performance standards

The increased volume of traffic created by both the construction and operational phases of the Proposal may potentially increase public safety issues and/or reduce amenity of the area (e.g. increased noise emissions). In order to mitigate these impacts, the following management measures will be incorporated into the LSP preparation and design phase:

- road design according to the City of Rockingham standards
- routing of construction traffic to avoid existing high volume and/or residential areas
- upgrade of Memorial Drive (Section 19.4.3) to cater for increased demand, including the installation of appropriate intersection controls.

19.6 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

With the implementation of management measures outlined in Section 19.5, it is not anticipated that the increased traffic flow generated by the Proposal will have significant negative impacts on local road traffic. A Traffic Management Plan, outlining actions to minimise impacts to safety and amenity will be developed prior to the commencement of the construction phase of the Proposal.

The Proposal will generate increased traffic on the road network in the vicinity of Cape Peron, during both the construction and operational phases. This will be adequately managed through road upgrades and route planning.

20. Contaminated sites and acid sulfate soils impact assessment

20.1 Relevant environmental objectives, policies, guidelines, standards and procedures

20.1.1 EPA objectives

In most circumstances, including this assessment, the EPA applies the following objectives in its assessment of Proposals that may affect surface water, groundwater, water quality and the ecology that surface water and/or groundwater supports:

To ensure that emissions do not adversely affect environment values or the health, welfare, and amenity of people and land uses by meeting statutory requirements and acceptable standards.

For development Proposals the EPA objective for soil quality is:

To ensure that rehabilitation achieves an acceptable standard compatible with the intended land use and consistent with appropriate criteria.

20.1.2 Legislation, policy and guidance

The objective of the *Contaminated Sites Act 2003* (CS Act) is to protect human health, the environment and environmental values by providing for the identification, recording, management and remediation of contaminated sites.

The EP Act and CS Act provides provisions for the Proponent to control the extent and discharge of dewatering at a site and to ensure that soil, groundwater and surface water are of an acceptable standard compatible with the intended land use, and consistent with appropriate criteria, as well as minimising the risk to human and ecological health. This involves the identification, recording, management and remediation of contaminated sites and ASS.

Government and industry guidelines

Regulatory agencies and industry bodies have established guidelines (industry best-practice) to assist Proponents achieve acceptable standards for site development. The Department of Conservation (DEC) is the regulatory agency for assessing the management and rehabilitation of contaminated sites and ASS in Western Australia. The DEC has developed a number of guidelines and environmental notes in relation to mining and rehabilitation, which include:

- Contaminated Sites Management Series (DEC 2010b)
- Acid Sulfate Soils Guideline Series:
- Identification and Investigation of Acid Sulfate Soils (DEC 2009b)
- Treatment and management of soils and water in acid sulfate soil landscapes (DEC 2011c)

Other relevant policies and guidelines include:

- Australian New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000)
- National Ocean Disposal Guidelines for Dredged Material (Commonwealth of Australia 2002)
- National Assessment Guidelines for Dredging (Commonwealth of Australia 2009).
- Contaminated Sites Regulations (Government of Western Australian 2006).

20.2 Findings of surveys and investigations

20.2.1 Acid sulfate soils

Acid sulfate soils (ASS) are naturally occurring soils and sediments containing iron sulfides, most commonly pyrite. When ASS are exposed to air the iron sulphides in the soil react with oxygen and water to produce a variety of iron compounds and sulfuric acid. Initially a chemical reaction, the process is accelerated by soil bacteria. The resulting acid can release other substances, including heavy metals, from the soil and sediments into the surrounding environment (DEC 2009b). Disturbance of these soils and sediments can generate large amounts of sulfuric acid, resulting in the leaching of contaminants (heavy metals) naturally occurring in soils. Flushing of acidic leachate to groundwater and surface waters can cause offsite impacts including:

- ecological damage to aquatic and riparian ecosystems
- effects on estuarine fisheries and aquaculture projects
- contamination of groundwater with arsenic, aluminium and other heavy metals
- reduction in agricultural productivity through contamination of soils (predominantly by aluminium)
- damage to infrastructure through the corrosion of concrete and steel pipes, bridges and other subsurface assets.

Land development area

A preliminary site investigation (PSI) was undertaken by Strategen (2010) over the Proposal area. A search of the ASS Swan Coastal Plain risk map (DEC 2003) (search conducted 03/02/2010) indicated the site was within an area of "low to no risk of ASS occurring within 3 m of the natural soil surface" (Figure 126).

Geotechnical investigations undertaken by GHD (2010) included sampling for ASS. A total of 42 samples were submitted to a National Association of Testing Authorities accredited laboratory for analysis and pH values ranged from 7.8 to 9 pH units and values of pH_{FOX} from 6.2 to 6.7 pH units. The change in pH from pH_F to pH_{FOX} ranged from 1.3 to 2.7 pH units. The results suggest that the majority of soil samples contain neutral to alkaline soils with a significant amount of acid neutralising capacity. Suspension Peroxide Oxidation Combined Acidity and Sulfate (SPOCAS) tests were conducted on 19 of the samples to confirm the minimal risk of ASS and identify net acidity. No exceedances of DEC reporting criteria were recorded (Strategen 2010).

Inland marina and access channel

Monosulfidic black ooze (MBO) is associated with many marine, estuarine and riparian developments within the southern Perth Metropolitan and South West Regions. Sullivan and Bush (2002) describe MBO as:

"Monosulfidic black ooze (MBO) are gels (moisture contents usually >70%), black, often oily in appearance, greatly enriched in monosulfide (i.e. up to 27% compared to a maximum of 1% for estuarine sediments), high in organic matter (usually >10% organic carbon) and can form thick (i.e. >1 m) accumulations in waterways (e.g. drains) within ASS landscapes… MBOs are easily mobilised during runoff events and can be distributed into rivers or if flooding occurs, distributed over surrounding landscapes… They have the capability to cause both severe acidification and/or severe de-oxygenation of flood waters."

Therefore, the formation of MBO requires a combination of acid sulfate runoff, carbon, and a low flow environment. Often these elements are found in drains in coastal ASS areas, therefore with the right conditions, MBO has the potential to contaminate marine environments, including marine fauna and flora by acidifying and deoxygenating waters.

In addition to the ASS studies and results described in Section 20.2.1, an offshore sediment analysis and bore log analysis were undertaken within and surrounding the Proposal area. Review of the results in

each of these studies and information indicate the potential for MBO to occur within the marina and offshore within the access channel is low, given the limited potential for the local soils to be acid generating.

Oceanica (2011) offshore sediment analysis

Due to the proposed dredging activities, the sediments in Mangles Bay that will be disturbed were tested for sedimentary sulfides, mainly as acid volatile sulfides, pyrites and metal complexes by Oceanica (2011). The offshore sediment analysis conducted by Oceanica (refer to Section 10) indicates the potential for low ASS. For 12 sites sampled within the vicinity of the proposed channel footprint[20], sediment cores were taken to the full depth of dredging[21] and split into layers of 0.5 m for analysis. In addition, four sites were sampled according to the methods specified in the Cockburn Sound SEP (EPA 2005b), in areas adjacent to the proposed access channel. This sampling was undertaken to provide baseline data on sediment contamination in the surface sediments of the region, to detect any future contamination should the Proposal proceed. Results of this testing are included in Section 10. The low ASS potential of soils in the Proposal area, together with the calcareous nature of the sediments sampled by Oceanica indicate that the access channel has a low probability of producing MBO offshore of the Proposal area.

MWH (2011a) bore logs

The groundwater investigations undertaken by MWH (MWH 2011a) (Appendix 5) included a series of groundwater monitoring bores to be drilled within and surrounding the Proposal area. The bore logs recorded for each of the bores drilled were examined to determine the nature of the soils present to confirm the potential for ASS to occur deeper within the soil profile. The soils encountered in the shallow samples undertaken by GHD (2010) ASS investigation, were present within the deeper soils encountered in the groundwater monitoring bores. The soils recorded in the bore logs were typically sandy, with shell fragments present, with little organic matter present within the soil profile.

The sediment in Mangles Bay that will be disturbed by the proposed dredging activities for this Proposal poses a minimal risk of ASS.

Lake Richmond

An ASS investigation surrounding Lake Richmond was undertaken by ENV in 2005 (ENV 2005) for the Water Corporation in response to maintenance work to be carried out to the SDOOL. The following results of the ENV ASS investigation are described below an adapted from the ENV report unless otherwise stated.

A total of 22 soil bores were drilled to a final depth between 3 m and 6 m below ground level (ENV 2005). One sample from each soil bore was tested for ASS by either the Chromium Reducible Sulphur (S_{CR}) suite method of the full SPOCAS method (ENV 2005).

A total of 304 soil samples were collected from the 22 soil bores. All soil samples were tested, with field tests consisting of pH_F and pH_{FOX}. The field and peroxide pH for all samples did not indicate the presence of ASS. The average field pH of the soil samples was an alkaline 9.0, likely to be due to a significant proportion of shell fragments and carbonate observed in the soil. The average peroxide pH of the soil samples was neutral (pH6.9). All soil samples exhibited an extreme reaction with hydrochloric acid, which is also likely to be due to the significant amount of shell fragments and other carbonaceous material. Groundwater was recorded to have an average of ph 8 (slightly alkaline).

[20] The proposed channel design altered slightly after sediment sampling had been undertaken, resulting in several sampling locations being located outside of the proposed dredge channel. The sites sampled are still considered sufficiently representative of the region.

[21] The NAGD indicates that *"For capital dredging, samples are needed from the full depth of contaminated as well as potentially contaminated sediment. Full depth is taken to mean at least the top 1 metre of sediment, and more if contamination could be found deeper..."* consequently cores did not exceed a depth of 150 cm.

The findings of this investigation indicate that ASS around Lake Richmond are unlikely to cause environmental harm from the exposure of PASS due to the high buffering capacity of the soils within the area.

20.2.2 Contamination (other than PASS/AASS)

Sediment contamination

The Proposal will involve dredging for the construction of the marina access channel. The excavation will result in some suspension of sediment into the water column, and there is potential for dissolved and particulate contaminants in the excavated material to come into contact with the marine environment. There is also some potential for dissolved and particulate contaminants in the sediment to enter the harbour through reclamation runoff.

The identification of potential contamination and management of sediments for the Proposal is discussed further in the Marine Water Quality impact assessment (Section 10).

Soil and groundwater contamination

The results of the site PSI (Strategen 2010) indicated that no potential contaminating land uses exist over the majority of the Proposal area south of Point Peron Rd and that no soil contamination was detected in samples taken from part of the site associated with historical land use activities. Groundwater was not tested for contamination in the PSI but soils samples indicated that there is no reason to suspect groundwater contamination.

Based on the PSI and historical soil sampling results the majority of the Proposal area does not require reporting under the CS Act. The investigation did however identify three small localised locations where soil contamination may have occurred within the Proposal area:

- Mangles Bay Fishing Boat Club
- The Cruising Yacht Club
- Holiday Parks caravan park.

Source:
Cadastral Data supplied by Landgate
Acid Sulphate Soils Data supplied by CSIRO
Coordinate System: MGA94 Zone 50
Date: 8/2/2012

NB: Potential errors may occur in some areas

STRATEGEN
environmental consultants

Drawn:
CAD Resources

CAD Resources File No:
g1937_MB_PER_F017.dgn

Potential acid sulfate soils within and surrounding the Proposal area

Figure No:
126

Source: Imagery supplied by Landgate (2010)
Contamination Hot Spots supplied by GHD (2010)
Coordinate System: MGA94 Zone 50
Date: 8/2/2012
NB: Potential errors may occur in some areas

STRATEGEN environmental consultants

Drawn: CAD Resources

CAD Resources File No: g1937_MB_PER_F022.dgn

Proposal site contamination 'hot spots' including sampling site locations

Figure No: **127**

20.3 Evaluation of options or alternatives to avoid or minimise impact

Alternative locations of the Proposal to avoid or minimise impact are limited. The key management strategy to limit impact on ASS from alteration of groundwater levels across and surrounding the Proposal area and water levels within Lake Richmond is the construction methods used to assist in the dewatering of the inland marina.

The wet excavation methods used for the construction of the marina will minimise the overall impact of dewatering will have on groundwater levels within and surrounding the Proposal area and delay the intrusion of the saltwater interface. Further details are available in Section 6.

Potential contamination hot spot areas were identified within the Proposal area. These will be subject to a detailed site investigation and will be remediated or removed, if required, prior to development.

20.4 Assessment of likely direct and indirect impacts

20.4.1 Potential sources of impact

The potential sources of impact during development works are:

- earthworks (excavation and dewatering) have the potential to disturb and expose contaminated soil, sediment and/or water if contamination exists on site
- excavation onsite or along service infrastructure corridors has the potential to disturb ASS if they occur on the site
- exposure of contaminated sediments during the dredging of the marina access channel.

20.4.2 Acid sulfate soils

Based on the findings of the PSI, it is considered that no further ASS investigations or management is likely to be required prior to commencement of onshore earthworks, provided that excavation works are limited to no deeper than 3 m below current ground level.

Should excavation works extend below 3 m it is recommended that further ASS investigation is carried out to confirm the absence of ASS soils and to ensure that the proposed earthworks are carried out in accordance with relevant DEC ASS guidelines.

20.4.3 Monosulfidic black ooze

The Proposal has the very low potential for producing MBO within the proposed marina and offshore access channel. The low potential for MBO to occur is a result of the low to no presence of sulfidic soils and organic materials together with the high buffering capacity of the soils present within the soil profile.

20.4.4 Contamination

Marine sediments

Analysis of the proposed dredge spoil (i.e. sediment in Mangles Bay) did not identify any potential contaminants (Oceanica 2012). The impact on marine environmental receptors by movement of contaminated material though the marine water column from dredging activities will be negligible. In addition to this, the risk that leaching of water from the stockpiled dredge spoil will contaminate the groundwater aquifer below the site is also negligible.

When disposal of stockpiled dredge spoil is required during the construction stage of the Proposal due to restricted land availability, the stockpiled dredge spoil will tested for various contaminants (metals, TBT

etc) in collaboration with advice from the contaminated sites branch of the DEC, to determine the most appropriate management and disposal strategy.

Soil and groundwater

Limited soil testing undertaken during the PSI indicated that specified analytes were under prescribed criteria. If material excavated at the site is intended for disposal at a landfill facility, stockpile sampling will be undertaken. Following this sampling, the soil will be classified before being disposed of at the appropriate class of landfill. DEC guidance for contaminated sites also states that any soil used for backfilling should be tested for contamination, including soil excavated on site.

To minimise the risk to environmental receptors within or surrounding the Proposal area during the construction phase of the Proposal and on the post construction land users, the Proponent will conduct further investigations in the three small localised location identified in the PSI as being potentially contaminated. The Proponent will conduct a detailed health and receptor risk assessment to determine whether the Proposal poses a risk to environmental receptors within or surrounding the Proposal area and the extent of this risk.

20.5 Potential for and nature of any cumulative impacts

There are no other known major developments in the area and therefore the Proposal is unlikely to result in cumulative impacts in relation to impacts to environmental receptors by soil and groundwater contamination.

Even though it is unlikely that dredging activities will lead to contamination of Mangles Bay and effect marine environmental receptors, modelling shows that the dredge spoil plume will have no cumulative impacts with other surrounding dredging activities such as dredging of Cockburn Sound (APASA 2011).

20.6 Management measures and performance standards

Management measures will be implemented by the Proponent and include:

- undertaking due diligence onshore ASS investigations during construction as part of a dewatering management program
- undertaking due diligence ASS monitoring of the access channel during the dredge program
- undertaking due diligence ASS monitoring of the dredge spoil from construction of the access channel
- stockpiled dredge spoil will be tested for contaminants (such as metals and TBT) on advice from DEC Contaminated Sites Branch
- establish a monitoring program encompassing the marina and access channel sediments to monitor the potential for MBO formation
- conducting further investigations at three small localised locations of potential contamination
- maintaining an up to date contaminated sites inventory.

Any areas of contaminated land within the Proposal area will be identified, remediated and managed by the Proponent for clearance by the DEC prior to the cessation of the construction period and the use of the potential contaminated land by the public and/or residents. This condition is a requirement to ensure that the land is in a condition that does not present an environmental health risk for the future land use.

The Proponent will maintain a contaminated sites register throughout the pre-construction and construction period at the Proposal area as required by the CS Act. The register will be used at the end of the construction period to identify any contaminated sites remaining at the site and clean-up requirements before approval by government agencies for the release of land by the Proponent.

20.7 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

Contaminant levels in the sediment to be excavated are such that ecological values in the vicinity of the Proposal area will not be affected as no EILs or HILs are exceeded, no marine guidelines for sediment are exceeded, and no marine water quality guidelines are exceeded in sediment elutriate waters or leachate waters. In addition, the Proposal is unlikely to produce MBO as a result of the construction of the marina and the access channel. The implementation of the aforementioned management measures will detect the potential for MBO to occur during the operation of the development. Therefore, the EPA objectives to protect environmental values in marine waters and to ensure sediments are of an acceptable standard for the intended land use will be met.

Elutriate testing of sediments in the breakwater footprints meet marine water quality guidelines. Therefore, the EPA objectives to protect environmental values in marine waters will be met following suspension of sediments during placement of breakwater material.

The risk of ASS (sediments and soil) for this Proposal is negligible and contaminated sites within the Proposal area are unlikely to cause any environmental impacts as all sediment, soil and water contamination will be effectively identified, remediated and managed by the Proponent in a timely manner as per the DEC CSMS Guidelines.

21. Other environmental factors impact assessment

The other relevant factors of relevance to the Proposal are:

- Subterranean fauna
- Noise
- Dust
- Waste
- Fire.

21.1 Relevant environmental objectives, policies, guidelines, standards and procedures

21.1.1 EPA objectives

Subterranean fauna

In most circumstances, including this assessment, the EPA applies the following objective in its assessment of proposals that may affect subterranean fauna:

To maintain the abundance, diversity, geographic distribution and productivity of fauna species and ecosystems levels through the avoidance or management of adverse impacts and improvements in knowledge.

Air quality

The EPA environmental objective for air quality is:

To ensure that emissions do not adversely affect the environment values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

Noise

The EPA environmental objective for noise is:

To protect the amenity of nearby residents from noise impacts resulting from activities associated with the Proposal by ensuring the noise levels meet statutory requirements and acceptable standards.

Emissions

The EPA environmental objectives for emissions:

To ensure that emissions do not adversely affect environmental values or the health, welfare and amenity of people and land uses by meeting statutory requirements and acceptable standards.

21.1.2 Legislation, policy and guidance

State regulatory framework

Section 6 of the Australian Standards 2436-1981 “Guide to noise control on construction, maintenance and demolition site”.

EPA Draft Guidance Statement No. 8

The EPA's Guidance Statement No. 8 (EPA 2007a) provides guidance on the EPA assessment process for the compliance with statutory noise regulation requirements during the construction of a Proposal.

EPA Guidance Statement No. 18

The EPA's Guidance Statement No. 18 (EPA 2000c) provides guidance on the process for the assessment of air quality impacts from land development sites and management measures required during the preparation of land for development.

In its assessment of proposals, the EPA will expect the Proponent to demonstrate that cleared areas on land development sites will be stabilised following vegetation clearance.

EPA Guidance Statement No. 54 and Draft Guidance Statement No. 54a

EPA Guidance Statement No. 54 (EPA 2003) provides guidance on the information the EPA will consider when assessing proposals where subterranean fauna is a relevant factor.

The draft EPA Guidance Statement No. 54a (EPA 2007b) has been developed as a technical appendix to EPA Guidance Statement No. 54 and provides guidance on sampling for subterranean fauna, including sampling effort, sampling design and ongoing monitoring.

State protection

In a legislative context, the preservation and conservation of subterranean fauna is covered primarily by the following Western Australian legislation:

- Wildlife Conservation Act 1950 (WA)
- Conservation and Land Management Act 1984 (WA).

In Western Australia, rare or endangered species are protected by the Wildlife Conservation (Specially Protected Fauna) Notice 2008, under the WC Act. Schedules 1 and 4 in this Notice are relevant to this assessment, providing a listing of those species protected by this Notice.

The DEC (Nature Conservation Division) Priority Fauna List also nominates conservation species from Priority 1 to 5. It is expected that the potential impacts of a proposal to these Priority listed species should be managed such that the species do not meet the IUCN criteria for threatened species.

21.2 Findings of surveys and investigations

No surveys or investigations have been conducted to assess the environmental impact of noise, dust and waste generation as the environmental impacts are expected to be insignificant and short-term only.

21.2.1 Stygofauna

Stygofauna are subterranean fauna that live below the watertable in caves and large pores. Typical stygofauna are pale and blind with elongated appendages, because of their subterranean existence (Subterranean Ecology 2010a). A high proportion of these species are SREs. As such, the presence of stygofauna in an area may be of conservation significance.

A desktop assessment of the Study Area for stygofauna was undertaken by Bennelongia (2011). The assessment found that the inland intrusion of seawater into the superficial formations suggests conditions may be suitable for stygofauna with anchialine affinities, and is likely to be the case all along the coastline of the Swan Coast plain where Tamala Limestone is present (Bennelongia 2011).

A freshwater lake (Lake Richmond) which occurs in proximity to the Proposal area is likely to contribute significant nutrients to the surrounding groundwater and it is possible that stygofauna abundance is greater in the vicinity of the lake (Bennelongia 2011).

Both Safety Bay Sand and Tamala Limestone of the superficial aquifer are likely to contain sufficient voids to provide stygofauna habitat (Bennelongia 2011). The stygofauna habitat review concluded that there is a moderate to high likelihood that stygofauna occurs in the Proposal area, largely owing to the nature of the underlying geological substrates and the carbonate-rich groundwaters, as well as the biological productivity of Lake Richmond and its connectivity to the local groundwater systems (Subterranean Ecology 2010b). The habitat present is well connected to the extensive regional habitat within the sands and limestone of the Swan Coastal Plain (Bennelongia 2011).

In their assessment Bennelongia (2011) conclude that it is unlikely that development of the Proposal at Mangles Bay will threaten persistence of any species of stygofauna. Stygofauna species are considered likely to occur within the impact footprint; however, the spatial extent of the impacts associated with the Proposal will be very small at the scale of which species are likely to be distributed. The impact footprint is not expected to exceed 75 ha. Thus, the spatial extent of impact footprint is several orders of magnitude less than the likely range of a restricted stygofauna species. To provide context, Harvey (2002) defined SREs as species with ranges <1,000,000 ha.

Further investigation of risk to stygofauna, in particular, field survey, was not recommended by Bennelongia (2011).

21.2.2 Troglofauna

Troglofauna are subterranean fauna that live above the watertable in caves and large pores. Troglofauna are generally invertebrates such as spiders, pseudoscorpions, millipedes and insects (Subterranean Ecology 2010b).

A desktop assessment of the Study Area was undertaken for troglofauna by Subterranean Ecology (2010b). The troglofauna habitat assessment (Subterranean Ecology 2010c) found that for the following reasons there is a very low likelihood of troglofauna being present at the Proposal area:

1. Geological substrates that occur within the Proposal area comprises unconsolidated sands, which area not known to provide prospective troglofauna habitat.
2. If limestone occurs below the unconsolidated sands within the Proposal area it is likely to be saturated and therefore unsuitable as habitat for air-breathing troglofauna (Subterranean Ecology 2010c).

On the basis of the Subterranean Ecology (2010c) assessment no further troglofauna investigations (surveys) have occurred.

21.3 Evaluation of options or alternatives to avoid or minimise impact

No other options or alternatives to avoid or further minimise impact have been evaluated.

21.4 Assessment of likely direct and indirect impacts

21.4.1 Potential sources of impact

No long-term discharge of pollutants are expected from the Proposal, however aspects or activities associated with the construction stages of the Proposal that may have the potential to affect amenity values, not considering mitigation efforts include:

- short-term emissions during the construction phase from noise and dust as a result of clearing and demolition on existing structures on site
- excavation of the marina and dredging resulting in solid wastes
- excess water from dewatering the watertable to allow for the dry excavation of the marina
- use of hydrocarbons and ignition sources onsite resulting in potential fire risk
- indirect impacts from increase in saltwater interface as a result of the land based marina impacting groundwater-dependent ecosystems (such as subterranean fauna).

No long-term discharge of pollutants will result from the Proposal. However, short-term emissions during the construction phase of the Proposal will occur including noise, vibration, odour and dust.

21.4.2 Subterranean Fauna

It is considered that there is a very low likelihood of troglofauna occurring within the Proposal area (Subterranean Ecology 2010c). Hence the Proposal is unlikely to impact upon these subterranean species.

The Proposal will result in a minor proportion of the freshwater aquifer becoming saline (refer to Section 6). As stygofauna live in freshwater aquifers, this has the potential to result in habitat loss (Bennelongia 2011). However, the Proposal is unlikely to impact upon stygofauna regionally as there is extensive and continuous stygofauna habitat occurring outside the Proposal area (Bennelongia 2011).

21.4.3 Noise

The likely direct impacts from noise resulting from the Proposal are expected to occur during 0700 - 1700, Monday to Friday during the construction phases of the Proposal. It is likely that potential noise issues will be experienced by residences east along Hymus St/Safety Bay Road and recreation camps west of Memorial Drive and Point Peron Road during these time periods.

21.4.4 Dust

Dust will be generated by the Proposal primarily by mechanical disturbances such as vegetation clearing, earthmoving and road traffic on unsealed surfaces. In dry, windy conditions, particles can lift from open or disturbed areas resulting in visible dust emissions. The generation of dust from the Proposal will likely result from:

- the frequency at which dust generating activity takes place
- meteorological conditions such as wind speed
- moisture content of the dust source
- composition of dust, including particle size distribution, particle density
- the condition of the dust source.

Potential direct dust emissions are most likely to be experienced by residences east along Hymus St/Safety Bay Road and recreation camps west of Memorial Drive and Point Peron Road during the construction stages of the Proposal.

21.4.5 Waste (other than ASS)

Wastes generated by the Proposal include:

- waste water from limited dewatering
- dredged spoil from dredging of channel
- domestic solid and liquid wastes (including food scraps) during construction
- waste oils and lubricants
- general office waste (from site offices).

Solid wastes are expected to occur as a result of excavation of the marina and dredging the channel of the Proposal. Dredge spoil is expected to be settled and the water infiltrated onsite via infiltration ponds and where required solid material will be disposed offsite. Any sand suitable for use as fill from the dredge spoil will be used on site, however as the dredging is relatively shallow it is expected that the majority of the dredge spoil (maximum 50 000m^3) will have organic content and will need to be disposed of offsite.

The excavated material for the marina is expected to be sand and will largely re-used onsite as fill. All material will be tested for geotechnical stability and any material that contains organic matter will be disposed of offsite.

Dewatering will be very limited given that a wet construction technique will be employed in the construction of the marina. Dewatering will be undertaken using dewatering spears, with excess water returned to the groundwater system via infiltration basins located within the Proposal area. Excess water will be settled and treated where necessary via a series of infiltration basins and settlement ponds, lined appropriately with geofabric, as part of routine dewatering management requirements.

21.4.6 Fire

Construction activities may increase the risk of fire, particularly as construction is in close proximity to native bushland and will include activities in the summer season. Activities that can increase fire risk include:

- storage, handling and disposal of hydrocarbons
- storage, handling and disposal of solid waste materials
- ignition sources such as machinery and smoking.

21.5 Management measures and performance standards

21.5.1 Subterranean fauna

Potential impacts on subterranean fauna within, and adjacent to the Proposal area will be mitigated through the management measures implemented under various management plans, including the Hydrocarbon Management Plan, Groundwater Management Plan and Vegetation and Flora Management Plan as part of the CEMP Appendix 1). The key management measures relevant to subterranean fauna are:

- restricting canal disturbance to areas approved in accordance with the Proposal, in compliance with legislative requirements including Schedule 1 of any Statement issued by the Minister for the Environment
- monitoring the extent of groundwater drawdown associated with the Proposal
- containing and bunding hydrocarbon storage facilities, re-fuelling locations and areas of stationary hydrocarbon usage in compliance with corporate policy, relative standards and legal requirements.

21.5.2 Noise

The Proposal will be subject to Environmental Protection (Noise) Regulations 1997 during the construction phase of the Proposal. However, under Regulation 13, construction noise from construction sites are not required to meet the assigned levels, provided certain conditions are met. The Proponent will ensure that:

- construction equipment is the quietest reasonably available
- construction work will be carried out in accordance with section 6 of the Australian Standards 2436-1981 "Guide to noise control on construction, maintenance and demolition sites"
- screens, enclosures and other noise mitigating devices shall be used where there is a risk of unacceptable noise levels to the community
- establishment of a complaints management system by the Proponent to ensure complaints by nearby residents are captured and the source of noise is addressed.

21.5.3 Dust

The Proposal is subject to the EP Act (for air quality impacts) during the construction phase of the Proposal. The Proponent will ensure the following measures are employed onsite for the management of offsite impacts of dust:

- screens (wind fencing) around the development site to block out wind
- dust suppression to damp down prone dust generation areas
- hydromulching of dust generation areas
- transplant valuable species from areas to be cleared to POS
- cleared areas on land development areas will be stabilised following vegetation clearance
- restricted speed limits on unsealed roads
- chip cleared vegetation and use as much mulch for soil stabilisation.

21.5.4 Waste

The storage and disposal of wastes generated by the Proposal will be controlled in accordance with conditions set out in the environmental licence, and also through implementation of the following management measures to be included within the Waste Management Plan and Hydrocarbon Management Plan (as part of the EMP):

- re-use dredge spoil and excavated sands as necessary if testing identifies the material is geotechnical stable and contains no organic matter
- disposing of waste (both dredge spoil and excavated material and municipal waste) to an appropriately licensed landfill or recycling facility.

21.5.5 Fire

Fire management will take into consideration and adhere to the requirements of all applicable legislation and regulations associated with that legislation. Applicable State legislation includes:

- Bush Fires Act 1954;
- Bush Fires Regulations 1954;
- Dangerous Goods Safety Act 2004;
- Dangerous Goods Safety (General) Regulations 2007;
- Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007;and
- Dangerous Goods Safety (Explosives) Regulations 2007.

Applicable Australian Standards include:

- AS/NZ 1221 – 1997, Fire Hose Reels
- AS 12239 – 2004, Fire Detection and Alarm Systems – Smoke Alarms
- AS 1841.1 – 1997, Portable Fire Extinguishers – General Requirements (Includes Amendment 1 – 2001 and Amendment 2 – 2003)
- AS 1841.5 – 1997, Portable Fire Extinguishers – Specific Requirements for Powder Type Extinguishers
- AS 1841.6 – 1997, Portable Fire Extinguishers – Specific Requirements for Carbon Dioxide Type Extinguishers
- AS 1851 – 2005, Maintenance of Fire Protection Systems and Equipment
- AS 2441 – 2005, Installation of Fire Hose Reels
- AS 2444 – 2001, Portable Fire Extinguishers and Fire Blankets Selection and Location
- AS 3786 – 1993, Smoke Alarms.

The Proponent will ensure the following measures are employed onsite for the management of fire impacts:

- install signs to indicate the prohibition of smoking and other ignition sources onsite during construction
- appropriate management of fuels, oils and other hydrocarbons onsite during refuelling of construction equipment, in accordance with the Hydrocarbon Management Plan
- appropriate storage and management of solid waste onsite during construction, in accordance with the Waste Management Plan
- manage fire in accordance with the City of Rockingham's Local Emergency Management Committee guidance
- comply with fire control provisions established by FESA.

21.6 Predicted environmental outcomes against environmental objectives, policies, guidelines, standards and procedures

Given the distances of noise sensitive premises and recreational areas from the construction areas and the above management measures, noise and dust emissions and waste generation by the Proposal are unlikely to impact on sensitive environmental premises or recreational areas.

Due to the proximity of native bushland, there is potential for construction activities to increase the risk of fire generation. However the proposed management and adherence to relevant standards will significantly mitigate this risk.

After application of mitigation measures described in Section 21.5.1, the Proposal is expected to result in no significant impact to any troglofauna or stygofauna species on the basis of:

- no presence of a troglofauna habitat within the Proposal area
- broad distribution of stygofauna species outside the Proposal area.

22. Summary of likely environmental measures and controls

22.1 Environmental management framework

22.1.1 Overview

In addition to implementing the requirements of specific environmental conditions set by the EPA if the Proposal is approved the Proponent will minimise environmental impacts through:

- maintaining an Environmental Management System (EMS)
- implementing the CEMP for the Proposal (Appendix 1)
- regularly reviewing the performance of the EMS, EMP and developing environmental improvement plans for priorities identified in the reviews
- continually updating construction (including ASS and dewatering) management plans and measuring success
- training staff and contractors in environmental requirements and considerations of their work
- ensuring that stakeholder views are sought, respected and considered
- regularly reporting to stakeholders on performance.

Cedar Woods will abide by all relevant current and future statutory requirements.

22.1.2 Environmental Policy

Environmentally Sustainable Development principles are key drivers for Cedar Woods projects. The following principles are the central objectives for Cedar Woods projects:

Green Estates and Buildings

- the preservation and enhancement of natural ecosystems
- proponent of 'Greensmart' principles
- intelligent water use and solar orientation of lots, facilitation of passive solar design
- comprehensive Design Standards applied to each estate facilitating Environmentally Sustainable Development best practice
- energy efficiency – 6 star apartments and townhouses
- provision of landscaping packages which contain a water wise selection of plants and grass types.

Urban Water Management

- water sensitive design features – bio filtration systems incorporated into estate water features which treat and reuse stormwater throughout the development
- rainwater tanks are encouraged through design standards and in some projects actually supplied and installed by Cedar Woods
- use of recycled water for public areas.

Urban Renewal, Waste & Heritage Preservation

- adoption of stringent waste minimisation plans for all projects which incorporate the reuse of viable materials within the development and mandate the sustainable disposal of all disused materials
- minimisation of development impact upon surrounding community
- utilisation of comprehensive urban renewal strategies for disused or under-utilised urban sites
- preservation and restoration of pre-existing heritage features influenced by ethnographic findings
- implementation of site remediation and decontamination programs
- adding value to the existing communities by enlivening tired streetscapes as part of project design strategy.

Cedar Woods' Environment Policy emphasises the commitment to protecting the natural environment.

The Proposal's environmental intent is to:

- create a development that respects the marine and land environment of the area
- improve long-term viability of seagrass in Cockburn Sound
- improve management of both the surrounding land and marine environments
- include a commitment to more than offset any environmental impact to the land.

22.1.3 Environmental Management System (EMS)

Cedar Woods is proactively working to ensure that the environmental impact from their activities is minimal and that they meet or exceed their approval obligations. Activities are supported by their EMS's, which cover environmental approvals, environmental management plans, incident management systems, internal audits and awareness and training programs.

22.1.4 Environmental Management Program (EMP)

The proposed management of the key issues associated with the Proposal has been documented in the EMP (Appendix 1) to be implemented to manage specific environmental aspects of the Proposal. Implementation of the Proposal in accordance with the EMP will ensure that the Proposal meets all respective environmental obligations including internal objectives, legislation, regulations and conditions of approval relating to operation of the Proposal.

The EMP is comprised of management sub-plans that describe the specific environmental objectives and targets for each environmental factor, the management measures to be applied to avoid and minimise the environmental impact of the Proposal, monitoring measures to measure the performance of management against the targets and contingency measures to mitigate unavoidable or accidental impact. The sub-plans are as follows:

- groundwater management plan
- surface water management plan
- dredge spoil management plan
- terrestrial biodiversity and habitat management plan
- marine biodiversity and habitat management plan
- graceful sun-moth management plan
- dust management plan
- noise and vibration management plan
- fire management plan
- cultural heritage management plan
- hydrocarbon management plan

- waste management plan
- contaminated sites and ASS management plan
- public access and beach management plan
- rehabilitation management plan
- community issues management plan
- visual amenity management plan
- road traffic management plan.

The EMP will be regularly will be regularly reviewed and revised as appropriate.

The EMP in Appendix 1 primarily focuses on the construction aspects of the Proposal. The EMP will be regularly reviewed and revised as appropriate. An Operational Environmental Management Plan (OEMP) for the Proposal will be developed during the construction phase.

22.2 Summary of potential impacts, proposed management commitments and environmental outcomes

Table 76 provides a summary of the potential impacts, proposed management commitments and environmental outcomes for each of the environmental factors assessed.

Table 76 Summary of impacts and proposed management commitments

Management objectives	Relevant standards and guidance documents	Existing environment	Potential impacts	Management strategies/proponent commitments	Predicted outcomes
Groundwater					
To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected. To ensure that emissions do not adversely affect environmental values or the health, welfare or amenity of people and land uses by meeting statutory requirements and acceptable standards.	• National Water Quality Management Strategy (ANZECC/ARMCANZ 2000) • Guidelines for Groundwater Protection in Australia (ANZECC/ARMCANZ 1995) • Guidelines on national water quality management - released by the Natural Resource Management Ministerial Council (NRMMC) • Rights in Water and Irrigation Act 1914 • Rockingham – Stakehill Groundwater Management Plan (DoW 2008) • State Water Quality Management Strategy 2001 • State Water Strategy 2003 • Stormwater Management Manual (DoW 2004-2007) • Operational Policy 5.12 – Hydrogeological reporting associated with a groundwater well licence • Operational Policy 1.02 Water conservation/efficiency plans	The key environmental value of groundwater in the area is in maintaining groundwater levels in Lake Richmond over the winter months. Groundwater in the area is used for irrigation of public open space and gardens. The superficial lithology in the Proposal area consists of two main superficial geological units (1) the Safety Bay Sand; and (2) the Tamala Limestone. The hydraulic conductivity (K) of the Safety Bay Sands is relatively high, with estimates ranging between 5 and 174 m/day (MWH 2011b). The hydraulic conductivity (K) of the Tamala Limestone is very high because of its' porous nature, with estimates ranging between 100 and 3,000 m/day (MWH 2011b). Groundwater flow in the superficial aquifer in the Rockingham area is generally in a westerly direction, towards the Indian Ocean (Department of Environment 2004).	Changes to groundwater levels due to the presence of the marina allowing more interaction between local groundwater and the sea, resulting in: • lowering of water levels in nearby private garden bores • exposure of acid sulfate soils if they exist within the land development area. Saltwater intrusion caused by the inland movement of the saltwater-groundwater (fresh) interface due to the inland marina that may result in: • increasing salinity in local bores • salt entering the root zone of potentially salt sensitive native species.	Use of a wet construction method involving the use of excavators and dredges to construct the marina with the use of no to very little dewatering to minimise groundwater drawdown. Limited dewatering may be required for the relocation of the SDOOL and construction of services such as sewer. This will be below the threshold for a dewatering licence. Design modifications to reduce impacts to groundwater include reducing the length of the south eastern arm of the marina and reduction in depth of canals. The Proponent will develop a Groundwater Quality Management Plan to address potential changes in salinity on groundwater users, including measures to inform householders, investigating potential changes in locations for council irrigation bores and measures to mitigate impacts to affected households. This will be supported by a groundwater salinity monitoring program. A Local Water Management Strategy will be prepared to accompany the Local Structure Plan and will outline management measures for groundwater quality and quantity, and potable and non-potable water supplies (which would be initiated should these criteria be breached). Establishment of a contingency plan where domestic groundwater bore supply and quality is diminished. A Local Water Management Strategy will be prepared to accompany the Local Structure Plan and outline management measures for groundwater quality and quantity, and potable and non-potable water supplies Using the construction methods advised by the Water Corporation, the construction of the SDOOL without the marina present resulted in a decrease in water levels at Lake Richmond of 0.24 m. With the marina being constructed at the same time, the decrease was 0.25 m. The cumulative impact of the two proposals on Lake Richmond is predominantly due to the construction of the SDOOL.	After mitigation measures as described, the proposal is expected to be able to: • result in a minimal reduction in groundwater levels at Lake Richmond of 0.032 m during construction and 0.038 m during operation • ensure no impact to groundwater quality at Lake Richmond during construction or operation • manage the limited impacts to bore users in the Rotary Park area through the implementation of mitigation measures in line with the proposed Groundwater Quality Management Plan These impacts are considered to be acceptable as the key environmental values for groundwater surrounding the Proposal will not be significantly affected.
Surface water					
To maintain the integrity, ecological functions and environmental values of wetlands. To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected. To maintain biological diversity where that represents different plants, animals and micro-organisms, the genes they contain and the ecosystems they form, at the levels of genetic diversity, species diversity and ecosystem diversity.	• National Principles for the Provision of Water for Ecosystems (ANZECC/ARMCANZ 1996) • National Water Quality Management Strategy (ANZECC/ARMCANZ 2000) • State Water Quality Management Strategy 2001 (Waters and Rivers Commission 2001) • State Water Strategy 2003 • Stormwater Management Manual (DoW 2004-2007) • Wetlands Conservation Policy for Western Australia 1997 • Environmental Protection of Wetlands Preliminary Position Statement - Position Statement No. 4 (EPA 2004e) • Environmental Protection (Swan Coastal Plain Lakes) (EPA 1992) • Guideline for the Determination of Wetland Buffering Requirements (WAPC 2005b).	The soils of the Proposal area and surrounds are Safety Bay Sands, which are known for their high permeability (Gozzard 1983). Runoff is unlikely to occur, except perhaps during extreme events such as the 1 in 100 year rainfall event. Runoff from the Proposal area is not expected to enter Lake Richmond. Lake Richmond is a perennial, freshwater lake with an area of approximately 40 ha and a depth of approximately 14 m (MWH 2011a). The Lake Richmond Outlet Drain runs through the site, close to the southern and western boundaries of the Proposal area. Lake Richmond is a groundwater throughflow lake receiving groundwater from south and discharging water to the north towards Cockburn Sound (CALM 2003b). Water levels in the lake vary seasonally from between approximately 0.2 and 1.2 mAHD, with water levels generally peaking in spring and being lowest in summer/autumn, prior to the commencement of winter rainfall. Water quality in the lake is fresh, with values of between 400 mg/L and 1400 mg/L total dissolved salts (TDS) being recorded (MWH 2011a).	Construction and operation of the marina waterbody will lower regional groundwater levels which may lead to: • lowering of water levels in Lake Richmond • exposure of acid sulfate soils if they exist around Lake Richmond • saltwater intrusion caused by the inland movement of the saltwater-groundwater (fresh) interface due to the inland marina. Increased population as a result of development may increase indirect impacts on Lake Richmond through uncontrolled access, rubbish and domestic pets.	Minimising the amount of dewatering associated with the Proposal through adopting a wet construction method. Undertaking rehabilitation of areas not to be cleared within the Proposal area and within the Proposed Service Corridor. Installing best Management Practices that treat stormwater prior to infiltration or discharge in line with the Stormwater Management Manual (DoW 2004-2007). A Local Water Management Strategy will be submitted with the Local Structure Plan for the development outlining the details of the measures to be undertaken to manage stormwater water quality and quantity in the development. Possible raising of the weir wall on the Lake Richmond Outlet Drain to decrease the amount of water leaving the lake as surface water each year. This measure will be considered in consultation with the City of Rockingham, Water Corporation, DEC, DOW and DSEWPaC.	The Proposal is likely to result in a decrease of water levels in Lake Richmond of 0.032m during construction and 0.038m during operation. This is not considered to significantly impact the lake ecology. The change in the location of the saltwater interface within the groundwater will not impact upon Lake Richmond during dewatering or following construction of the Proposal. The moving of the Lake Richmond Outlet Drain will not impact water levels in the lake. Stormwater from the proposal will not directly enter the lake and hence there will be no change in surface water quantities or quality entering the lake. The increased population within the Lake Richmond area is not expected to significantly impact the lake. The Proposal is not expected to significantly impact upon the TECs present at Lake Richmond. As the 50 m buffer will generally be retained intact and rehabilitation will occur, the impact of the Proposal upon the integrity of the buffer of Lake Richmond is considered to be minimal. The Proposal will not impact upon lake water quality, and hence will not result in an increase in the frequency of algal blooms in the lake. The Proposal is not expected to have an impact on the function and ecology of Lake Richmond.

Terrestrial flora and vegetation					
To maintain the abundance, species diversity, geographic distribution and productivity of flora and fauna at species and ecosystems levels through the avoidance or management of adverse impacts and improvements in knowledge.	• EPA Position Statement No. 2 (EPA 2000a) • EPA Position Statement No. 3 (EPA 2002) • EPA Guidance Statement No. 33 (EPA 2008a) • EPA Guidance Statement No. 51 (EPA 2004b) • EPA Guidance Statement No. 10 (EPA 2006a) • Wildlife Conservation Act 1950 (WA) (WC Act) • Environmental Protection Act 1986 (EP Act) • Conservation and Land Management Act 1984 (WA) • Bush Forever Policies, Principles and Processes • State Planning Policy 2.8 Bushland Policy for the Perth Metropolitan Region (WAPC 2005a) • Environment Protection and Biodiversity Conservation Act 1999 (Australian Government) (EPBC Act)	Bennett (2005) recorded and described 25 different vegetation units as occurring in the Proposal area. Keating & Trudgen (1986) recorded 16 vegetation units, one of which was not recorded by Bennett (2005). Eight Floristic Community Types (FCTs) have been identified as occurring onsite (ENV 2010 and Bennett 2005) and were mapped by ENV (2010). One TEC is located within the Proposal area and is in 'good' to 'degraded' condition. Two PECs occur within the Proposal area. Much of the Proposal area is located within the Bush Forever Site 355. Bush Forever Site 355 is 174.5 ha in area of which approximately 107.1 ha is vegetated. A total of 54 vascular plant families, 112 genera and 132 taxa, of which 67 are endemic and 65 are weeds, were recorded by Bennett (2005) and/or ENV (2010). Four DRF and 15 Priority Flora species were identified from the DEC database as potentially occurring in the Cape Peron area (ENV 2010); however no Declared Rare Flora (DRF) or Priority Flora species were recorded during the Bennett (2005) or ENV (2010) survey.	• clearing of vegetation for the development will directly reduce the extent of vegetation communities with minimal disturbance expected to occur to threatened ecological communities (TECs) • creation of new saltwater interface as a result of the land based marina may affect saltwater/freshwater interface dependent vegetation • increased population as a result of development may increase indirect impacts on vegetation through uncontrolled access, rubbish and domestic pets • vehicle movements and earthworks have the potential to introduce and spread weed species • fragmentation of Bush Forever site 355 as a result of clearing for the development • dust generation due to earthworks and vehicle movements has the potential to smother vegetation • potential edge effects to surrounding vegetation from clearing and construction activities.	Clearing of vegetation will be minimised as far as practicable to allow construction and operation to be undertaken in a safe manner. Management strategies include a ground disturbance authorisation procedure, clear demarcation of areas approved for clearing and environmental awareness training to ensure all employees are aware of the requirement to minimise ground disturbance. Implementation of a rehabilitation Program for the remnant vegetation of Cape Peron within the Bush Forever Protection Area including: • weed control program • planting and/or seeding disturbed areas with local provenance species where appropriate • consolidating and formalising walking tracks • fencing where required to protect vegetation • stabilisation of disturbed dune areas • establish a monitoring program to evaluate rehabilitation. Development of an offsets and rehabilitation package in consultation with DEC, OEPA, DoP and the City of Rockingham, to offset the vegetation loss and area excised from the RLRP and Bush Forever Site 355. The potential for the introduction of weeds will be managed through vehicle hygiene procedures for earth-moving equipment during the pre-construction and construction phases. Ongoing weed management will be undertaken through regular weed spraying programs. Dust will be managed through the use of water trucks or other dust suppression methods.	Development will result in the clearing of up to 40 ha of remnant vegetation which has been assessed as being of varying condition. FCT 30a near the corner of Memorial Drive and Safety Bay Road is 4.63 ha in area and is a an example of a TEC. The Proposal will clear 1.93 ha of TEC FCT 30a. It is proposed to retain and consolidate TEC FCT 30a into a more sustainable shape of a remnant of approximately 3.95 ha, where the boundary to area ratio is improved when compared to the current configuration of the remnant. This will comprise the retention of 1.12 ha of Very Good condition vegetation, rehabilitation of 1.61 ha that currently does not support FCT 30a and 1.22 ha of FCT 30a that has been identified as being in Good – Degraded condition. The consolidation of the area of FCT 30a will provide an area slightly less than the current mapped extent and an area of the occurrence which has a better area to boundary ratio. Confidence in the ability of the rehabilitation to improve the values of the remnant TEC occurrence is provided by the fact that the current occurrence of the TEC appears to have been an area of recolonisation / rehabilitation. The Proposal will not result in any vegetation complexes being cleared to less than 10% of the original extent. Approximately 48% of the pre-European extent Quindalup Vegetation Complex remains in the Metropolitan area. No DRF or Priority Flora will be affected by the Proposal. Changes in groundwater quality and levels are not anticipated to impact vegetation in the area The development will provide offsets in accordance with EPA Position Statement No 9.
Terrestrial fauna					
To maintain the abundance, diversity geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement of knowledge. To maintain biological diversity that represents the different plants, animals and microorganisms, the genes they contain and the ecosystems they form, at the levels of genetic diversity, species diversity and ecosystem diversity.	• Wildlife Conservation Act 1950 (WA) (WC Act) • Conservation and Land Management Act 1984 • Environment Protection and Biodiversity Conservation Act 1999 (Australian Government) (EPBC Act) • EPA Position Statement No. 3 (EPA 2002) • EPA Guidance Statement No. 56 (EPA 2004c) • EPA Guidance Statement No. 20 (EPA 2009a)	Bamford (2005) identified 187 non-marine species that either may potentially occur or have previously been recorded in the surveyed area. Surveys within and in the vicinity of the Proposal area recorded 17% of the native mammals, 52% of the birds, 45% of the reptiles and 71% of the amphibians potentially occurring. Six species of migratory birds were found in the survey area, but no other conservation listed species (ENV 2011a). One reptile of conservation significance has been recorded in the Proposal Area (ENV 2011a). Two other reptiles of conservation significance may occur within the Proposal area. No Priority or EPBC listed mammals and amphibians are recorded as occurring in the Proposal area (ENV 2011a). No conservation significant scorpions, millipedes or land snails were found in the Proposal Area. Four terrestrial fauna habitats were identified within the Survey Area: • shoreline habitat • coastal heath habitat • woodland habitat • wetland habitat (ENV 2011a).	• clearing of vegetation for the Proposal will directly disturb fauna habitat, create fragmentation of fauna linkages and may result in the loss of individual terrestrial fauna • vehicle movements and construction activities in the Proposal area may result in the loss or disturbance of individual terrestrial fauna • predation on terrestrial fauna species from introduced domestic pets from the land development • indirect impacts from increase in population degrading habitat quality over time thereby reducing habitat quality for terrestrial fauna • indirect impacts from increase in saltwater interface as a result of the land based marina impacting groundwater-dependent vegetation.	Management measures to minimise the impact of construction and operation of the Proposal on fauna include: • not undertaking clearing outside authorised areas • relocating mammals, reptiles and amphibians prior to clearing where practicable • conducting clearing in stages to allow for the movement of any remaining fauna • limiting noise and vibration that may disturb fauna during construction • restricting the time and length excavated trenches are opened/exposed • preventing vehicle access outside authorised areas during construction, and limiting vehicle speeds inside the construction area • providing suitable areas as conservation offsets • rehabilitating habitat areas in the vicinity of the Proposal area.	The loss of 38.28 ha of habitat, of which 35.2 ha is coastal heathland, 0.01 ha is shoreline, and 2.18 ha is woodland. The Proposal will result in a small reduction in potential Quenda habitat within the Proposal area due to clearing of coastal heathland. Rehabilitation will increase the availability of coastal heathland woodland, and improve the condition of existing habitat outside the Proposal area. The Proposal will result in a small impact to numbers of Perth Lined Skink, Jewelled Ctenotus and Carpet Python. The Proposal is considered unlikely to have an impact on short range endemic or subterranean fauna. The Proposal will result in the clearing of 32.6 ha of GSM habitat; however, the Proposal is unlikely to significantly impact upon GSM population due to the existing habitat fragmentation. The Proposal is not expected to result in significant impact to migratory species as the Proposal area does not support important habitat for these species. The Proposal will result in a significant impact to the potential black cockatoo habitat, with 1 ha of roosting habitat proposed to be cleared.

Marine water quality					
To maintain the integrity, ecological functions and environmental values of the seabed and coast. To ensure that emissions do not adversely affect environmental values or the health, welfare and amenity of people and land use by meeting statutory requirements and acceptable standards.	• State Environmental (Cockburn Sound) Policy 2005 (Cockburn Sound SEP) (Government of Western Australia 2005b). • Western Australian Planning Commission Policy Number DC1.8 (WAPC 1999). • National Health and Medical Research Council Guidelines (NHMRC 2008). • Contaminated Sites Act 2003 (CS Act). • Department of Environment and Conservation Contaminated Sites Management Series (DEC 2010b). • National Assessment Guidelines for Dredging (NAGD; Commonwealth of Australia 2009). • SIMP Management Plan (DEC 2007).	Mangles Bay is sheltered by the Garden Island Causeway and Cape Peron, and is therefore relatively calm and poorly flushed by marine waters under most circumstances, but is exposed to storms from the north (Strategen 2006). **Nutrient enrichment** Chlorophyll-a levels in the shallows of Mangles Bay are generally higher than most other areas in Cockburn Sound, largely due to the reduction in flushing in Mangles Bay caused by the construction of the Garden Island Causeway. Baseline water quality surveys indicate chlorophyll-a levels in the shallows of Mangles Bay do not meet the phytoplankton biomass EQG or EQS set under the Cockburn Sound SEP for high ecological protection, or the EQG for moderate ecological protection (the EQS is met). Nutrient inputs into Mangles Bay come mainly from groundwater discharge and stormwater drainage, largely in organic forms available for plant growth. **Other contaminants** Studies for the Proposal have found low concentrations of metals in groundwater (MWH 2011a). Other contaminants sources include boat traffic and stormwater drainage (including faecal bacteria, metals, antifoulants, and fuels). Contaminant concentrations (metals, hydrocarbons, tributyltin) in sediments to be dredged for the Proposal access channel meet relevant guidelines (NAGD, and Cockburn Sound EQG), as do Mangles Bay sediments adjacent to the channel. Concentrations of ammonia in sediment elutriates also meet the toxicity guideline of the NAGD, and Cockburn Sound EQG for high ecological protection.	• changes to marine water quality (mainly turbidity) during construction may adversely affect marine ecology and function • outflow of marina waters into Mangles Bay may result in changes in turbidity, nutrients, and/or contaminants, which in turn may adversely affect marine ecology and function • changes in flushing of Mangles Bay may affect marine ecology and function • operational aspects with potential to impact on marine water quality include an increase in the number of boats in Mangles Bay and adjacent water, with the potential to release contaminants into the water.	• baseline and ongoing monitoring of water quality and seagrass health at agreed sites • agreed reporting requirements, management triggers for water quality and seagrass health, and required actions if management triggers are exceeded • post construction monitoring of seagrass health it is also proposed to include monitoring of water and sediments in the infiltration ponds used for temporary storage of dredged material, to confirm predictions that overall concentrations of contaminants (especially tributyltin) meet relevant EQG. Operational management plan will include: • fuel spill management plan • maintenance and management plan for marina facilities • codes of conduct for users of the marina • ongoing monitoring of water and sediment quality within the marina • monitoring of seagrass health • addition of sullage facilities. Best Management Practises for stormwater should ensure minimal Increases in stormwater runoff to Mangles Bay from the Proposal area. The realignment of the Lake Richmond drain will also redirect the single largest source of stormwater-borne contaminants into better flushed waters east of the Proposal.	The potential for contaminant release during dredging and disposal is considered very low, as contaminant concentrations in the sediments met NAGD screening levels (Commonwealth of Australia 2009) It is considered that the Proposal will not result in any significant lessening of water quality in Mangles Bay, and that EQC for those environmental indicators that are presently met will continue to do so. Marina waters will also meet WAPC Policy No. DC1.8 guidelines for artificial waterways.

Coastal processes					
To maintain the integrity, ecological functions and environmental values of the seabed and coast.	• Planning and Development Act (2005) • Town Planning and Development Act (1928) • Statement of Planning Policy No. 2.6: State Coastal Planning Policy (SPP2.6) (WAPC 2006) • Sea Level Change in Western Australia – Application to Coastal Planning (DoT 2010)	The shallow sheltered waters of Cockburn Sound (and Mangles Bay) support extensive seagrass meadows and a wide range of marine fauna (Strategen 2010). Cockburn Sound is bound to the west by Garden Island and to the north by Parmelia Bank, resulting in the sound being relatively sheltered from swell energy. Limited swell does penetrate through from the northern entrance to the Sound. The local seas are dependent on wind conditions and basin dimensions. In the southern portion of Cockburn Sound, the locally generated seas have been found to come from the south or south west in summer, and from the west to northwest in winter. The coast where the Proposal is located, experiences diurnal microtidal conditions, with a maximum spring tidal range of 0.6 m. The beaches at Mangles Bay have been identified as low energy beaches. A number of shoreline structures have been constructed in the vicinity of the Proposal area since 1971, the most significant of which is the Garden Island Causeway. The coastline spanning the Proposal area is currently divided into distinct sub compartments by existing coastal structures.	• construction of the marina entrance breakwater and channel which may interrupt longshore sediment transport • construction of the breakwaters may result in the accumulation of seagrass wrack against the structure. In addition to consideration of the potential impacts of the Proposal on coastal processes, the effects of sea level rise and processes on coastal infrastructure need to be considered in the design of coastal structures.	Management, measures to protect the shore from erosion while ensuring that existing and planned recreation areas are not compromised include the installation of coastal defence structures, specifically: • two groynes located on either side of the marina breakwater entrance • buried sea wall adjacent to the development along the beaches within the Proposal area, exact location yet to be finalised • beach nourishment involving deposition of sediment along beaches at Mangles Bay to improve and protect social amenity and public access. The Proponent will undertake management and maintenance works until landscaping handover. The recommended coastal setback allowance calculation, as outlined in SPP 2.6 (WAPC 2003) is comprised of four distinct components, each of which have been addressed for the Proposal (JFA 2011). The calculated setback requirement for the Proposal also considered the management structures and beach nourishment activities which have been incorporated into the Proposal design.	• reorientation of beach profiles at Mangles Bay, with sediment deposition on either side of the marina breakwater • minor seagrass accumulation in the dredge channel and harbour • minimal impact to development and foreshore area by sea level rise and storm events.
Benthic primary producer habitats					
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.	• EPA Environmental Assessment Guideline No. 3 (EPA 2009b) • EPA Environmental Assessment Guideline No. 7 (EPA 2011) • Western Australian Government's Environmental Offsets Policy • EPA Position Statement No. 9 (EPA 2006c) • EPA Guidance Statement No. 19 (EPA 2008b) • State Environmental (Cockburn Sound) Policy 2005 (Government of Western Australia 2005b) • SIMP Management Plan 2007-2017 (DEC 2007)	Cockburn Sound has a history of poor water quality and large scale seagrass loss dating from the 1960s and 1970s. The shallow flats of Mangles Bay contain approximately 100 ha of seagrass. There has been an estimated 3 ha of seagrass loss within Mangles Bay due to mooring scars. Seagrass monitoring was undertaken in January 2010 at one reference site west of the Garden Island Causeway and one potential impact site east of the causeway in Mangles Bay. Shoot density counts were documented based on standard operating procedures established for Cockburn Sound. The median shoot density at the reference site met the 1 year shoot density EQS for high ecological protection but the potential impact site did not (Oceanica 2012) Seagrass monitoring in 2011 measured shoot density counts at four locations adjacent to the Proposal access channel. Three sites met the 1 year EQS for high ecological protection and one site did not, indicating considerable spatial variability in seagrass health (Oceanica 2012). Studies for the Proposal included seagrass transplant trials into mooring scars in Mangles Bay, where traditional moorings were replaced by seagrass-friendly designs. Results indicated regrowth of existing seagrass would achieve infilling of scars in about seven years, and a combination of transplanted seagrass and natural regrowth into the scars would reduce this time to around four to five years	The following aspects of the Proposal have the potential to affect BPPH values: • direct removal of seagrass to allow for the construction of the marina access channel and breakwaters • indirect impacts to seagrass meadows as altered patterns of sediment movement and water flow due to the breakwaters result in the erosion or smothering of seagrass, creating a 'halo' effect around breakwaters • indirect impacts to seagrass meadows as a result of alteration in water quality within Mangles Bay as a result of the creation of the marina.	The proposed dredging program has been designed to avoid or minimise impact on seagrass communities including: • dredging only between April and August when seagrasses are not actively growing • reduced period of dredging (3-4 months) • use of silt curtains to control turbidity release and dispersion. Seagrass health and water quality will be monitored during construction and contingency measures will be implemented, if necessary, to avoid impacts to seagrasses. Trained operators will be employed to operate machinery to ensure the loss of BPPH does not exceed the predicted footprint area. The number of swing moorings in the Mangles Bay area is proposed to be reduced, in turn reducing the damage to seagrass from these types of moorings. A CEMP will be prepared to identify the proposed breakwater and other construction methods and proposed management measures. After construction, seagrass will be monitored for two years through high resolution vertical digital imagery. The cessation of most boat launching activities across the beach adjacent to the Proposal area should reduce scouring damage to seagrass. The realignment of the Lake Richmond drain may also benefit seagrass. Any loss of seagrass will be offset by rehabilitation of at least an equal area of seagrass within Cockburn Sound. The proposed target for the total area of seagrass rehabilitation of 6 ha will exceed the total losses. A Seagrass Rehabilitation Plan will be developed identifying rehabilitation sites, species to be used, transplanting units and techniques, spacing of planting units and monitoring and management measures for transplanted seagrass. Development of an offsets and rehabilitation package for seagrass will be in consultation with OEPA, DEC and CSMC to offset the seagrass loss and area for replanting	The construction of the Proposal will potentially result in the loss of approximately 5.66 ha of direct and indirect seagrass loss. Approximately 1.7 ha of bare, unvegetated habitat (primarily mooring scars) will also be removed. No losses are expected due to turbidity generated during dredging, as this is expected to be minimal. The loss of seagrass will be offset by the rehabilitation of 6 ha of seagrass in Cockburn Sound, but this will probably target areas other than mooring scars. Transplant trials in mooring scars indicate that natural regrowth of existing seagrass should achieve infilling of scars in about seven years, once seagrass-friendly moorings are used (resulting in an estimated 3ha of seagrass). The Proposal is not expected to significantly impact on marine flora.

Marine fauna					
To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge. To maintain the integrity, ecological functions and environmental values of the seabed and coast. To conserve WA's marine environment by managing and reducing the impacts of introduced marine species and by preventing further introduction and spread.	• Wildlife Conservation Act 1950 • Conservation and Land Management Act 1984 • Environmental Protection and Biodiversity Conservation Act 1999 • State Environmental (Cockburn Sound) Policy 2005 (Government of Western Australia 2005b) • SIMP Management Plan 2007-2017 (DEC 2007) • Fisheries Resources Management Act 1994	Mangles bay provides significant habitat for a high fish diversity and abundance, in comparison to the broader Cockburn Sound area, most likely due to its sheltered waters, extensive seagrass meadows close to shore and high availability of food. It is also an important nursery for fish species targeted by fishers and baitfish. Marine invertebrate surveys in Mangles Bay have identified polychaetes, nematodes, amphipods (small crustaceans) and juvenile decapods (e.g. crabs, prawns). The blue swimmer crab, *Portunus pelagicus*, octopus, southern calamari squid and mussels are fished commercially within Cockburn Sound. Common bottlenose and Indo-Pacific bottlenose dolphins occur and forage within Mangles Bay. Leatherback and green turtles are seen occasionally in Cockburn Sound, being visitors brought southwards from tropical waters by storms and/or the southward flowing Leeuwin Current. Loggerhead turtles are more commonly seen. Australian sea lions use the islands of the SIMP as haul-out sites (males only) during the non-breeding season, and are often seen in waters around Garden Island (including Cockburn Sound). A colony of Little Penguins is found on Garden Island. The Southern Right Whale is often seen in Perth coastal waters and may occasionally enter Cockburn Sound. The Humpback Whale is likely to occur offshore of Garden Island but is unlikely to enter Cockburn Sound.	The following aspects of the Proposal may affect marine fauna: • temporary changes in water quality during construction (turbidity, nutrient-related water quality, contaminants) due to dredging and the discharge of return water • ongoing changes in water quality due to outflow of lesser water quality from the marina into Mangles Bay • direct and indirect loss of habitat due to construction of the access channel and breakwaters of the marina • increased risk of introduced marine species due to increased numbers of large recreational vessels berthing in the marina • increased human access causing littering • increased vessel numbers causing increased fishing pressure and the potential for boat strike • increased interactions between humans and marine fauna.	Management measures to reduce potential impact of habitat loss on marine fauna include: • improvement of habitat value of seagrass meadows in Mangles Bay • seagrass transplantation in other areas of Cockburn Sound • no removal of sea wrack • establishment and enforcement of no-wake zones in shallow surface waters • promoting/displaying information on ecological values and appropriate behaviour, sustainable fishing practices, wildlife regulations, boat speeds • providing a base for surveillance, monitoring and research in the marine environment • provision of fishing line discard bins and information signs • patrolling of marina to remove line and other entanglement sources and to support clean up measures • prohibiting fishing within the marina • implementing strict environmental management standards for the marina • encouraging recreational and charter boat owners to participate in penguin monitoring program • encourage and promote best practice measures for refuelling, cleaning vessels, oil spills, bilge water, detergents, stormwater runoff • collaboration with department of fisheries to prevent and respond to incidents of introduced marine pests, or significant amounts of fouling organisms or sediment.	Construction of the Proposal will likely result in: • minor temporary turbidity and noise associated with dredging, with minimal effect on marine fauna • direct loss of 5.66 ha of seagrass meadow and 1.69 ha of bare sediment and offset of 6 ha of seagrass in Cockburn Sound. Operation of the Proposal will likely result in: • increased shore based recreational activity and increased recreational vessels and fishing pressure, which will be offset through management measures described.
Matters of National Environmental Significance					
To provide for the protection of the environment, especially matters of NES, promote ecological sustainable development through the conservation and ecological sustainable use of natural resources and control of international movement of wildlife, wildlife specimens and products made or derived from wildlife.	• Environment Protection and Biodiversity Conservation Act 1999 (Australian Government) (EPBC Act). • Matters of National Environmental Significance: Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999 (DEWHA 2009) • Japan Australia Migratory Bird Agreement (JAMBA) • China Australia Migratory Bird Agreement (CAMBA) • Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) • Ramsar Convention.	Based on previous surveys, databases and literature searches of the Proposal area and surrounds, one endangered terrestrial species and 32 migratory bird species listed under the EPBC Act may occur in the Proposal area. A search using the EPBC Protected Matters Database search identified a number of matters of NES that may occur within the Proposal area as follows: • 3 wetlands of international significance • 2 TECs • 21 threatened species • 23 migratory species • 38 marine species • 13 whales and other cetaceans. *Synemon gratiosa* (GSM) is an endangered day flying moth endemic to the area between Beekeepers National Park (10 km North of Leeman) and Preston Beach (Bishop *et al.* 2010). Two EPBC listed TECs occur within close proximity to the Proposal area.	• vegetation clearing for the development will result in clearing of fauna habitat • construction of a inland marina may result in the inland migration of the saltwater interface and changes to water quality, which may potentially impact fauna habitat and threatened ecological communities • construction of the access channel and breakwater of the marina may result in the direct and indirect loss of marine habitat • increased boat movements and berths may potentially impact fauna habitat and individual fauna species by increasing the risk of introduced marine species, increasing fishing pressure and the increasing the potential for boat strike of marine fauna • increased recreational access may potentially impact fauna habitat through littering • edge effects may potentially impact habitat at Lake Richmond.	Implementation of a CEMP will include management of dredge spoil, dust GSM and noise and vibration. Measures to minimise impacts to matters of NES include: • no clearing outside authorised areas • clearing in stages to allow for fauna movement • planting/seeding of disturbed areas with local provenance species where appropriate • limiting noise/vibration • limiting time and length excavated trenches are open • no vehicle access outside authorised areas and vehicle speed limits imposed • fencing to protect vegetation where required • monitoring to evaluate rehabilitation • offset plan • rehabilitation of areas in vicinity of Proposal area • landscape median strips of Memorial Drive and Safety Bay Rd • designing proposal in water sensitive manner • strategic weed control program.	The Proposal is expected to have minimal impacts on matters of NES, as follows: • reduction in area of available GSM habitat through clearing of 32.6 ha • the Proposal will not result in a significant impact to the potential black cockatoo (Carnaby's and Forest Red-Tailed) habitat (1 ha cleared) or the population of black cockatoo species that may potential occur • terrestrial migratory species – the Proposal is not expected to result in significant impacts to these species • marine migratory species – the Proposal is not expected to result in significant impacts to these species. Overall, there are likely to be some local reductions in fauna populations within the Proposal boundary; but the Proposal is unlikely to significantly affect the regional diversity or abundance as the habitats are well distributed locally and regionally. With management and offsets, it is considered that the Proposal can meet EPA objectives, as well as other applicable policy and guidelines objectives.

Aboriginal and European heritage					
To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.	• Aboriginal Heritage Act 1972 • Native Title Act 1993 (Commonwealth) • EPA Guidance Statement No. 41, "Assessment of Aboriginal Heritage" (EPA 2004d) • Planning Policy 3.1.7 – Heritage Conservation and Development Policy.	Two 'Registered' sites are located within and/or adjacent to the Proposal area: • Lake Richmond (15974) • Rotary Park (3471). Two 'Other Heritage Places' are also included within the vicinity of the Proposal area: • Mooribirdup Ceremonial Ground (22888) • Lake Richmond (352). In April 2011, a detailed consultation program was undertaken to determine the significance of the sites located within / adjacent to the Proposal area. Sites / buildings of European heritage significance include: • Cape Peron Battery Complex • the Point Peron Recreation Camp buildings • the 'Turtle Factory' building.	As a result of the Proposal, one registered heritage site (Rotary Park) and one other heritage site (Mooribidup Ceremonial Grounds) will be affected through the following: • physical disturbance of the land surface during clearing and construction including removal of topsoil and overburden, and landform modification has the potential to disturb heritage sites and affect ethnographic values • presence of construction and operational personnel has the potential to disturb heritage sites, disrupt cultural association meetings and gatherings, and affect ethnographic values.	Where the Proposal may impact on any Aboriginal site, an application to disturb will be made under section 18 of the AH Act. Continue consultation and discussions with heritage site informants and the Native Title Claimants for the area throughout the planning, development and implementation stages of the Proposal. Install public art displays and signage to interpret and present the cultural and historical values held for the area, in close consultation with the Nyungar community. The Nyungar community will be given the opportunity to conduct appropriate proprietary rituals prior to ground disturbance associated with the sites mentioned above. Clearing is to be monitored by a qualified archaeologist and two Nyungar community members. Rehabilitation will be conducted utilising any indigenous seeds and plants are salvaged from the Proposal area. Employment opportunities for Nyungar people will be provided where possible throughout the construction phase of the Proposal. The Proponent will investigate the option for the former Sister Kate's Children's Home site to be leased to the Nyungar community. The site should also be registered with the DIA under the AH Act. Consideration will be given to relocating the Turtle Factory building, however, this may not be plausible given the building is constructed of asbestos material. The Proponent will consult with the relevant government heritage agencies, community groups and the City of Rockingham to determine the best outcome for this building.	The Proposal will potentially affect the cultural heritage values associated with the Cape Peron area, including two Aboriginal heritage sites (Rotary Park and Mooribirdup Ceremonial Grounds) and a European heritage site (the Turtle Factory). An appropriate 'interpretative site' will be established to recognise the Aboriginal heritage values of the area whilst providing for use by the local Aboriginal community as a meeting place. There are also other opportunities to recognise the Aboriginal connections with Cape Peron within the development (e.g. public art, information).
Recreation and public access impact assessment					
To ensure that existing and planned recreational uses are not compromised.	• Perth's Coastal Waters position paper (EPA 2000b) • Draft Perth Coastal Planning Strategy (DPI and WAPC 2008) • RLRP Management Plan (DEC 2010a) • City of Rockingham Strategic Plan 2006-2011 (CoR 2007).	The Mangles Bay foreshore comprises of sandy beaches backed by low sand dunes. A large proportion of this foreshore is presently occupied by the local yacht club, fishing club (with associated jetty and boat ramp) and chalet accommodation. The use of the land by these facilities currently restricts public access to these foreshore areas, although access along the beach is mostly unimpeded. The beach is not a popular swimming area, and beach-based recreation is more focussed on walking, and the launching of boats. Cape Peron is as a popular though neglected sightseeing destination, as well as providing for activities including fishing, walking, exercising dogs, diving, swimming, picnicking and windsurfing (DEC 2010a). Lake Richmond is an attractive expanse of water in an urban setting and is used for walking, bird watching and nature observation (DEC 2010a). Public facilities provided at Cape Peron include lookout points and an extensive walk trail.	• dredge movements may cause temporary disruption to yachting and recreational fishing activities • construction noise may affect recreational amenity • increased turbidity from dredging may affect local fish and crab behaviour and recreational swimming • direct removal of a small amount of beach due to the construction of the access channel and breakwaters to allow access to the marina • interruption of pedestrian traffic flow along the beach due to the access channel and breakwaters • increased traffic and use of both land and water based recreation areas • interruption of adjacent gazetted water-ski area and power craft area • construction of marina will reduce public access to the beach.	The proposed marina development is primarily a boating and tourist facility proposed to cope with the high demand for boating facilities in the City of Rockingham area. Within the Cape Peron and Lake Richmond area of the RLRP, it is proposed to: • improve recreational opportunities by providing hard walking and cycling paths without creating additional disturbance to the natural environment • formalise beach access points, provide parking and remove unnecessary paths to minimise dune erosion • recognise cultural heritage (Aboriginal and European) links with the area (e.g. providing interpretive signage at sites of significance and contributing to the maintenance of these sites) • contribute to research and educational opportunities through the provision of facilities within the marina and interpretative walk trails/signage The Proposal will provide new recreation facilities and funds to positively contribute to the management of the RLRP offset measure.	Overall the Proposal will provide positive outcomes increasing the recreation and tourism values for the Mangles Bay area and the wider Rockingham Region. The Proposal will be developed in accordance with the City of Rockingham's Strategic Plan (CoR 2007) and the RLRP Management Plan (DEC 2010a) targets and vision. Once operational, the Proposal will greatly enhance recreational fishing and yachting activities. There may be some temporary disruption of recreational fishing and yachting due to dredge movements, and effects on fishing movements due to turbidity and noise during construction. The Proposal will improve access to the beach, which is currently constrained by existing land uses.

Conservation areas					
To protect the environmental values of areas identified as having significant environmental attributes. To maintain the integrity, functions and environmental values. To maintain the integrity, ecological functions and environmental values of the seabed and coast.	• National Strategy for Ecologically Sustainable Development (Commonwealth of Australia 1992) • *Australia's Biodiversity Conservation Strategy 2010-2030 (Natural Resource Management Ministerial Council 2010)* • EPA Guidance Statement No. 10 (EPA 2006a) • Bushland Policy for the Perth Metropolitan Region, Statement of Planning Policy 2.8 (WAPC 2005a) • RLRP Management Plan (DEC 2010a) • SIMP Management Plan 2007–2017 (DEC 2007) • State Environmental (Cockburn Sound) Policy (SEP) • Japan Australia Migratory Bird Agreement (JAMBA) • China Australia Migratory Bird Agreement (CAMBA) • Republic of Korea Australia Migratory Bird Agreement (ROKAMBA).	All land within the proposal area south of Point Peron Road is within Bush Forever Site 355 (Government of Western Australia 2000) and within the RLRP. The total area of Bush Forever Site 355 is 174.5 ha of which 106.1 ha is vegetated (Bennett 2005). The remaining 68.4 ha consists predominately of holiday cottages, the Water Corporation waste water treatment plant and recreational camps (Bennett 2005). The development will result in the clearing of approximately 40 ha of Bush Forever Site 355. The RLRP has significant conservation value owing to its geomorphic features, the presence of diverse wetland types, habitat, flora and fauna. The development will result in the clearing of approximately 37 ha within the RLRP or less than 1% of the total area of the RLRP, which covers an area of 4 720 ha. The SIMP covers an area of approximately 6 658 ha and contains the chain of islands that run parallel to the coast between Cape Peron, Becher Point, the waters of Shoalwater Bay, Warnbro Sound and a part of Cockburn Sound off Cape Peron. The SIMP covers an area of approximately 6 658 ha and contains the chain of islands that run parallel to the coast between Cape Peron, Becher Point, the waters of Shoalwater Bay, Warnbro Sound and a part of Cockburn Sound off Cape Peron.	• decrease in the representation of regionally significant bushland in the Swan Coastal Plain portion of the Perth Metropolitan Region as a result of clearing and earthworks associated with the development • fragmentation of bushland as a result of clearing for the development which may disrupt recreational activities and the movement of terrestrial fauna • potential increase in recreational activity and opportunity to better manage recreation • potential loss of visual amenity associated with the natural coastal environment through the development; however, visual amenity may also be enhanced through rehabilitation measures.	An offset package has been formulated to compensate the impacts of the development. The package includes improving the quality of the surrounding Bush Forever Site and the RLRP, rather than buying land elsewhere. A Recreational Management Plan will be implemented with the primary aim of educating recreational users of the Mangles Bay and SIMP of the restrictions on use, to ensure that the conservation values of the SIMP are protected. Establishment of a Mangles Bay Heritage trail with informative signs and displays illustrating the heritage values of the area.	The Proposal is not expected to impact the regional significance of Cape Peron Bush Forever Site 355 or Lake Richmond Bush Forever Site 358, including TECs, fish species, flora and fauna and hydrological regimes of these sites. The proposed rehabilitation within Cape Peron is predicted to improve the biodiversity of the area, consistent with the objectives of the RLRP. The Proposal will not impact directly on the SIMP.
Visual amenity					
To ensure that aesthetic values are considered and measures are adopted to reduce visual impacts on the landscape as low as reasonably practicable. To maintain the integrity, ecological functions and environmental values of landscapes and landforms.	• EPA Guidance Statement No. 33 (EPA 2008) • Visual Landscape Planning in Western Australia manual (WAPC 2007) • State Planning Policy No. 2 (WAPC 2003)	The vantage points of the proposed development were classified into three zones for assessment including: • zone 1 – perimeter • zone 2 – coastline • zone 3 – vantage points. Two primary vantage points were located, including Battery Hill within Cape Peron and the dunal ridge along Shoalwater Bay. The Proposal area will not be visible from John Point in Point Peron which is used frequently by the public.	• clearing vegetation will alter the appearance of the natural environment which may be visible from identified significant sites • physical attributes of significant infrastructure that may obstruct or change views of existing natural features considered aesthetically significant. The infrastructure may, in itself, be aesthetically displeasing.	Existing visual amenity values within, and surrounding the Proposal area will be maintained as far as practicable through the implementation of the following measures: • retaining vegetation associated with areas of public open space • the shore disturbance required for the Proposal is concentrated in the area of existing yacht club activity • aligning roads on existing contours where practicable • avoiding interruption of the natural ridgeline • contributing to rehabilitation and management works in adjacent RLRP • connecting the new development with the existing residential and commercial areas through legible pedestrian access ways • guiding building height and distribution to provide diversity, permeability and limit mass • developing design guidelines that specify architectural designs, colours and materials that blends well with the natural landscape and are visually sensitive to the area • developing a Local Structure Plan that maintains key view corridors • maintaining a landscape buffer around Proposal area that minimizes visual impact on the area • maintaining a landscape buffer along the coastline.	Visual amenity of the coastline and surrounding views is an aesthetic value that may be compromised following the implementation of Proposal, though the view sheds are currently broken by the existing infrastructure, industry and residential housing.

Road traffic					
To ensure that the increase in traffic resulting from the Proposal does not adversely impact on the amenity of social surroundings or increase the risk to local public safety.	Main Roads Western Australia (MRWA) Road Hierarchy Criteria (MRWA 2011) Western Australian Restricted Access Vehicles Network City of Rockingham infrastructure guidelines	The road network within and around the Proposal area consists of local access, local distributor and distributor roads that service the area. These existing roads provide access to Garden Island and direct access to residential, retail, commercial and recreational areas. Key roads connected to the Proposal area: • Point Peron Road • Naval access road • Memorial Drive • Lease Road • Boundary Road • Parkin Street • Rae Road • Safety Bay Road.	• public safety issues (e.g. road traffic and pedestrian safety) • reduction in amenity (e.g. increase in noise emissions from vehicles).	The increased volume of traffic created by both the construction and operation phases of the Proposal may potentially increase public safety issues and / or reduce amenity of the area (e.g. increased noise emissions). In order to mitigate these impacts the following management measures will be incorporated into the Local Structure Plan preparation and design phase: • design of roads according to the City of Rockingham standards • routing of construction traffic to avoid existing high volume and/or residential areas • upgrade of Memorial Drive (Section 21.5.2) to cater for increased demand, including the installation of appropriate intersection controls. A Traffic Management Plan, outlining actions to minimise impacts to safety and amenity will be developed prior to the commencement of construction phase of the Proposal.	It is not anticipated that the increased traffic flow generated by the Proposal will have significant negative impacts on local road traffic. The Proposal will generate increased traffic on the road network in the vicinity of Cape Peron, during both the construction and operation phases. Memorial Drive will be realigned and upgraded to improve traffic flow with multiple road connections to Mangles Bay and the marina. The service corridor will have provision for a dual road to accommodate increased traffic volumes to HMAS Stirling.
Contaminated sites and acid sulfate soils					
To ensure that emissions do not adversely affect environment values or the health, welfare, and amenity of people and land uses by meeting statutory requirements and acceptable standards. To ensure that rehabilitation achieves an acceptable standard compatible with the intended land use and consistent with appropriate criteria.	• Contaminated Sites Act 2003 (WA) • Contaminated Sites Regulations 2006 • Environmental Protection Act (EP Act) • Contaminated Sites Management Series (developed by the DEC) • Acid Sulfate Soils Guideline Series (developed by the DEC) • Australian New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000) • National Ocean Disposal Guidelines for Dredged Material (Commonwealth of Australia 2002) • National Assessment Guidelines for Dredging (Commonwealth of Australia 2009).	A search of the ASS Swan Coastal Plain risk map (DEC 2003) indicated the site was within an area of "low to no risk of ASS occurring within 3 m of the natural soil surface. Results of geotechnical investigations suggest the majority of soil samples contain neutral to alkaline soils with a significant amount of acid neutralising capacity. Concentrations of metals within the sediments to be dredged did not exceed, EILs, HILs or EQGs), indicating that there was a low risk of adverse ecological effects due to dredging or disposal, and that the material was suitable for use on land. Concentrations of ammonia in elutriates of Mangles Bay sediments did not exceed the toxicity guideline of the NAGD or Cockburn Sound EQG for high ecological protection. The median TBT concentration at baseline sediment sampling sites also met the EQG.	• earthworks (excavation and dewatering) have the potential to disturb and expose contaminated soil, sediment and/or water if contamination exists on site • excavation onsite or along service infrastructure corridors has the potential to disturb ASS if they occur on the site • exposure of contaminated sediments during the dredging of the marina access channel.	Management measures will be implemented by the Proponent and include: • undertaking due diligence onshore ASS investigations as part of a dewatering management program • undertaking due diligence ASS monitoring of the access channel during the dredge program • undertaking due diligence ASS monitoring of the dredge spoil from construction of the access channel • stockpiled dredge spoil will be tested for contaminants (such as metals and TBT) on advice from DEC Contaminated Sites Branch • establish a monitoring program encompassing the marina and access channel sediments to monitor the potential for Monosulfidic black ooze formation. • conducting further investigations at three small localised locations of potential contamination, • maintaining an up to date contaminated sites inventory. Any areas of contaminated land within the Proposal area will be identified, remediated and managed by the Proponent for clearance by the DEC prior to the cessation of the construction period and the use of the potential contaminated land by the public and/or residents. The Proponent will maintain a contaminated sites register throughout the pre-construction and construction period at the Proposal area as required by the *Contaminated Sites Act 2003* (WA).	Contaminant levels in the sediment to be excavated are such that ecological values in the vicinity of the Proposal area will not be affected as no EILs or HILs are exceeded, no marine guidelines for sediment are exceeded. Elutriate testing of sediments in the breakwater footprints meet marine water quality guidelines. The risk of ASS (sediments and soil) for this Proposal is negligible and contaminated sites within the Proposal area are unlikely to cause any environmental impacts.

23. Environmental Offsets Strategy

23.1 Policy summary

23.1.1 Western Australian State Government Offsets Policy and Guidance

WA Environmental Offsets Policy, September 2011

The Western Australian Government's *Environmental Offsets Policy September 2011* (Government of Western Australia 2011) seeks to protect and conserve environmental and biodiversity values for present and future generations. The policy is not intended to replace appropriate higher order proactive environmental practices, including avoidance and mitigation.

Offsets are off-site actions to address significant residual environmental impacts of a development or activity. There are two categories of environmental offsets:

1. Direct offsets, which are actions providing for on-ground improvement, rehabilitation and conservation of habitat on a 'like for like' basis. These include the acquisition, restoration, revegetation and rehabilitation of areas outside the Proposal footprint.
2. Indirect offsets are actions aimed at improving scientific knowledge or community awareness of environmental values that are impacted by a development or activity and may include research or contributions to existing State Government initiatives, policies or strategic funds.

When committing to a state environmental offset, the following principles apply:

1. Environmental offsets will only be considered after avoidance and mitigation options have been pursued.
2. Environmental offsets are not appropriate for all projects.
3. Environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being impacted.
4. Environmental offsets will be based on sound environmental information and knowledge.
5. Environmental offsets will be applied within a framework of adaptive management.
6. Environmental offsets will be focussed on longer term strategic outcomes.

An Environmental Offsets Register will be established by the State Government to record all WA offset agreements in a central register. The register will provide transparency and accountability across offset agreements for monitoring, auditing and reporting and will centralise all relevant information regarding offsets across the State.

EPA Position Statement No. 9: Environmental Offsets

The Environmental Protection Authority (EPA) is in the process of updating *Position Statement No. 9: Environmental Offsets* (EPA 2006) and refining the list of critical environmental assets therein. 'Critical assets' represent the most important environmental assets in the State that must be fully protected and conserved for:

- the State to fulfil its statutory and policy requirements
- the State to remain sustainable in the longer term
- the EPA to comply with its general principles for advice and decision making.

For current information on offsets, the statement recommends a referral to the *Guidance Statement No. 19* and *Environmental Protection Bulletin: environmental offsets - biodiversity*. The purpose of this Position Statement is to provide overarching advice about the intent and appropriate use of environmental offsets to the community, government agencies, industry, developers, consultants, business and other key stakeholders. The EPA holds the view that environmental offsets should not be considered in isolation, but

rather as part of an integrated framework for environmental management that includes regulatory and behavioural incentive programs.

EPA Guidance Statement No. 19: Environmental Offsets – Biodiversity

This Guidance Statement (EPA 2008) specifically addresses environmental offsets for proposals or schemes that impact on biodiversity. This Statement provides advice for the development of offsets packages by proponents, which the EPA assesses on a case-by-case basis against the principles established in the WA Environmental Offsets Policy. It identifies the EPA's expectations for development proposals and planning schemes referred to the EPA that have significant adverse impacts on biodiversity assets of 'high' or 'critical' value. The Statement also identifies the responsibilities of the EPA, the Department of Environment and Conservation (DEC) and the Proponent in relation to environmental offsets.

This Statement does not apply to offsets associated with greenhouse gas emissions or other pollutant emissions. There are currently no state greenhouse gas offset policies or guidance notes.

23.1.2 Consultation Draft: *Environment Protection and Biodiversity Conservation Act 1999* Offset Policy, August 2011

The aim of the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) Offsets Policy is to ensure that offsets deliver high quality conservation outcomes for Matters of NES that are protected under the EPBC Act (to improve or maintain viability). It is intended to be applied with flexibility and to provide a transparent framework. It also is intended to provide certainty for proponents and the community and will be applied with scientific rigour. Suitable offset packages must be built around direct offsets; however, they may also include indirect offsets. The size of the offset is to be in proportion to the impact and to the level of statutory protection that applies to the species or community. It is intended that the offset maintains or improves the viability of the species or community while managing the risk that the offset may not succeed through monitoring and management (DSEWPaC 2011a).

Offsets are defined as:

> *measures to compensate for environmental impacts that cannot be adequately reduced through avoidance or mitigation. Offsets do not reduce the impacts of an action. Instead they provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures. These remaining impacts are termed 'residual impacts'* (DSEWPaC 2011a).

Offsets are considered to be a management tool for proponents seeking to undertake an action that will have residual impacts. They are not to be presented at referral stage even though the residual impact should be measureable at this stage. The decision maker will request an offset proposal if it is applicable and will advise the proponent to include them as a condition of approval. As defined in the *Significant Impact Guidelines 1.1: Matters of National Environmental Significance* (DEWHA 2009) offsets are generally not required when no significant impact is likely (DSEWPaC 2011a).

There are two types of offsets: direct and indirect, as outlined below.

Direct offsets

The EPBC Act Offsets Policy requires direct offsets to be aimed at on-ground maintenance and improvement of habitat or landscape values. A minimum of 75% of the total offset points required must be derived from direct offsets. They may include:

- long-term protection of existing habitat – including the acquisition and inclusion of land in the conservation estate, and covenanting arrangements on private land
- restoration or rehabilitation of existing degraded habitat
- re-establishing habitat.

Wherever possible, a 'like for like' approach should be taken, such that the offset measure should target the specific environmental value being impacted by the proposed action.

Contracting this work through an accredited third party organisation or through buying credits in an accredited biodiversity banking scheme is acceptable.

Indirect offsets

Indirect offsets are aimed at increasing knowledge, understanding and management of environmental values to improve the conservation outcomes. Indirect offsets may include:

- implementation of recovery plan actions (including surveys)
- contributions to relevant research or education programs
- removal of threatening processes
- on-going management activities such as monitoring, maintenance, preparation and implementation of management plans etc.

Offsets that have positive socio-economic benefits and build on those required by the state or territory are encouraged. Therefore, a state or territory offset will count toward an offset under the EPBC Act to the extent that it compensates for the residual impact to the protected Matters of NES identified under the EPBC Act. The impact on the protected Matters of NES needs to be well defined to assist with the determination of offsets.

Offsets are required to be readily measured, monitored, audited and enforced. This process is enhanced by setting clear completion criteria, which are regularly monitored. Offsets will be registered to ensure that they are not used more than once and all costs are to be borne by the proponent.

Biodiversity banking schemes based on reproducible and scientifically robust metrics are acceptable as the means of determining the conservation value of the proposed action site and the potential offset. Biodiversity banking schemes encourage private landholders to conserve biodiversity on their land; management actions to improve biodiversity values in perpetuity will count towards the generation of 'biodiversity credits'. Developers could purchase these credits to offset adverse ecological impacts.

The Australian Government has developed eight principles for the use of environmental offsets under the EPBC Act. These are:

1. Environmental offsets should be targeted to the Matters of NES protected by the EPBC Act, that is being impacted.
2. A flexible approach should be taken to the design and use of environmental offsets to achieve long-term and certain conservation outcomes which are cost effective for proponents.
3. Environmental offsets should deliver a real conservation outcome.
4. Environmental offsets should be developed as a package of actions — which may include both direct and indirect offsets.
5. Environmental offsets should, as a minimum, be commensurate with the magnitude of the impacts of the development and ideally deliver outcomes that are ‘like for like’.
6. Environmental offsets should be located within the same general area as the development activity.
7. Environmental offsets should be delivered in a timely manner and be long lasting.
8. Environmental offsets should be enforceable, monitored and audited.

23.2 Overview of impacts

The significant residual environmental impacts of the Proposal, after consideration of other mitigation measures to be applied, are expected to be:

1. Clearance of 1.93 ha of FCT 30a *Callitris preissii* (or *Melaleuca lanceolata*) forest and woodlands, which is identified as a Threatened Ecological Community by the State of Western Australia.
2. Clearing of 32.6 ha of graceful sun-moth habitat and potential direct impact to individuals, with one individual being recorded in the Proposal area.
3. Clearing of approximately 1 ha of woodland assessed as providing potential roosting habitat for Black Cockatoo species.
4. Loss of 5.66 ha of seagrass meadow.
5. Clearance of 37 ha of native vegetation that is located within the Rockingham Lakes Regional Park.
6. Clearance of 40 ha of native vegetation that is located within the Cape Peron Bush Forever Site 355.

23.3 Significance of residual impacts on 'critical' environmental assets

The proposed site is considered a ‘critical’ environmental asset under definitions in EPA Position Statement No. 9 (2006a); given that the Proposal Area constitutes part of a public conservation reserve system (Regional Park); a Bush Forever Reserve; habitat for the Endangered graceful sun-moth; habitat for Black Cockatoo species; part of a threatened ecological community (FCT 30a); and, impacts to marine environments managed by the State Environmental (Cockburn Sound) Policy 2005 (Cockburn Sound SEP) (including Benthic Primary Producer habitat and seagrass meadows).

Given consideration to the scale of the expected residual impact on both ‘critical’ and ‘high value’ assets, the Proponent does not consider there to be any significant adverse impacts to critical assets from the Proposal. Furthermore, together with the offsets package to be negotiated as discussed in the following section (Section 23.4), the Proponent believes that there would be a ‘net environmental benefit’ resulting from implementation of the Proposal, in accordance with EPA objectives. This is considered sufficient to limit application of a presumption of unacceptability of the Proposal.

23.4 Environmental offset strategy

This offset strategy is being developed in consultation with DEC, DoP and DSEWPaC based on the principles set out in EPA Guidance No. 19 (EPA 2008) and Commonwealth draft offsets policy statement (DEWR 2007).

The basic components of the offsets package have been qualitatively defined and are reported in Table 77 (the environmental offsets reporting form prescribed by the EPA [EPA 2008]).

It is intended that a detailed offsets strategy, once agreed with the DEC, DoP and DSEWPaC, will be provided to the EPA at the time of submission of the Summary and Response to Public Submissions on the PER.

The Proponent believes that the finalised offsets strategy would represent a substantial ‘net environmental benefit’ in respect of both ‘critical’ and ‘high value’ assets, and the conservation of Matters of NES. It would provide for adequate mitigation of the residual impact on an area with high biodiversity values, such that the overall outcome can be considered environmentally acceptable, in accordance with EPA objectives.

Table 77 Environmental offsets information

Section A: Administrative information.

1. Proposal or scheme name: Mangles Bay Marina Based Tourist Precinct

2. Summary of proposal or scheme:

The Proponent, Cedar Woods Properties Limited (Cedar Woods) proposes to develop a tourist based marina development located in Mangles Bay, at the southern end of Cockburn Sound. The Mangles Bay Marina Based Tourist Precinct (the Proposal) comprises a single entrance marina to accommodate up to 500 pens and moorings and a surrounding land development comprising tourism, accommodation, commercial, public open space (POS) and residential land uses.

Section B: Type of environmental asset(s) – State whether Critical or High Value, describe the environmental values and attributes.

The proposed site is considered a 'critical' environmental asset under definitions in EPA Position Statement No. 9 (2006a); given that the Proposal Area constitutes part of a public conservation reserve system (Regional Park); a Bush Forever Reserve; habitat for the Endangered graceful sun-moth; habitat for Black Cockatoo species; part of a threatened ecological community (FCT 30a); and, impacts to marine environments managed by the State Environmental (Cockburn Sound) Policy 2005 (Cockburn Sound SEP) (including Benthic Primary Producer habitat, seagrass meadows).

The following is a summary of environmental assets for the Proposal Area:

- occurrence FCT 30a *Callitris preissii* (or *Melaleuca lanceolata*) forest and woodlands, which is identified as a Threatened Ecological Community by the State of Western Australia
- occurrence of two Priority 3 Ecological Communities (State) Priority 3 PECs by the state, FCT SCP30b Quindalup *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands and FCT SCP29b *Acacia* shrublands on taller dunes
- 37 ha of native vegetation that is located within the Rockingham Lakes Regional Park
- 40 ha of native vegetation that is located within the Cape Peron Bush Forever Site 355
- potential for decrease of water levels in Lake Richmond during construction and operation to impact upon values of Lake Richmond which include:
    - Bush forever site 358 (Lake Richmond)
    - TEC (State and Federal) Thrombolite community
    - TEC (State and Federal) FCT 19 a
- approximately 36 ha of graceful sun-moth habitat known to be utilised by at least one individual specimen
- approximately 6 ha of woodland assessed as providing potential roosting habitat for Black Cockatoo species
- likely presence of several Priority vertebrate fauna species (Quenda, Perth lined skink, jewelled ctenotus and carpet python)
- potential presence of EPBC Act listed migratory terrestrial species
- potential presence of migratory marine species
- potential presence of cetaceans
- Benthic Primary Producer habitat (seagrass meadow)
- impact on marine waters within the State Environmental (Cockburn Sound) Policy 2005 (Cockburn Sound SEP).

Section C: Significant impacts (describe the significant adverse environmental impacts related to the proposal or scheme before mitigation measures are applied).

- clearance of 1.93 ha of FCT 30a Callitris preissii (or Melaleuca lanceolata) forest and woodlands, which is identified as a Threatened Ecological Community by the State of Western Australia. The condition of the area FCT 30a proposed to be cleared ranges from Very Good - Degraded
- clearing of 32.6 ha of Graceful Sun Moth habitat and potential direct impact to individuals, with 1 individual being recorded in the Proposal area
- clearing of approximately 1 ha of woodland assessed as providing potential roosting habitat for Black Cockatoo species
- loss of 5.66 ha of seagrass meadow
- clearance of 37 ha of native vegetation that is located within the Rockingham Lakes Regional Park
- clearance of 40 ha of native vegetation that is located within the Cape Peron Bush Forever Site 355
- construction impact of water level reduction 0.42m under 'dry' construction scenario.

Section D: Mitigation measures (describe all measures to Avoid, Minimise, Rectify and Reduce).

Avoid

The Marina concept and design forming the MBTBMP represents a refinement of previous concepts. The design is responsive to those environmental values that have been identified as highly valuable during past assessments.

Having determined (through a community consultation process and Section 16 EPA review) that the Proposal could proceed to assessment under the EP Act, it is difficult to effect substantial changes in design and footprint in order to limit impacts. Notwithstanding these limitations, the following changes to design have been made to avoid impacts:

- the design has been contracted to the north to increase the separation distance between the Marina and Lake Richmond
- the marina breakwater and access channel have been designed to occupy a smaller area
- following an assessment of suitability, dredge spoil will be disposed on the Marina site and sea water captured and returned in a manner that minimises adverse water quality impacts. This alternative (to disposal at sea) avoids impact to a secondary marine site.

Minimise

On the basis of adverse modelling results, the marina construction method has been changed from 'dry' to 'wet' to minimise the need for dewatering. The change in construction methodology represents a significant cost to the Proposal but was considered necessary.

The service corridor providing for the road and Water Corporation infrastructure has been designed to minimise the footprint of this infrastructure.

Following an assessment of suitability, dredge spoil will be disposed on the Marina site and sea water captured and returned in a manner that minimises adverse water quality impacts.

Rectify/Reduce

Long-term impacts would be reduced through the rehabilitation of adjacent native vegetation within the RLRP and Bush Forever Site 355, including significant areas of GSM habitat and the two Priority 3 Priority Ecological Communities.

The rehabilitation of 2.83 ha of FCT 30a *Callitris preissii* (or *Melaleuca lanceolata*) forest and woodlands would also include tuarts for Black Cockatoo habitat.

Cedar Woods would seek to engage the Department of Environment and Conservation to investigate options for the purchase of, or contribution to the purchase of an area of Conservation Estate.

The rehabilitation of 6 ha of seagrass in Cockburn Sound, with the additional potential to rehabilitate swing mooring seagrass scars (estimated at 3 ha) resulting in no net loss.

Cedar Woods would also implement environmental management plans (Appendix 1) to reduce impacts to key environmental assets.

Section F: Proposed offsets for each significant residual impact (identify direct and contributing offsets). Include a description of the land tenure and zoning / reservation status of the proposed offset site. Identify any encumbrances or other restrictions on the land that may impact the implementation of the proposed offset and provide evidence demonstrating how these issues have been resolved.

As offset negotiations are at a preliminary stage, and considering the components of the package carry some commercial sensitivity, a brief description of the offset concepts being considered is provided below. These include a number of options of direct and indirect offsets that could be pursued. These are divided into 'primary' offsets and 'supporting' offsets.

Primary Offsets (Direct and Indirect/Contributing Components).

Rehabilitation of Rockingham Lakes Regional Park and Purchase of Conservation Estate

The Rockingham Lakes Regional Park Management Plan (DEC 2010) identifies the Park's values and management objectives (Management Zones). The Management Plan identifies five (5) management zones, being Conservation and Protection, Natural Environmental Use, Recreation, Special Use and Area Subject to Further Planning (Indicative). The Proposal site is identified by the Management Plan as Area Subject to Further Planning (Indicative), deferring the identification of the Management Zone until the determination of Mangles Bay Marina Based Tourist Precinct.

There is no legal stipulation to the ratio of land affected to land replaced or restored as part of an environmental offset. The Statement of Planning Policy 2.8 does, however, establish environmental offset ratios applicable to Bush Forever sites.

The Proposal area is considered to support an area of 'medium to high' conservation significance. The presence of Graceful Sun Moth habitat and the location of one individual in the Proposal area is assessed as being of conservation significance. The density of GSM recorded on-site and adjacent sites is low (DEC 2011 *pers comm*) and therefore the significance of the isolated, small population requires consideration in the context of more extensive populations located elsewhere on the Swan Coastal Plain.

The site does not support any populations of flora of significance. The site's vegetation ranges from Very Good to Good to Degraded. The site supports the Quindalup Vegetation Complex. Forty-eight percent of the pre-European settlement extent of this complex remains, 20% of this complex is designated as Bush Forever, exceeding the 10% retention objective of this policy. The site supports two FCTs that are listed as Priority 3 PECs - FCT SCP30b Quindalup Eucalyptus *gomphocephala* and/or *Agonis flexuosa* woodlands and FCT SCP29b *Acacia* shrublands on taller dunes. The Proposal will impact upon FCT 29b. This vegetation community type is dominant in the area identified for rehabilitation/restoration effort and is in Good to Degraded condition in this area.

SPP 2.8 establishes an equivalent gain environmental offset ratio of 1:1 for an area of medium conservation significance which is cleared and a net gain ratio of 1:1.5 for an area of high conservation significance. SPP 2.8 notes that gains can include active improvements of quality and/or avoiding potential losses of quality by agreement to forego permitted uses.

On the basis of a ratio of 1:1.5, the Proposal proposes to rehabilitate native vegetation within the Rockingham Lakes Regional Park in the Cape Perron vicinity and purchase an area suitable for inclusion in the Conservation Estate.

Rehabilitation of TEC FCT 30a

FCT 30a near the corner of Memorial Drive and Safety Bay Road is 4.63 ha in area and is an example of a TEC. The Proposal will clear 1.93 ha of FCT 30a. The condition of the area to be cleared ranges from Very Good to Degraded.

Cedar Woods proposes to consolidate the area of FCT 30a via rehabilitation of 1.61 ha that currently does not support FCT 30a and 1.22 ha of FCT 30a that has been identified as being in Good – Degraded condition. The consolidation of the area of FCT 30a will provide an area larger than the current mapped extent and an area of the occurrence which has a better area to boundary ratio. Confidence in the ability of the rehabilitation to improve the values of the remnant TEC occurrence is provided by the fact that the current occurrence of the TEC appears to be an area of recolonisation/rehabilitation.

Graceful sun-moth

Clearing for the Proposal will include graceful sun-moth habitat which has been observed within and adjacent to the development area. Sampling to date has only located three individuals, one within the site and two in the area adjacent to the south (proposed as an area of rehabilitation). The area to the south is contiguous with the site, supports densities of *Lomandra maritima* similar to that supported by the site and is therefore considered to form part of the habitat area for the local population (DEC 2011 *pers comm.*).

The GSM offset proposed seeks to rehabilitate the area directly south of the site. The site is contained with the Bush Forever Protection Area and is within the Rockingham Lakes Regional Park. The site is approximately 35 ha, and currently supports vegetation of Good to Degraded condition. The vegetation communities mapped on the site suggest the site has excellent potential to support greater densities of *Lomandra maritima* and subsequently GSM. Whilst the site does support densities of *Lomandra maritima*, the densities reflect the degraded nature of the site. Rehabilitation of the site would seek to increase the densities of *Lomandra maritima* and increase the habitat values for GSM.

Rehabilitation of seagrass

No net loss of seagrass is allowed in Cockburn Sound as it has been identified as a Category F system under EPA Environmental Assessment Guidelines No. 3.

The EPA's environmental objective in these areas is to ensure no net loss of Benthic Primary Producer habitat and where possible, to generate a net gain in the area of Benthic Primary Producer habitat and/or their associated BPP communities.

The Proposal is expected to result in the loss of approximately 6 ha of seagrass. To compensate for the loss an equal area will be re-established with the Proposal area. A trial seagrass replacement program is currently underway to determine the viability of seagrass replacement in the area. The trial will monitor the seagrass rehabilitation for 12 months. Preliminary results suggest success in the order of 70%; however, conclusions cannot be reached until the completion of a full 12 month trial period. The final results of the trial will be available shortly.

In addition, an opportunity exists for rehabilitation with the removal of the swing moorings currently present in the Bay. The scar area associated with these moorings is estimated at 3 ha. These moorings have a significant combined impact on seagrass. The ability of the Proposal to influence the use of these moorings is under consideration and will be confirmed throughout the EIA process.

Section G: Spatial data relating to offset site/s (see *EPA Guidance Statement No. 19: environmental offsets- biodiversity*, Appendix 4).

Spatial data and metadata statements would be provided to the EPA when the offsets package is finalised. This is expected to coincide with submission of the Summary and Response to Public Submissions on the PER.

Section H: Relevant data sources and evidence of consultation (consultation with agencies, relevant stakeholders, community and references to sources of data/information). Include details of specific environmental, technical or other relevant advice and information obtained to assist in the formulation of the offset.
N/A

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25. List of acronyms and short titles

Short Title/Acronym	Full Title
%	Percentage
µg/l	Micrograms per Litre
AASS	Actual acid sulfate soils
ABA	Acid Base Accounting
AH Act	*Aboriginal Heritage Act 1972*
ACMC	Aboriginal Cultural Material Committee
ADCP	Acoustic Doppler Current Profilers
ANZECC	Australian and New Zealand Environment and Conservation Council
APASA	Asia Pacific Applied Sciences Associates
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASA	Applied Science Associates
ASS	Acid Sulfate Soils
BoM	Bureau of Meteorology
BPPH	Benthic Primary Producer Habitat
CAMBA	China–Australia Migratory Bird Agreements
CEMP	Construction Environmental Management Plan
CITES	Convention on International Trade in Endangered Species
Cockburn SEP	State Environmental Policy (Cockburn Sound)
CoR	City of Rockingham
CS Act	*Contaminated Sites Act 2003*
CSMC	Cockburn Sound Management Council
CSMS	Contaminated Sites Management Series
DEC	Department of Environment and Conservation
DIA	Department of Indigenous Affairs
DIN	Dissolved Inorganic Nitrogen
DO	Dissolved Oxygen
DoF	Department of Fisheries
DoW	Department of Water
DRF	Declared Rare Flora
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EC	Electrical Conductivity
EFDC	Environmental Fluid Dynamics Code
EIL	Ecological Investigation Levels
EMP	Environmental Management Plan
EMS	Environmental Management System
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPP	Environmental Protection Policy
EQC	Environmental Quality Criteria
EQG	Environmental Quality Guidelines
EQO	Environmental Quality Objectives
EQS	Environmental Quality Standards

Short Title/Acronym	Full Title
ESD	Environmentally Sustainable Development
EV	Environmental Values
FCT	Floristic Community Types
GSM	Graceful sun-moth
ha	Hectares
HIL	Health Investigation Levels
IMS	Introduced Marine Species
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JAMBA	Japan–Australia Migratory Bird Agreements
km	Kilometre
L	Litres
L/s	Litres per Second
LAU	Local Assessment Units
LOR	Limit of Reporting
LSP	Local Structure Plan
LWMS	Local Water Management Strategy
m	Metres
m^3	Cubic Metres
MAFRL	Murdoch University's Marine and Freshwater Research Laboratory
mAHD	Metres Australian Height Datum
MBMBTP	Mangles Bay Marine Based Tourism Precinct
MBO	Monosulfidic Black Ooze
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Litre
ML/yr	Megalitres per Year
mol H+/tonne	Moles of Hydrogen per tonne
MPRA	Marine Parks and Reserves Authority
MRS	Metropolitan Region Scheme
MRWA	Main Roads Western Australia
NAGD	National Assessment Guidelines for Dredging
NES	National Environmental Significance
NHMRC	National Health and Medical Research Council
NRMMC	Natural Resource Management Ministerial Council
NTU	Nephelometric Turbidity Units
NWQMS	National Water Quality Management Strategy
OEPA	Office of the Environmental Protection Authority
PAH	Polycyclic Aromatic Hydrocarbons
PASS	Potential Acid Sulfate Soils
PD Act	*Planning and Development Act 2005*
PEC	Priority Ecological Communities
PER	Public Environmental Review
pH	Potential of Hydrogen
POS	Public Open Space
ppt	Parts Per Thousand
PRAMS	Perth Region Aquifer Modelling System

Short Title/Acronym	Full Title
PSI	Preliminary Site Investigation
PWC	Personnel Water Craft
RAV Network	Restricted Access Vehicles Network
RiWI Act	*Rights in Water and Irrigation Act 1914*
RLRP	Rockingham Lakes Regional Park
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
S_{CR}	Chromium Reducable Sulfur
SDOOL	Sepia Depression Ocean Outlet Landline
SE	Standard Error
SEP	State Environmental Policy
SER	Strategic Environmental Review
SIMP	Shoalwater Islands Marine Park
SPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulfate
SRE	Short Range Endemic
SRG	Stakeholder Reference Group
SSFATE	Suspended Sediment FATE
SWALSC	South West Aboriginal Land and Sea Council
SWAN	Simulating Waves Nearshore
TBT	Tributyltin
TDS	Total Dissolved Salts
TSS	Total Suspended Solids
TEC	Threatened Ecological Community
The Marine Park	Shoalwater Islands Marine Park
The Proposal	Mangles Bay Marina Based Tourist Precinct
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
TPS	Town Planning Scheme
TRH	Total Recoverable Hydrocarbons
UCL	Upper Confidence Limit
vpd	Vehicles Per Day
vph	Vehicles Per Hour
WA	Western Australia
WAPC	Western Australian Planning Commission
WC Act	*Wildlife Conservation Act 1950*

List of appendices

Marine Water and Sediment Quality

Mangles Bay Marina-Based Tourist Precinct, Baseline Data Report (Oceanica Marine and Coastal Specialists 2012)

Mangles Bay Marina, Marine Modelling Study (Asia-Pacific Applied Sciences Associates [APASA] 2011)

Coastal Processes

Mangles Bay Marina Based Tourism Precinct Project, Coastal Processes Assessment (TABEC 2011)

Benthic Primary Producer Habitat

Mangles Bay Marina-Based Tourist Precinct, Baseline Data Report (Oceanica Marine and Coastal Specialists 2012)

Marine Fauna

Potential Impacts of the Mangles Bay Marina Based Tourism Precinct on Little Penguins (Cannell 2011)

Potential Impacts of the Proposed Mangles Bay Marina Based Tourist Precinct on Fish and Invertebrates (McLean 2012)

Mangles Bay Marina Based Tourist Precinct: Assessments of Impacts on Bottlenose Dolphins (*Tursiops aduncus*) (Murdoch University School of Biological Sciences & Biotechnology, Centre for Fish and Fisheries Research 2011)

Underwater Noise – Letter from Duncan A to Deshon M (Curtin University 2011)

Aboriginal Heritage

An Aboriginal Heritage Survey of a Proposed Marina and Tourism Precinct at Mangles Bay in Rockingham, Western Australia (Goode 2011)

Traffic

Cape Peron – Proposed Marina & Residential Development, Traffic Report (Transcore 2011)

Proposed Water Corporation Services & Road Cross-Section Option 4 Figure (TABEC 2011)

Contaminated Sites and Acid Sulfate Soils

Cape Peron Preliminary Site Investigation (Strategen 2010)