CHAMPION LAKES MASTERPLAN DEVELOPMENT
LAKE ROAD ARMADALE

PUBLIC ENVIRONMENTAL REVIEW

(EPA ASSESSMENT NO. 1400)

Prepared for:
Western Australian Planning Commission and City of Armadale
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Invitation to make a submission

The Western Australian Planning Commission and the City of Armadale propose to develop the Champion Lakes Masterplan. The Environmental Protection Authority (EPA) invites people to make a submission on this proposal. In accordance with the Environmental Protection Act, a Public Environmental Review (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 4 weeks from 10th February 2003 closing on 10th March 2003. Submissions will help the EPA to prepare an assessment report in which it will make recommendations to Government.

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 by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group 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 more environmentally acceptable.

When making comments on specific elements of 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; and whether you want your submission to be confidential. The closing date for submissions is: 10 March 2003.

Submissions should preferably be emailed to: marie.ward@environ.wa.gov.au
Submissions may also be posted to:

Chairman
Environmental Protection Authority
Westralia Square 141 St George's Terrace
PERTH WA 6000
Attention: MARIE WARD

If you have any questions on how to make a submission, please ring the EPA Project Officer, **Marie Ward**, on (08) 9222 7083. If you have any questions on the PER or aspects of the proposal please call **Gavin Cann** at the City of Armadale on (08) 9399 0111.

EXECUTIVE SUMMARY

Introduction

The City of Armadale and the Western Australian Planning Commission (WAPC), in conjunction with the Armadale Redevelopment Authority, propose to create a regional and international standard sporting facility that will provide a variety of sporting uses. The facility is to be contained within a proposed Regional Park to be named 'Champion Lakes'. A number of water based activities are included in the proposal, together with other associated urban and conservation land uses and concepts.

The Proposal

The proposed location for the facility is approximately 21km southeast of the Perth Central Business District and 4.5km north of the Armadale Town Centre, situated on Lake Road within the City of Armadale.

The current Champion Lakes Preferred Concept Plan provides for the following facilities:

- International standard rowing course and associated facilities;
- Whitewater rafting course and fun park with water based theme;
- Conference centre and short stay accommodation;
- Urban land uses;
- Conservation area and constructed watercourse;
- Aboriginal centre;
- Public launch and picnic area;
- Amphitheatre; and
- A range of potential passive and active recreational facilities which may include:
    - Cable water ski park;
    - Regional sporting stadium;
    - Indoor sport and aquatic centre;
    - Non-designated playing fields;
    - Tennis courts;
    - Fun park with water based theme;
    - Light rail/sky gondola.

The site covers a total area of approximately 138 ha which is predominantly cleared land historically used for agricultural activities, with the seasonal wetland Wright Lake

located at the northern end. The rowing course is the dominant proposed facility, approximately 2,150m long, 130m wide and a minimum of 3.5m in depth. Adjacent to the rowing course a rowing and canoeing warm up lake is proposed, which will be approximately 800m long and 200m wide. With the rowing return lane from the end of the rowing course to the warm up lake, the total open water area within the proposal is 52ha.

The final detailed design stage for the project (i.e. what specific configuration or layout will be implemented into each precinct) has not yet commenced, and will be the subject of a separate planning and landscape study once the environmental assessment of the concept and other feasibility studies have been completed.

Proposal Justification and Alternatives

Considerable analyses over a long period of time have been applied to the selection of a site for an international standard rowing facility and associated uses. The Champion Lakes site has been selected as the preferred site based on a multitude of criteria.

The provision of an international standard rowing and canoeing course will enable Western Australia to host Australian and International events. Further, the project has an unrivalled potential to provide an active recreational focus for current and future communities within the south-east corridor of the Perth Metropolitan Area, with associated social, economic and employment derivatives and benefits.

Importantly, the project has strong links with the Main Roads WA extension of the Tonkin Highway, through a co-operative arrangement whereby soil excavated from the project to form the rowing course may be utilised for fill beneath the highway extension. This outcome has a number of benefits, including the best use of the sand resources at the site, which will result in a reduced need to use other valuable sand resources, and a potential cost benefit to the Champion Lakes Project in that bulk earthworks will be completed as compensation for the sand removed.

Public Environmental Review

This Public Environmental Review (PER) describes the existing environment and the potential environmental impacts resulting from the proposal, together with design and management strategies.

The following relevant environmental factors have been assessed in this PER:

- Terrestrial Flora – Vegetation
- Terrestrial Flora – Threatened Ecological Communities
- Terrestrial Flora – Bush Forever Site No 260
- Terrestrial Flora –Weeds
- Terrestrial Flora - Disease
- Terrestrial Flora – Significant, Declared Rare and Priority Flora
- Fauna
- Wetlands
- Water Quality
- Groundwater Quality
- Contamination (new factor)
- Noise
- Public Risk and Safety
- Light Overspill
- Dust
- Acid Sulphate Soils (new factor)
- Mosquito and Midges
- Aboriginal Heritage and Culture
- European Heritage and Culture

A summary of the EPA's objectives, potential impacts and proposed environmental management for these factors are contained within Table A. A summary of the proponent's commitments is provided in Table B.

TABLE A: SUMMARY TABLE OF ENVIRONMENTAL IMPACTS AND MANAGEMENT

Factor	Site Specific Factor	EPA Objective	Potential Impacts	Environmental Management
BIOPHYSICAL				
Terrestrial Flora	Loss of Terrestrial Flora	Maintain the abundance, species diversity, geographic distribution and productivity of vegetation.	88% of the site is currently cleared or void of terrestrial vegetation. Approximately 8.97ha of the Southern River and Forrestfield Vegetation Complexes, predominantly of Degraded to Completely Degraded condition is proposed to be cleared. Approximately 0.15ha of this vegetation that has some local, and possibly regional, significance. Indirect impacts on the ~7.4ha of remnant vegetation to be retained within the development area comprise: • Temporary alteration to groundwater levels during construction from dewatering; • Potential spread of weeds and diseases; • Dust from construction activities; • Increased use of the conservation areas by residents and visitors as a passive recreation area; • Pressure on wetland vegetation through uncontrolled access; and • Increased potential for fire as a result of adjoining development.	Retention of ~7.4ha of remnant vegetation within the development and creation of a ~21ha conservation reserve. Preparation of a: 1. Construction Environmental Management Plan; and 2. Foreshore Management and Revegetation Plan for the site which includes: • Weed and disease management during construction, followed by a Comprehensive Weed Control Program; • Comprehensive Dust Management Program during construction; • Control of stock, vehicle and human access into the conservation area by erection of fencing and construction of access ways; • Revegetating and restoring conservation areas with appropriate indigenous flora of the Southern River and Forrestfield Complex; • Long-term monitoring of the success of the revegetation and weed eradication program; • Retention or placing of strategic firebreaks around the perimeter of the conservation areas and positioning of fire hydrants in the near vicinity; • Following construction of the development, provision of educational and interpretative materials within the area.
	Threatened Ecological	Maintain the abundance, species	Assigning Floristic Community Types (FCT) could not be done with any certainty given the degraded nature of	As for Terrestrial Flora Retention of: 0.14ha ha of FCT 8, 0.17ha of FCT 10a and a

Factor	Site Specific Factor	EPA Objective	Potential Impacts	Environmental Management
	Communities	diversity, geographic distribution and productivity of vegetation.	the vegetation on the site. Assuming that the assignments provided by Weston (2002) are correct, in a worse case scenario approximately 0.78ha of FCT 3b and 2.6ha of FCT 20b, both very degraded, may be cleared as a result of the development.	minimum of 1.3ha of FCT 20b.
	Bush Forever	Maintain the abundance, species diversity, geographic distribution and productivity of vegetation.	No direct impacts to Bush Forever site No 260. Indirect impacts as described in Terrestrial Flora.	As for Terrestrial Flora
	Spread of Weeds	Ensure that regionally significant flora and vegetation are adequately protected from the spread of weeds.	Weeds currently widely distributed through the study area, including Bush Forever Site no 260, with 90 alien species recorded including four declared plants and 16 Priority 1 weeds.	A Weed Control Program will be developed within the Foreshore Management and Revegetation Plan for the site which will focus on eradicating the declared, and Priority 1 and Priority 2 weed species from conservation areas.
	Spread of Diseases	Ensure that regionally significant flora and vegetation are adequately protected from the spread of diseases, including dieback.	Majority of site considered to be dieback 'uninterpretable' but given level of disturbance considered dieback infected. Three areas considered to be dieback free. During construction dieback could be spread by: • Movement of infested soil and plant matter into uninfested areas during clearing and earthmoving activities; • Movement of infested water into uninfested areas during dewatering and clean-down points; • Movement of infested soil into uninfested areas	The spread of dieback will be controlled by: • The two areas considered to be dieback free that are to be retained in the development are to be demarcated (and fenced for the period of any construction) with appropriate signage. Vehicle, plant or soil movement into any of these stands that is not known to be free of infection will not be taken into or dumped in either of them; • Any plant matter cleared within assumed dieback infested areas must be disposed of in a manner and site selected and approved by CALM;

Factor	Site Specific Factor	EPA Objective	Potential Impacts	Environmental Management
			on vehicles and construction machinery; and • Introducing infested soil, mulch and live plants into uninfested areas during planting and rehabilitation activities. During operation dieback could be spread by: • Movement of infested soil into uninfested areas by maintenance vehicles and machinery; and • Movement of infested water or soil unto uninfested areas in recreational craft.	• All machinery capable of carrying dieback disease from assumed infested to dieback free areas will be cleaned at designated clean-down points; • Machinery will be inspected prior to commencement of work or prior to movement through any dieback free areas; • Stormwater and dewatering spoil will be directed away from dieback free areas. All other areas, including the Tonkin Highway reserve, will be considered to be dieback infested. Dieback management will be detailed and implemented through the Construction Environmental Management Plan and in the Foreshore Management and Revegetation Plan to be prepared for the development.
	Loss of Declared Rare and Priority Flora	Protect Declared Rare and Priority Flora, consistent with the provisions of the Wildlife Conservation Act 1950. Protect other flora of conservation significance.	No loss of, or disturbance to, any populations of Declared Rare and Priority Flora. Some loss of some flora species considered to be poorly reserved on the Swan Coastal Plain.	The JsX+ vegetation type which contains the significant flora species will be protected within the detailed design of the plan.
Terrestrial Fauna including Specially Protected (Threatened)	Potential loss and change in fauna habitat.	Maintain the species abundance, diversity and geographical distribution of fauna. Protect Specially	Two Migratory species protected under the Commonwealth Environmental Protection and Biodiversity Conservation Act, Wanderer Butterfly and Great Egret, have been recorded within the site. 6 other migratory birds are expected to use Wright Lake. 1	The introduction of fish for recreational angling is not recommended. Rehabilitation and habitat creation will occur between Southern River and Wright Lake which will increase the

Factor	Site Specific Factor	EPA Objective	Potential Impacts	Environmental Management
Fauna		Protected (Threatened) Fauna and Priority Fauna species and their habitats, consistent with the provisions of the Wildlife Conservation Act 1950.	Endangered species may also be a regular visitor. 1 Schedule 4 species and 7 Priority species are also known or expected. Potential environmental impacts include: • loss of aquatic invertebrate species that were adapted to changing salinity and seasonality: • reduction of habitat for some waterbirds, particularly migratory waders, that use Wright Lake as it gets shallow and dries; • potential competition from introduced fish for invertebrates; • disturbance to fauna from boating traffic; • supplying habitat suitable for Mosquito fish which may adversely affect aquatic invertebrates and frogs; • introduction of more domestic animals (cats and dogs) to the area; • loss of large trees which are used for roosting and /or nesting by species of birds or bats.	fauna linkage between these two areas. Dogs will only be allowed on leads around the waterbody, while owners of cats will be encouraged to keep them in at night, and preferably at all times. It is proposed to trap Quendas within the densely vegetated portions of the study area a few weeks before construction begins to impact on these areas. The mobility of birds should enable them to escape direct construction impacts however wherever possible timing of the construction around Wright Lake will avoid periods of peak water levels, from July-August through to October-November which coincides with peak breeding and nesting times. This will be addressed in the Construction EMP for the proposal.
Wetlands	Modifications to wetlands within the study area	Maintain the integrity, functions and environmental values of wetlands.	The Southern River Conservation Category wetland vegetation is proposed to be included in a conservation and rehabilitation area within the Champion Lakes Regional Recreation Park Master Plan and will therefore will be protected from any direct impacts. A minimum 50m buffer will provided to this wetland. The most significant potential indirect impacts on the conservation area as a result of increased development will be:	A Construction EMP will be prepared to protect the remnant wetland vegetation proposed to be retained within the development. In order to compensate for wetland impacts the proponent will prepare and implement a Wetland Mitigation Strategy to offset these losses. The objectives for the Strategy will be to: • Avoid direct and minimise indirect impacts on all Conservation Category wetlands. • Avoid impacts on Resource Enhancement and Multiple

Factor	Site Specific Factor	EPA Objective	Potential Impacts	Environmental Management
			• Increased use of the dampland by residents and visitors as a passive recreation area; • Pressure on wetland vegetation through uncontrolled access to the dampland; • Invasion of weeds and possibly diseases through the disturbance of natural habitats; • Change in hydrology; • Increased potential for fire as a result of adjoining residential development. With the exception of Wright Lake, most of the Resource Enhancement or Multiple Use wetlands areas have been cleared or parkland cleared. The construction of the rowing course, rowing facilities, warm up lake and spectator areas will have direct impacts on almost the entire bed of Wright Lake and a large proportion of the wetland and adjoining vegetation (a maximum of approximately 60%). Multiple Use and Resource Enhancement wetlands will also be extensively directly impacted. The most significant impacts relate to the loss of areas for summer shallow feeding areas within Wright Lake and the loss of Aboriginal archaeological and ethnographic sites. Most of the other wetland functions will be retained, enhanced or gained.	Use wetland vegetation wherever possible. • Where Resource Enhancement and Multiple Use wetlands will be impacted, the proponent will ensure no net loss of Resource Enhancement and Multiple Use wetland values and functions. • Impacts to Resource Enhancement and Multiple Use wetlands will be compensated by: - fencing and limiting access by humans and stock into the Conservation Category wetland vegetation at Southern River; - establishing a dryland buffer zone to Southern River from the development; - revegetating and restoring the riverine and wetland vegetation as well as the buffer with the Southern River Vegetation Complex; - undertaking a weed eradication program at Southern River and the conservation area adjacent to Wright Lake; - rehabilitating and restoring part the conservation area and vegetation within the boat launch area adjacent to Wright Lake; - creating and actively maintaining a large permanent waterbody and living stream to enhance and expand the previous wetland functions and values.
Water Quality	Change in local hydrology, hydrogeology and water quality. Release of saline water/pollutants	Ensure that the beneficial uses of surface water can be maintained, consistent with the Australian and New Zealand Guidelines for Fresh	Nutrient concentrations in groundwater exceed the ANZECC/ARMCANZ (2000) trigger values. It is anticipated that top up water quality obtained from the Yarragadee aquifer will comply with the trigger values. It is proposed to utilise superficial aquifer water collected during dewatering in construction to partially fill the waterbody. Combined with the continual mixing	Each component of the development will require the preparation of a Nutrient Management Plan (NMP), as part of the overall drainage, nutrient, irrigation and water quality management plan (DNIWQMP). The DNIWQMP will nominate a monitoring schedule and contingency in the event that unacceptable nutrient levels are detected in the waterbody and groundwater.

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	into aquifer.	and Marine Water Quality (ANZECC 2000). Maintain or improve the quality of groundwater to ensure existing and potential uses are protected.	of the waterbody that will be required during the operation of the rowing course significant dilution of the existing high nutrient groundwater is anticipated. Potential sources of nutrients and pollutants into Wright Lake, the future rowing course and Southern River include a former piggery, landfill and the existing duck farm. Potential contaminants associated with these activities could include trace metals, pesticides, nutrients, phenols, nonyl phenols, solvents, detergents and hydrocarbons. A lined waterbody would isolate the IRC from the surrounding superficial aquifer, which means little exchange between the IRC water and the groundwater would occur. With an unlined waterbody, nutrient rich superficial groundwater could enter the IRC resulting in a higher potential for conditions that result in the development of algal blooms Seepage of brackish water from an unlined IRC is likely to result in an increase in the salinity of Southern/Canning Rivers. It is apparent that the ecology of Wright Lake has adjusted to widely fluctuating salinities. The salinity of an IRC will fluctuate over a much smaller range than the existing Wright Lake. Fringing vegetation will have to be tolerant of brackish conditions. The preferred option is that the IRC waterbody will be lined and therefore isolated from contamination and existing nutrient plumes.	A Preliminary Site Investigation (PSI) has been completed. A detailed site contamination assessment and management will be developed to the satisfaction of the DEP. Once the salinity of the groundwater to be used as top-up water is known, a study will be undertaken to determine the flushing requirements, associated impacts and management options, to the satisfaction of the WRC and DEP. The preferred option is to construct a lined waterbody. This would isolate the waterbody from the groundwater reducing any impacts form saline seepage or high nutrient levels within the superficial aquifer. The evaporation from a lined IRC will result in the concentration of salts over time. The salinity of the water source is unknown but is likely to be brackish. To avoid the excessive build up of salt in the IRC, routine flushing may be required. This may involve discharge back into either the Yarragadee or Leederville aquifers or into Southern River during winter. This flushing could potentially impact the riverine system in terms of water quality but could help restore environmental flows. The overall salinity of the Yarragadee or Leederville aquifers would not be affected by the re-injection of brackish water, as the amount of water injected would be small compared to the overall through flow in the area. Modelling would be undertaken to assist the design and location of injection well/s. If an unlined waterbody was constructed, brackish water would be desalinised using reverse osmosis (RO) prior to the top up of the IRC. Use of RO is unlikely due to the high

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				annual operating costs. If an unlined IRC was constructed, a positive head would be maintained in the IRC to ensure that contaminants and nutrients did not enter the waterbody.
Groundwater Quantity	Changes in local hydrogeology and groundwater abstraction.	Maintain the quantity of groundwater to ensure existing and potential users are protected.	The presence of a rowing course whether lined or unlined will increase the amount of groundwater discharge into the waterbody compared to that currently discharging into Wright Lake, either from through flow or groundwater abstraction. Existing stormwater flows into Southern River will not alter from present. Stormwater from the proposed Champion Lakes development is likely to be recharged to the superficial groundwater or piped directly into the rowing course. Modelling was undertaken to determine the impact of groundwater data to maintain the IRC level based on two water use regimes: - 0.79GL/year (expected use) - 1.42GL/year (worst case scenario) Results indicate that abstraction from the Yarragadee aquifer to supply the bulk of the water requirements and 150Ml/year from the superficial aquifer for the irrigation of public open space will produce the least impact on other groundwater uses and groundwater dependent ecosystems. Modelling predicts an unlined waterbody would result in a drawdown of up to 0.5m from Canning River without top-up water. Drawdown of up to 0.5m is predicted in the superficial aquifer at the Southern River after 25 years if top-up	The preferred option is for the waterbody to be lined with suitable clay or synthetic materials, as available superficial groundwater is insufficient to maintain an average water level of 3.5m. Evaporation and a small amount of seepage within the IRC will result in a requirement for "top up" water derived from an external source. A lined IRC will isolate the waterbody from the superficial aquifer, minimising the drawdown of the Canning and Southern Rivers. Water conservation measures are recognised as important design elements and will be applied within the development. These include (but are not necessarily limited to) the following: • Promote use of plant species which have low water and fertiliser requirements. • Utilise local native varieties. • Consider the collection and transfer of road stormwater drainage to recharge the superficial aquifer or, if the quality is suitable, directly into the IRC. • Promote landscape treatments sympathetic to climatic conditions and prevailing site conditions – soil types, topography, environment, wetlands etc. • Utilise "cluster or clump" plantings to provide useable shade areas and better use of reticulated water in preference to single item or symmetrical planting regimes. • Irrigate grass and garden areas at appropriate times to minimise evaporative and transpiration losses.

Factor	Site Specific Factor	EPA Objective	Potential Impacts	Environmental Management
			water is sourced from the Yarragadee aquifer. The water level in an unlined IRC will be harder to maintain at a constant level, which could affect the development of fringing vegetation and the aesthetics of the IRC. A lined IRC would allow better management of water levels and reduce any potential impacts associated with fluctuating water levels, especially during the establishment of vegetation	• Ensure that irrigation regime is responsive to prevailing weather conditions. Once final design has been developed a Dewatering Program will be developed which will determine the potential impacts of dewatering during the construction phase on the vegetation within the conservation areas, surrounding wetlands, Southern River, Canning River and groundwater quality.
Noise	Noise from construction and recreation facilities.	Protect the amenity of residents from noise impacts resulting from activities associated with the construction and operation of the proposal by ensuring that noise levels meet statutory requirements and acceptable standards.	There are several sources of noise associated with the project which have the potential to impact noise sensitive premises. These include noise from: • Construction activities; • Rowing and whitewater events; • Tonkin Highway; and the • Commercial Area. Noise received at the north east end of the proposed residential area from vehicles travelling along the Tonkin Highway is expected to exceed the DEP acceptable criteria by approximately 1dB(A).	Noise received at the existing residence from construction equipment will need to comply with the requirements of the Environmental Protection (Noise) Regulations 1997 and specifically Regulation 13 “Construction sites”. To ensure that noise emissions from construction activities comply with the regulations, a Construction Noise Management Plan will be developed for this site within the overall Construction Environmental Management Plan. Noise emissions from the PA system will be managed by using a larger number of small speakers carefully positioned along the course. For any large regattas that are going to involve the use of an extensive PA system and possible entertainment after the regatta, a Regulation 18 “Venues used for sporting, entertainment purposes” will need to be obtained for the event. To reduce the possibility of any complaints from any future residences, memorials will be placed on new residential titles to provide a warning that the area is subject to noise generated at the rowing course. Noise emissions from white water generating pumps will be controlled by placing them in acoustic enclosures or at a suitable distance from the residential area.

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Public Risk and Safety	Risks from high pressure gas pipeline and power transmission lines.	Ensure that risk is managed to meet the EPA's criteria for individual fatality risk off-site and the Department of Minerals and Petroleum Resources' requirements in respect of public safety.	A 20m gas pipeline easement is located along the western edge of the future Tonkin Highway, approximately 60m from the western edge of the Champion Lakes development and 275m from any proposed residential development at its closest point. The spectator stands are approximately 60m from the pipeline whilst the remainder of the spectator areas are a minimum of 120m from the pipeline. These separation distances are substantially greater than the 45m required to achieve the $1x10^{-6}$ individual risk criterion. Therefore it is considered that the societal risk to spectators at rowing events is acceptable. A Western Power transmission corridor containing two 330KV transmission lines is located along the western edge of the development area. The environmental risks associated with construction of the proposal in proximity to the development are: • The potential impacts of electromagnetic fields (EMFs) on the amenity and health of residents; • The risk of Earth Potential Rise (EPR) on the Rowing Course; and • The risk of electrocution during construction.	No further mitigation measures to reduce societal risk from the gas pipeline are considered necessary. EMF emissions will be well below NHMRC guidelines and as such will not impact on the health and amenity of residents and the general public. Any rise in soil voltages adjacent to the power lines as a result of EPR will still be within safety guidelines. The main risk associated with the location of the power lines will be that of electrocution to construction personnel. To minimise this risk, the proponent will agree safety guidelines with Western Power prior to the commencement of construction. The guidelines will be documented within the Construction Environmental Management Plan.
Light Overspill	Light overspill from proposed recreation activities.	The EPA's objective in relation to light is to manage potential impacts from light overspill and comply with acceptable standards.	As the detailed planning for the area has not been completed, the distance of any lighting towers to the residences at this stage has not been determined. However, given the proximity of the rowing course and whitewater centre to existing and proposed residences, the issue of light overspill is likely to require definitive preventative measures.	The obtrusive effects of outdoor lighting are best controlled by appropriate design. The design of the lighting systems in the Champion Lakes Regional Recreation Park will be undertaken in accordance with AS4282-1997 and the recommended limits.
Dust	Dust from construction	Protect the surrounding land users such that	Dust and particulate emissions will be generated throughout construction of the project, in particular	Dust arising from construction works and bare ground will be controlled so as to comply with the requirements of the

Factor	Site Specific Factor	EPA Objective	Potential Impacts	Environmental Management
	activities.	dust and particulate emissions will not adversely impact on their welfare and amenity or cause health problems in accordance with EPA's Guidance Statement No 18 Prevention of Air Quality Impacts from Land Development Sites.	during excavation of the *insitu* proposed lake material and general cut and fill activities. The potential for dust nuisance will be highest in summer, when dry soil conditions and strong south-westerly prevailing winds will carry dust towards residential areas to the north-east of the site.	EPA's EIA Guidance No. 18: *Prevention of Air Quality Impacts from Land Development Sites*. Management measures specific to the construction phase will be detailed in a Construction Environmental Management Plan. Dust management will be carried out to the satisfaction of the City of Armadale.
Acid Sulfate Soil	Potential presence of Acid Sulfate Soil	Plan and manage development that may potentially impact on acid sulfate soils to avoid adverse effects on the natural and built environment and human activities and health.	Although Acid Sulfate Soils (ASS) are essentially benign while they remain in an anaerobic state, their disturbance through excavation or drainage works, can present serious potential risks to aquatic ecosystems and the built environment, through conversion of reduced inorganic pyritic sulfides to sulfuric acid. This can lead to adverse changes in the quality of soil water, groundwaters and surface waters. The generation of acidic leachates, combined with the release of significant levels of sulfate and potentially toxic elements such as aluminium, manganese, arsenic and cadmium can cause serious and long-lasting environmental damage.	Design and implementation of a comprehensive ASS Management Plan should ensure that that no unacceptable effects will occur to human health or the environment from the disturbance of soils within the proposed development area.
Contamination	Past land use contamination	To ensure that soil quality is at an acceptable standard compatible with the intended land use, and consistent with appropriate criteria.	A poultry farm, piggeries, orchards and market gardens have historically operated within the site and several abandoned landfills are located within and adjacent to the site. Horticulture, animal based industries and landfills are Potentially Contaminating Land Uses.	Assessment of potential contamination at the identified areas using the staged approach recommended in the *Contaminated Sites Management Series* (DEP, 2001). The next assessment phase will be an initial sampling and analysis program to assess the presence, nature and magnitude of contamination at the identified areas of potential contamination.

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SOCIAL SURROUNDINGS				
Mosquito and Midge	Mosquito and midge breeding habitat.	Protect health, welfare and amenity of existing and future residents.	The potential for increased habitat and breeding grounds for nuisance mosquito and midge populations within the site is considered minimal due to likely water quality, orientation of the course with the prevailing wind, water pumping, aeration, deep design, vegetation buffers and promotion of the establishment of food webs.	Nuisance proportions of mosquitos and midges will be prevented through the methods of mosquito and midge control discussed, which are in accordance with the EPA Guidance Statement No. 40 Management of Mosquitos by Land Developers. Details of further mosquito and midge control, management and monitoring programs will be provided in a Mosquito and Midge Management Plan.
Culture and Heritage	Aboriginal culture and heritage.	Ensure that changes to the biological and physical environment resulting from the proposal do not adversely affect cultural associations with the area. Ensure that the proposal complies with the requirements of the Aboriginal Heritage Act 1972.	Southern River is an ethnographic site. Southern River, which will be protected from the development by a Conservation/Rehabilitation area. Therefore it is considered that the impact on the existing ethnographic site will be negligible. Wright Lake has spiritual significance to some of the Aboriginals consulted during the survey. Wright Lake will be extensively modified. Six archaeological sites have been previously recorded within, or immediately adjacent to, the proposed development area. Three new archaeological sites and two isolated artefacts were identified during the archaeological surveys. Implementation of the preferred option for the development of the Champion Lake Regional Recreational Park will result in the disturbance of most of the recorded sites and the isolated artefacts.	The proponent has applied for clearance under Section 18 of the *Aboriginal Heritage Act 1972* to remove both previously and newly recorded sites located within the PDA that will be impacted by development The proponent will also undertake further archaeological investigations if required as part of the Section 18 clearance. Such investigations may include, but not be limited to: • Surface recording, mapping and collection of archaeological material; • Archaeological excavation and/or sub-surface evaluation; • Recovery of samples for radiometric dating; and • Analysis of recovered material. The proponent has committed to plan and develop an Aboriginal Interpretive Centre as part of the Champion Lakes Regional Recreation Park. In addition, a strategy will be developed which will encourage the employment of aborigines within the centre and throughout the Champion Lakes development.

Factor	Site Specific Factor	EPA Objective	Potential Impacts	Environmental Management
	European Culture and Heritage.	Ensure that changes to the biological and physical environment resulting from the proposal do not adversely affect cultural associations with the area. Ensure that the proposal complies with the Heritage of Western Australia Act 1990.	Sources did not reveal that any European Heritage is present within the site.	Environmental management is not required as there are no European Sites present.

TABLE B: SUMMARY TABLE OF PROPONENTS COMMITMENTS

	Topic	Objective	Action	Timing	Advice
1.	Construction Environmental Management Plan	To protect the remnant wetland vegetation identified for protection within *Bush Forever* and proposed to be conserved within the development from potential impacts associated with construction. To minimise (direct and indirect) impacts associated with the construction of the course and surrounds on fauna, surface and groundwater quality and quantity and local residents.	Contractors and the proponent will prepare a Construction Environmental Management Plan which addresses: • Weed and Disease Management; • Comprehensive Dust Management Program; • Control of stock and human access into the conservation areas by erection of fencing and construction of access ways; • Fire management including retention or placing of strategic firebreaks around the perimeter of the conservation areas; • Quenda Relocation Program; • Dewatering Program to determine and manage the potential impacts of dewatering on the vegetation within the conservation areas, surrounding wetlands, Southern River, Canning River and groundwater quality; • Timing of construction around Wright Lake to avoid wherever possible periods of peak water levels, from July-August through to October-November which coincides with potential for peak bird breeding and nesting times; • Construction Noise Management Plan.	Preparation prior to commencement of site works as applicable to each phase of construction	Bush Forever Office CALM Agriculture WA City of Armadale
2.	Construction Environmental Management Plan	As for Commitment 1	The proponent and contractors will implement the Construction Environmental Management Plan.	During design and construction	Bush Forever Office CALM Agriculture WA City of Armadale

	Topic	Objective	Action	Timing	Advice
3.	Foreshore Management and Revegetation Plan	To protect the conservation values identified for protection within the development adjacent to Wright Lake and Southern River. To mitigate proposed clearing within the development and enhance linkages and habitat value.	The proponent will prepare a detailed Foreshore Management and Revegetation Plan which addresses: • Comprehensive Weed Eradication Program; • Revegetating and restoring conservation areas with appropriate indigenous flora of the Southern River and Forrestfield Complex; • Increase the area and condition of native vegetation contained within Bush Forever Site No. 260; • Creation of habitat and wildlife corridors; • Controlling vehicle and pedestrian access; • Provision of public facilities; • Water conservation and harvesting principles (Commitment 12); • Soil and plant source material hygiene; • Fire management including provision of fire hydrants; • Provision of educational and interpretative materials within the area; • Long-term monitoring criteria to determine the success of the revegetation and weed eradication program; • Progress and Compliance reporting; • Timing and implementation schedule.	Preparation prior to construction of any buildings within the site.	Bush Forever Office CALM Agriculture WA
4.	Foreshore Management and Revegetation Plan	As for Commitment 3.	The proponent will implement the Foreshore Management and Revegetation Plan.	Implementation to be as per determined in Schedule within Foreshore Management and Revegetation Plan.	Bush Forever Office CALM Agriculture WA

	Topic	Objective	Action	Timing	Advice
5.	Wetland Mitigation Strategy	To minimise impacts on wetlands and to offset any wetland impacts to ensure no net loss of function or value.	Implement the Wetland Mitigation Strategy outlined in the PER which: • Avoids direct and minimises indirect impacts on all Conservation Category wetlands. • Avoids impacts on Resource Enhancement and Multiple Use wetland vegetation wherever practicable. • Where Resource Enhancement and Multiple Use wetlands will be impacted, the proponent's objective will be no net loss of Resource Enhancement and Multiple Use wetland values and functions. • Impacts to Resource Enhancement and Multiple Use wetlands will be compensated by: - fencing and limiting access by humans and stock into the Conservation Category wetland vegetation at Southern River; - establishing a dryland buffer zone to Southern River from the development; - revegetating and restoring the riverine and wetland vegetation as well as the buffer with the Southern River Vegetation Complex; - undertaking a weed eradication program at Southern River and the conservation area adjacent to Wright Lake; - rehabilitating and restoring the relevant part of the conservation area and vegetation adjacent to Wright Lake; - creating and actively maintaining a large permanent waterbody and living stream to enhance and expand the previous wetland functions and values.	All phases.	WRC
6.	Overall Drainage Nutrient Irrigation and Water Quality Management	To maintain acceptable water quality within the proposed waterbody and the Southern River.	A Drainage, Nutrient, Irrigation and Water Quality Management Plan (DNIWQMP) will be prepared for the Champion Lakes development as a whole site which will include: • water conservation and harvesting principles (Commitment 12); • nutrient control; • a monitoring schedule;	The overall DNIWQMP is to be prepared prior to subdivision or development of	WRC

	Topic	Objective	Action	Timing	Advice
	Plan		• determination of flushing requirements, associated impacts and management options; and • contingency in the event that unacceptable nutrient levels are detected in the waterbody and groundwater.	any component of the development.	
7.	Overall Drainage Nutrient Irrigation and Water Quality Management Plan	As for Commitment 6.	The proponent will implement or require the implementation of the Drainage Nutrient Irrigation and Water Quality Management Plans.	Implementation for various components as determined within the individual Drainage Nutrient Irrigation and Water Quality Management Plans	WRC
8.	Individual Drainage Nutrient Irrigation and Water Quality Management Plans	As for Commitment 6.	Once detailed planning has been undertaken within each individual component of the development, a more detailed DNIWQMP is required to be prepared to demonstrate how water quality will meet required targets set in the overall DNIWQMP.	Individual DNIWQMP's will be required to be prepared prior to subdivision or development of that individual component of the development.	WRC
9.	Individual Drainage Nutrient	As for Commitment 6.	The proponent will require the implementation of the Drainage Nutrient Irrigation and Water Quality Management Plans.	Implementation for various components as	WRC

	Topic	Objective	Action	Timing	Advice
	Irrigation and Water Quality Management Plans			determined within the individual Drainage Nutrient Irrigation and Water Quality Management Plans	
10.	Site Contamination Assessments	To determine nature and extent of any soil or groundwater contamination present within the site which may pose risk to human health or the environment.	A Preliminary Site Investigation (PSI) has been completed. Potential contamination will be assessed at areas identified in the PSI using the staged approach recommended in the *Contaminated Sites Management Series* (DEP, 2001). The next assessment phase will be an initial sampling and analysis program to assess the presence, nature and magnitude of contamination at the identified areas of potential contamination.	Prior to site works in areas identified in the PSI as potentially contaminated	Land and Water Quality, DEP
11.	Site Contamination Assessments	As for Commitment 10.	The proponent will conduct site contamination assessments for areas identified in the PSI.	Prior to site works in areas identified in the PSI as potentially contaminated	Land and Water Quality, DEP
12.	Water Conservation Principles	Water is an important public resource and availability within the Perth Metropolitan Area is limited.	Water conservation measures are recognised by the proponent as important design elements and will be applied within the development. These include (but are not necessarily limited to) the following: • The waterbody will be lined with suitable clay or synthetic materials to a specified permeability rating, as available superficial groundwater is insufficient to maintain an average water level of 3.5m. • Promote the use of plant species which have low water and	To be considered within preparation of the Foreshore Management and Revegetation	WRC

	Topic	Objective	Action	Timing	Advice
			fertiliser requirements. • Utilise local native varieties in landscaping. • Consider the collection and transfer of road stormwater drainage to the IRC. • Consider re-injection of stormwater into the superficial aquifer. • Promote landscape treatments sympathetic to climatic conditions and prevailing site conditions – soil types, topography, environment, wetlands etc. • Utilise "cluster or clump" plantings to provide useable shade areas and better use of reticulated water in preference to single item or symmetrical planting regimes. • Irrigate grass and garden areas at appropriate time so as to reduce evaporative loss and minimise transpiration losses. • Ensure that irrigation regime is responsive to prevailing weather conditions.	Plan and the DNIWQMPs (Commitments 3 and 6).	
13.	Noise	To maintain amenity of nearby sensitive land uses and to comply with the requirements of the *Environmental Protection (Noise) Regulations 1997*.	Measures to minimise noise levels will include: • using a larger number of small speakers carefully positioned along the rowing course; • Memorials will be considered for new residential titles to provide a warning that the area is subject to noise generated at the rowing course; • Noise emissions from white water generating pumps will be controlled by placing them in acoustic enclosures or at a suitable distance from the residential area.	During the design of the PA system and water pumps, and prior to the subdivision of the residential area.	DEP
14.	Lighting	To protect the amenity of nearby land users and comply with acceptable standards.	The design of the lighting systems in the Champion Lakes Regional Recreation Park will be undertaken in accordance with AS4282-1997 and the recommended limits.	During design of outdoor lighting	
15.	Acid Sulfate Soil	To ensure that that no unacceptable effects will occur to human health or the environment	Design and preparation of an Acid Sulfate Soil Management Plan.	Prior to earthworks or	Land and Water

	Topic	Objective	Action	Timing	Advice
	Management Plan	from the disturbance of soils within the proposed development area.		dewatering in areas identified as having potential for Acid Sulfate Soils	Quality, DEP
16.	Acid Sulfate Soil Management Plan	As for Commitment 15.	The proponent will implement the Acid Sulfate Soil Management Plan.	During construction.	Land and Water Quality, DEP
17.	Mosquito and Midge Management Plan	To prevent nuisance proportions of mosquitos and midges.	Mosquito and midge control, management and monitoring programs will be provided in a Mosquito and Midge Management Plan.	Prior to site activities which generate standing water	WRC Health Department WA
18.	Mosquito and Midge Management Plan	As for Commitment 17.	The proponent will implement the Mosquito and Midge Management Plan.	All phases as determined in the schedule within the Mosquito and Midge Management Plan.	WRC Health Department WA
19.	Archaeological investigations	To fulfil the requirements stipulated on the Section 18 clearance of the *Aboriginal Heritage Act 1972*	The proponent will undertake further investigations which may include, but are not limited to: • Surface recording, mapping and collection of archaeological material; and • Archaeological excavation and/or sub-surface evaluation.	Prior to site works	Department of Indigenous Affairs

	Topic	Objective	Action	Timing	Advice
			A Section 16 permit will be applied for by a qualified archaeologist and relevant Aboriginal people will monitor earth disturbing work during the excavation of Wright Lake and the general development area.		
20.	Aboriginal Interpretive Centre	To provide information and education opportunities on local Aboriginal heritage and culture.	To plan and develop an Aboriginal Interpretive Centre as part of the Champion Lakes Regional Recreation Park. The centre will be used for, among other things, the display of salvaged material. Substantial input into the decisions for the centre will be made by Aboriginal people, particularly those in the Armadale Shire Community. In addition, a strategy will be developed which will encourage the employment of aborigines within the centre and throughout the Champion Lakes development.	During the planning and design of the Champion Lakes Development	Department of Indigenous Affairs
21.	Community Education	To provide information on the sensitive nature of the Champion Lakes environment	Information will be provided to all purchasers within a 'Sense of Place' document the Champion Lakes development advising of: • Water conservation and harvesting measures including recommended landscaping; • Water quality issues and need for nutrient management; • Dog and cat control.	During marketing and selling of land and design of signage within Foreshore Management and Revegetation Plan.	DEP City of Armadale

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1.0 INTRODUCTION

The City of Armadale and the Western Australian Planning Commission (WAPC), in conjunction with the Armadale Redevelopment Authority, propose to create a local and regional sporting facility that will provide a variety of sporting uses for the Armadale region. The facility is to be contained within a proposed Regional Park to be named 'Champion Lakes'. A number of water based activities are included in the proposal, together with other associated urban land uses and concepts.

The Champion Lakes Master Plan proposal was referred by the City of Armadale and the (then) Ministry for Planning (now the Department of Planning and Infrastructure) to the Environmental Protection Authority (EPA) in September 2001, from which the EPA set a level of assessment at Public Environmental Review (PER). Guidelines for the PER were subsequently released by the EPA (Appendix A), and this document has been prepared to satisfy and address these guidelines.

The original referral to the EPA contained two alternative options for the proposal. One option contained an international standard rowing course whilst the other was without a rowing course. Since that time the proponent has resolved to only consider development of this area if the international standard rowing course is part of the proposal. Consequently this PER focuses on the assessment of the option to develop the site with the incorporation of a rowing course constructed to international standards specified by Rowing Australia Inc.

1.1 Background

Since the late 1970's, Western Australian State Planning authorities have clearly identified the need to establish a major active recreational facility in the southeast urban corridor of the Perth Metropolitan Area. This recreational need is reinforced by predicted population trends in the municipalities of Armadale, Gosnells and Serpentine-Jarrahdale.

Several strategic planning documents such as the *Planning Structure for the South East Corridor, Metroplan* and the *South-East Corridor Structure Plan South of Armadale* (refer Section 4.0 of Appendix B) earmarked approximately 136 ha of land situated on Lake Road for the development of a Regional Recreation Park. The land has over time

been reserved for Parks and Recreation in the Metropolitan Region Scheme and been acquired by the Western Australian Planning Commission.

In 1996 the City of Armadale and the (then) Ministry for Planning commissioned the preparation of the Wright Lake Regional Parks and Recreation Reserve Master Plan to establish the requirements and develop a concept for the park. The resultant Master Plan prepared by Hames Sharley (2000) included:

- A sporting and recreational needs assessment;
- A preliminary environmental assessment;
- Recommendations relating to potential commercial and residential uses complementing the primary sporting uses; and
- A schematic Master Plan showing the disposition and stages of uses.

1.2 The Proposal in Brief

The City of Armadale and the State Government have recently formed the Armadale Redevelopment Authority, which aims to stimulate growth in Armadale through development of key public and private sites, including the Champion Lakes Regional Park.

Since the release of the Master Plan and the EPA Guidelines for the project, investigations regarding the feasibility and requirements of Rowing Australia and Canoeing WA, together with consultation with the Armadale Redevelopment Authority and Aboriginal groups, has resulted in several redesigns of the Master Plan (refer to Section 9 of Appendix B).

The current Champion Lakes Preferred Concept Plan (Figure 2) now provides for the following facilities:

- International standard rowing course and associated facilities;
- Whitewater rafting course and water park;
- Conference centre and short stay accommodation;
- Urban land uses;
- Indoor sport and aquatic centre;
- Conservation area and constructed watercourse;
- Aboriginal centre;
- Cable water ski park;

- Amphitheatre; and
- Public launch and picnic area.

The following uses are now no longer anticipated to be part of the proposal:

- Par 3 Pitch and Putt Golf Course;
- Plant nursery;
- Equestrian centre; and
- Artificial planted wetland.

The detailed design stage for the project (i.e. what specific configuration will be implemented into each precinct) has not yet commenced, and will be the subject of a separate planning and landscape study once the environmental assessment and other feasibility studies have been completed. The PER has been prepared assuming that the full extent of the areas allocated within the Champion Lakes Preferred Concept Plan will be fully developed for the designated purpose, and a 'worse case' approach has been adopted within the PER to overestimate rather than underestimate any potential impacts arising from the project, and to derive appropriate management strategies.

1.3 This Public Environmental Review

The preparation of this PER document has been managed and completed by Bowman Bishaw Gorham, however substantial input to its contents has been provided from the following sub-consultants who have imparted specialist services and expertise to the project:

- Masterplan Consultants - Planning and Design;
- MJ and AR Bamford Consulting Ecologists – Fauna and Habitats;
- Dr Arthur Weston – Vegetation and Flora;
- Herring Storer Acoustics – Noise;
- Arbor Vitae - Landscape Architecture;
- TABEC Consulting Engineers – Engineering and infrastructure; and
- * Mc Donald Hales and Associates – Aboriginal heritage and culture.

*not within the PER Study Team

2.0 THE PROPOSALS

2.1 Project Location

The subject land consists of approximately 136 ha of land situated on Lake Road within the City of Armadale. It is located approximately 21km southeast of the Perth central business district and 4.5km north of the Armadale Town Centre (Figure 1). More specifically the site encompasses the following:

- Lot 194 Lake View Terrace;
- Lots 3 and 4 Ypres Road;
- Part Lots 5 and 90 Lake Road;
- Lots 2-7, 11, 13-17, 107 and 108 Lake Road;
- Portion of Lot 212 Lake Road;
- Recreation reserve 38820 and the portion of Lot 213 and Pt Lot 102 reserved under the Metropolitan Region Scheme for Parks and Recreation; and
- The portion of land between the Tonkin Highway Road Reservation and the above lots.

Figure 3 provides an aerial photograph of the project area.

2.2 Project Description

The Champion Lakes Preferred Concept Plan (the Concept Plan, Figure 2) reflects an intention to facilitate the planning and development of the pre-eminent water-based recreation area within Western Australia, incorporating two international standard competition facilities as well as a range of water and land based recreation opportunities (Masterplan, 2002). Table 1 summarises the key characteristics of the Concept Plan, which is described in detail in Section 10 of the Land Management Strategy and Masterplan Concept (Appendix B).

TABLE 1
Key Concept Plan Characteristics

Element	**Description** (all areas approximate)
Proposal Description	A water based recreational park incorporating an international rowing course, an island dedicated to rowing facilities, whitewater rafting facility, conference centre, shops, Aboriginal centre, cable ski and water park, short stay accommodation, indoor sport and aquatic centre, amphitheatre, conservation areas, parking areas, urban land uses, launch area and a residential development
Total area of proposal	~138 ha
Dimensions of rowing course	2150m long x 130m wide, 3.5-4.5m deep
Dimensions of artificial watercourse/rowing return lane	535m long x 30m wide
Dimensions of warm up lake	~800m long x 200m wide
Total Water Area	52.28 ha
Area set aside for conservation	21.07 ha
Area for conference centre, shops, whitewater rafting course, cable ski and water park, short stay accommodation, indoor sport and aquatic centre, amphitheatre and Aboriginal centre	16.5 ha
Spectator area / Start area	8.41 ha
Public Launch and Picnic Area	0.645 ha
Rowing Facility Island Area	6.9 ha
Event Day Parking Area	8.9 ha
Urban land uses	21.4 ha
Construction Duration	~18 months (rowing course only)

(see Figure 2)

2.3 The Proponent

For the purposes of assessment under the *Environmental Protection Act, 1986* the City of Armadale and Western Australian Planning Commission are joint proponents for the project. Subsequent developers, contractors and sporting bodies which become involved in the future design and construction of the facilities will be bound to fulfil the environmental conditions and commitments associated with PER through lease (or other) agreements on the land with the Western Australian Planning Commission and development approvals through the City of Armadale. They will also be bound to comply with development philosophies contained within guidelines for the preparation of future environmental management plans.

2.4 Proposal Implementation

Subject to environmental approval being granted, the Champion Lakes Preferred Concept Plan will be developed over a number of years to service the south-east corridor of the Perth Metropolitan Area, which potentially may contain 325,000 people.

It is anticipated that the construction of the rowing course will be the first stage of development within the site, and will begin in mid to late 2003 and is expected to be completed in 2005. The white water rafting facility is also expected to commence in 2003, and be completed in mid 2004.

The timing for the development of the other facilities and other areas has not yet been determined as further planning studies of the area are still to be conducted, and costs and funding are still largely to be determined. Possible development staging is discussed in Section 11 of Appendix B.

Initial funding for the project is expected to be from the Metropolitan Region Improvement Fund, with subsequent major facilities to be funded through the State Government's Sport and Recreation Facility Program and other sources.

Importantly, the project has strong links with the Main Roads WA extension of the Tonkin Highway, through a co-operative arrangement whereby soil excavated from the project to form the rowing course may be utilised for fill beneath the highway extension. This outcome has a number of benefits, including the best use of the sand resources at the site, which will result in a reduced need to use other valuable sand resources, and a

potential cost benefit to the Champion Lakes Project in that bulk earthworks will be completed as part compensation for the sand removed.

2.5 Community Consultation

During the preparation of this PER and supporting documentation, Bowman Bishaw Gorham, the proponents and the sub-consultants have consulted with the following stakeholder groups:

State Government Agencies
Water and Rivers Commission
Aboriginal Affairs Department
Department of Environmental Protection
Health Department
Department for Planning and Infrastructure
Department of Sports and Recreation
Main Roads WA
Armadale Redevelopment Authority

Local Government
City of Armadale
City of Gosnells
City of Penrith (NSW, home of the Olympic Rowing Facility)

Sporting Bodies
Rowing Australia
Rowing WA
Canoeing WA
Penrith Lakes Development Corporation Limited (Olympic Rowing Facility)

Aboriginal groups
Mr Robert Bropho's group
Bibbulumun Tribal
Independent Environment Group
Walley/Gentle family
Hansen family
Ballaruk Aboriginal Corporation

Heritage Organisations and Individuals
Australian Heritage Commission
Heritage Council of Western Australia
National Trust of Australia (WA)
Friends of Forrestdale
Mrs Emily Rigg
Mr George Csohany

Conservation Organisations
Upper Canning Southern Wungong Catchment Team

Consultations undertaken for previous studies are reported in Hames Sharley (2000).

3.0 JUSTIFICATION OF THE PROPOSALS

3.1 History

Since the late 1970's the State Government has identified a need for a major active recreational facility in the Southeast urban corridor of metropolitan Perth. This need is based on the absence of such a facility in the region and the population growth predictions of Gosnells, Armadale and Serpentine/Jarrahdale.

Strategic planning documents such as the *Planning Structure for the Southeast Corridor, Metroplan* and *the Southeast Corridor Structure Plan South of Armadale* earmarked approximately 136 hectares of rural land including Wright Lake, on Lake Road Kelmscott for the development of a Regional Recreation Park. The land was acquired in the early 1980's for Parks and Recreation by the then Metropolitan Region Planning Authority.

In the mid 1980's the State Planning Commission commenced investigations into the selection of a site for a major international water sports facility. In 1986, a report to the Metropolitan Planning Council outlined the sports requirements and analysed the suitability of five sites for the development of a facility. None of the sites investigated were deemed suitable and it was decided to undertake more extensive investigations for other potential sites.

As a result, a total of 21 sites within the metropolitan area were considered. These were narrowed down to seven and each was analysed in greater detail. Further details on all the alternative sites considered are provided in Section 3.4.

Wood and Grieve Engineers were engaged to carry out preliminary investigations on the seven sites identified by the then State Planning Commission that would provide information to:

1. Establish an international standard rowing course.

2. Incorporate additional aquatic recreational facilities (e.g. windsurfing, canoeing, sailing).

3. Assess the broad costs involved.

4. Examine the viability of incorporating residential and commercial development compatible with the water sports uses proposed.

5. Consider the sensitivity of land ownership, environmental, socio-political implications and timing to cater for major international events.

The study identified Walluburnup Swamp in Wanneroo and the Wright Lake Reserve as the two most favourable sites for the facility.

The environmental values at the Wright Lake site were perceived to be less significant than the Walluburnup site, and the socio-economic benefits considered to be greater for a development situated in the south east corridor that will have an estimated population of 325,000 by 2020.

In 1996 the City of Armadale, in conjunction with the then Ministry for Planning commissioned the preparation of a master plan to establish the requirements and develop a concept plan for the site. Hames Sharley were appointed to undertake the study, which included:

- a sporting and recreational needs assessment,
- a preliminary environmental assessment,
- recommendations relating to potential commercial and residential uses complementing the primary sporting uses, and
- a schematic master plan showing the disposition and stages of uses.

The plan was endorsed in principle and adopted in the South East Regional Sport & Recreation Facilities Strategic Plan supported by the Ministry for Sport and Recreation and the Ministry for Planning in December 1998. The project was officially launched as the Champion Lakes Recreation Park at a ceremony on the shore of Wright Lake in November 2000.

The Department for Sport and Recreation has identified Champion Lakes in its Sporting Facilities Plan as the venue for canoeing and rowing in Western Australia.

In order to gain an insight into the specific design requirements for an international rowing course and artificial white water facility, representatives from DPI, City of Armadale, Water Corporation and the consultant team travelled to Penrith in NSW in February 2002 to view the Olympic Rowing Course and adjacent white water centre. The study team subsequently prepared a preferred design concept for rowing and

canoeing that is considered to be an ideal response to the requirements for the site. The plan has received broad endorsement from all stakeholders.

The plan has made provision for a range of complementary site uses. The proposal as documented makes provision for the following:

- An international rowing course with dimensions of 2150 metres length x 130 metres width x 3.5-4.5 metres depth;
- A practice lake with dimensions of 800 metres x 200 metres for informal mixed aquatic uses (non engine aquatic craft such as windsurfers and sailboats);
- A return channel to the rowing start line;
- An artificial (i.e. engineered structure) white water course to Olympic standard;
- A small retail commercial precinct, comprising retail outlets, conference facilities and short stay accommodation;
- An aquatic and indoor sports centre;
- An Aboriginal interpretive centre;
- Conservation areas;
- A foreshore park with launching ramp adjacent to the practice lake;
- An island to contain the rowing building and services infrastructure (finish box, administration, boat storage, car and trailer parking)
- Urban land uses;
- Area for development of future sporting facilities; and
- A cable ski park.

These uses are considered functionally, economically, and socially compatible with the intent of the reserve.

The site is under the planning and development control of the Armadale Redevelopment Authority (ARA) following the completion and adoption of the Concept Plan for the area subject to the ARA Act. Development control is currently within the City of Armadale.

In the process of preparing a review of the Master Plan further consultation will be undertaken with sporting bodies, residents and the public to further canvas needs and objectives.

3.2 Current Opportunities

There are a number of associated issues and opportunities that are linked to the Champion Lakes Development that impact on the timing and composition of the development. These include the construction of the adjoining Tonkin Highway extensions, construction of an artificial white water kayaking and rafting course and provision of an Aboriginal Centre.

3.2.1 Tonkin Highway Extension

The proponents have entered into discussion, and finalised arrangements for Main Roads WA and its contractors to excavate the proposed water bodies within the Champion Lakes development to win fill material. The fill will be used in the construction of the next stage of the Tonkin Highway that is aligned adjacent to the Champion Lakes site.

This arrangement delivers the following benefits:

- Excavation of the rowing course and adjacent waterbody at no cost that would otherwise cost in excess of $14 m;
- Savings in the construction costs for the Tonkin Highway estimated at $13m; and
- Much of the savings will be utilised by the Contractor in providing and installing the lake floor lining and contouring the banks and balance of the site to the levels outlined in the Master Plan.

3.2.2 Aboriginal Interpretive Centre

Conditional upon gaining approval to develop Wright Lake (which is a registered Aboriginal site) from the Minister for Indigenous Affairs, the proponents have undertaken to develop an Aboriginal interpretive centre in the reserve, under the control of Council, and employ Aboriginal people where possible.

The centre will provide the opportunity for community activities, education and training, displays, and act as a tourist venue under the management of Council's Aborigine and Torres Straight Islander Advisory Committee. It is expected Federal, State and charitable sources will fund the centre.

3.2.3 White Water Course

The Waters and Rivers Commission's *Harvey Basin Surface Water Allocation Plan 1998* has recognised the highly valued recreational activity of white water canoeing on the Harvey River during the irrigation season. Traditionally the water releases from the Stirling Dam have corresponded to an annual water release of 16 – 19 gigalitres. The Water Corporation is therefore obliged to maintain an equivalent water release for white water canoeing on the Harvey River. However, the new Harvey Dam now provides all necessary water for irrigation so the release of 16 – 19 GL from Stirling Dam for canoeists would be surplus to requirements and a waste of drinking water. The Water Corporation has stated (West Australian 9.10.02) that the relocation of canoeists to an artificial course in the metropolitan area could add 14 gigalitres to the Water Corporation's available supply.

Canoeing WA has been pursuing the development of an artificial white water canoeing and rafting centre in the Perth metropolitan area for some time in exchange for giving up the historic right to canoe on the Harvey River. Backed by the Water Corporation, Canoeing WA has been engaged in the preparation of a feasibility study to determine the cost and viability of establishing a white water facility in the Perth metropolitan area.

Champion Lakes, designated as a water themed regional park is the logical place for the white water course to be located.

3.3 Strategic Need for Champion Lakes Development

The Champion Lakes development has been designed to provide significant recreation facilities for the current and future communities of Armadale, Gosnells and Serpentine-Jarrahdale, and the State of Western Australia.

An inventory of all regional open space and recreational facilities in this region was conducted by Hames Sharley (2000). The inventory determined that most facilities in the region cater to local needs and do not provide the infrastructure to warrant categorisation as 'regional' facilities. The analysis also indicated that although the region currently has a sufficient amount of open space allocated to it, the region contained a relatively large amount of passive open space and very few active recreational facilities that would rank as regional assets. There is no active recreational facility that provides a metropolitan-wide focus for the region, such as the Superdrome, Parry Field, WACA or Subiaco Oval.

An international rowing course will provide the state rowing fraternities and athletes with a suitable training and regatta venue. Currently Rowing WA holds any major regattas on the Canning River which due to its uneven depth, tidal movements and variation in wind conditions, creates an uneven course which does not allow for fair, competitive rowing. Consequently Western Australia cannot host any rowing events of national or international standard as it cannot be accredited by Rowing Australia due to these reasons. Australian events like the Kings Cup are no longer held in Perth.

The provision of an international rowing and canoeing course with adequate facilities will enable Western Australia to host Australian and International events. As an example, the World Masters Rowing event which was held in South Australia in 1997 attracting 4,500 competitors, half from overseas, and added $7 m to the South Australian economy.

The rowing course will also provide a fair and competitive venue for canoeing events including Sprint, Canoe Polo and Marathons, whilst the Whitewater Park will be provided to specifically cater for canoeing, kayaking and whitewater rafting. The Whitewater Park will also contain a water park for children and Australia's Moving Water Safety Centre, which will provide training facilities for surf lifesavers, defence force and emergency services personnel.

Both the rowing and whitewater facility will have close links with Western Australian schools, and will provide an opportunity for Western Australian children to participate in rowing/canoeing/kayaking through to Olympic level without the necessity of leaving Western Australia for training purposes.

Both courses will be designed to rigorous international standards, which will allow for the venue to host major State, National and International rowing, kayaking and canoeing events. The courses will attract significant numbers of tourists and are also expected to attract professional competitors from around the world to visit, or live and train in WA, particularly in the northern hemisphere's winter months.

The rowing course will also provide a venue for:

- Sailing;
- Dragon boating;
- Model boating;
- Windsurfing,
- Kite surfing;
- Bike riding, rollerblading and running (5km long dual use path); and
- Triathlons (dependent on ultimate water quality to be determined through monitoring).

The location of the white water park at Champion Lakes with the rowing course and other water sport activities will create a critical mass to attract active recreation, leisure seekers, corporate activities and tourists. This will support the development of convention, function room, short stay accommodation, management courses, other commercial activity and an Aboriginal Interpretive and Tourist centre.

The current plan of the white water park envisages a staff of 100 people. The National Institute of Economic and Industry Research have calculated that the establishment of a white water park at Champion Lakes will generate substantial secondary employment and value to the local economy. Australian and international events will provide greater benefits.

The aquatic facilities and associated development opportunities will have a number of benefits. It will enhance the profile of Armadale and improve its marketability. The park will provide active and leisure lifestyle benefits. There should be a positive effect on land values and there will be property development opportunities. The residential component will attract higher income residents providing social balance and greater disposable incomes.

The Champion Lakes Regional Park will provide a recreational facility for residents in the south-east urban corridor to participate in active and passive water based activities, and provide economic and social benefits.

3.4 Consideration of Alternatives

As described in the previous sections the development of an international rowing course in Western Australia has been discussed and planned for many years.

The (former) Metropolitan Region Planning Authority considered a report in 1977 which proposed a course to be developed on Lake Joondalup. This location was rejected on environmental and cost considerations, and a site at Wallubeunup Swamp was suggested as potentially more suitable.

In September 1979 Cabinet was advised by the (then) Minister for Urban Development and Town Planning that the Metropolitan Region Planning Authority had undertaken investigations, including geological drilling, into assessing the suitability of Wallubeunup Swamp. Cabinet recommended that further potential sites be examined and if they are found to be unsuitable, then the Wallubeunup Swamp option should be investigated in more detail.

The State Planning Commission, on behalf of the W.A. Sports Federation, commenced investigations into the selection of a site for a major international water sports facility in the 1980's based on the following site selection criteria:

- Required length of an international rowing course 2,200m, width 120m and depth of 3m (these requirements have slightly changed since that time);
- Prevailing wind direction and strength, consideration of possible course orientation;
- Areas of land required which are suitable for clubhouse, boat storage, toilets, change rooms, regatta centre, boat launching facilities and spectator viewing, areas for carparking;
- Access to the site to be convenient;
- Potential water quality, quantity and availability;
- Other environmental values including: disturbance to flora and fauna, impact on biological and hydrological systems, nutrient loads, groundwater regimes, algae growth, noise and visual impacts.

In October 1986, a report to the Metropolitan Planning Council indicated that potential sites on the Swan Coastal Plain which meet the requirements for a water sports centre venue were very limited, considering the large physical area required to construct a rowing course. The report analysed the suitability of six sites for the development of the facility:

1. Lake Pinjar, Wanneroo
2. Lake Coogee, Cockburn
3. Port Kennedy, Rockingham
4. Wallubeunup Swamp, Wanneroo
5. Lenzo Road Wetlands, Wanneroo
6. Existing Swan/Canning River

A summary of the identified opportunities and constraints of each of these sites is presented in Table 2.

TABLE 2

Potential Site Selection for an International Water Sports Facility
(Summarised from a Report to State Planning Commission Metropolitan Region from the Director of Environment and Estates in 1986)

Site	Opportunities	Constraints
Lake Pinjar	• Majority of wetland vegetation substantially modified • Large enough lake	• Access to lake difficult • Recommended in System 6 for conservation and recreation • Groundwater abstraction in the area may affect water levels of the lake • Mainly in private ownership
Lake Coogee	• Good accessibility	• Physical dimensions of the site would make it difficult to construct the rowing course to full size • System 6 indicates environmental values • Lake is saline, eutrophic and shallow.
Port Kennedy	• Good accessibility • Complemented by proposed resort development • Saline groundwater would inhabit algae and bacteria growth • Ocean water could be used	• Strong wind exposure on coast • Distance from Perth
Walluburnup Swamp	• Vegetation and terrain offers protection from wind • Sufficient size • Good accessibility • Cost of construction may be offset from sale of diatomaceous earth • Land is owned by the SPC	• High conservation and recreational values • Close proximity to residential uses may preclude power boats • Potential impacts on groundwater regime of the Joondalup/Goolellal Lake system
Lenzo Road wetlands	• Good accessibility • System 6 recognises that wetlands offer limited conservation value • Noise impacts should not be an issue • Can be designed to minimise wind interference • Cost of construction may be offset from sale of diatomaceous earth	• Within Underground Water Pollution Control Area and hydrological impacts is unknown • Possible environmental impacts not known • Land is in private ownership
Existing Swan-Canning River course	• Existing facilities	• Exposed to prevailing winds and tidal fluctuations limit competitive use • Some sections narrow and conflict with other water users, which also disturb the water's surface • Inadequate to cater for all year round training and is becoming increasingly congested.

None of these sites were considered completely suitable, and it was decided to undertake more extensive investigations for other potential sites (State Planning Commission, 1988). As a result, a total of 21 sites within the Metropolitan Area were considered (Appendix C). From these sites seven were selected and analysed in more detail:

1. Walluburnup Swamp, Wanneroo
2. Wright Lake, Armadale
3. Gnangara-Belhus pine plantation
4. Ranford Road, Forrestdale
5. Johnson Road, the Spectacles, Kwinana
6. Station Street, East Cannington
7. Anketell Road, Oakford

Consulting engineers (Wood and Grieve) were engaged to carry out preliminary investigations which included consideration of economic, environmental and social factors, including:

- Accessibility;
- Ownership;
- Zoning;
- Required earthworks volume;
- Geological setting;
- Groundwater regime;
- Environmental regime; and
- Commercial aspects.

Walluburnup Swamp was determined to be the most economically feasible site with a good location. Johnson Road in Kwinana was not considered favourable due to the remoteness, excessive earthworks, and low sand sales values of the area. The Cannington location was considered good, but physical problems and land acquisition in the area were expected to be very significant. The Anketell Road site was located within the Jandakot Underground Water Pollution Control Area, and was not considered to be financially viable.

The Ranford Road site adjacent to the Canning Vale prison required the relocation of a part of Nicholson Road, but otherwise was considered well located. The Gnangara site adjacent to Whiteman Park provided a good location, but abutted the Gnangara Groundwater Mound. This site was considered to be able to be completely privately funded if rezoning of the land proceeded.

The proposed Wright Lake site was considered to have many advantages. In particular the report states:

'Wright Lake is not identified in the System 6 report as an important conservation area and as such it would be more environmentally acceptable from the public and conservation groups point of view.

Some of the degraded land and lake margins could be rehabilitated to provide for wildlife habitat areas.

The development of this facility in this location would have many positive social and economic benefits for the surrounding areas and be a major attraction for the south-east corridor.'

Groundwater capacity at Wright Lake was, however, noted as requiring attention.

The previous section clearly demonstrates that considerable analyses over a long period of time has been applied to the selection of a site for an international standard rowing facility and associated uses. The Wright Lake site has been selected as the preferred site based on the multitude of criteria discussed.

4.0 ENVIRONMENTAL ASSESSMENT – BIOPHYSICAL FACTORS

4.1 Terrestrial Flora - Vegetation

4.1.1 EPA Objective

Maintain the abundance, species diversity, geographic distribution and productivity of vegetation.

4.1.2 EPA Scope of Work

- *Baseline studies by appropriately trained and experienced persons under appropriate seasonal conditions to identify the diversity, distribution and condition of the existing vegetation which may be directly or indirectly impacted by the proposal.*
- *Map and describe the vegetation and relate these mapped units to soil/ landform types.*
- *Describe the area of each vegetation complex and floristic community type to be cleared and provide details of offsets for the loss of significant vegetation. Define areas to be retained.*
- *Discuss whether changes in local hydrology and salinity levels will affect the long-term survival of the vegetation.*
- *Discuss the management required to protect the vegetation and document restoration/regeneration proposals to minimise clearing or loss of vegetation within a landscaping strategy.*
- *Detail how the management measures will be carried out, and to whose satisfaction this work will be done.*

4.1.3 Existing Environment

4.1.3.1 Vegetation Complexes

Approximately 88% of the project area has been cleared of native vegetation for rural activities (Figure 3). Heddle *et al.* (1980) depicts the north eastern "half" of the study area as the Forrestfield Vegetation Complex (Ridge Hill Shelf: 29) and the south eastern "half" as Southern River Complex (42).

Nine percent of the original 11,328 ha of the Forrestfield Complex in the Perth Metropolitan Area remains, and 17% of the original 31,148 ha of Southern River Complex remains. Both percentages are under the 30% "threshold level" specified by the EPA (2000) to remain uncleared.

Only 2% (219 ha) of the original Forrestfield Complex vegetation has some existing protection, and only 6% (1,775 ha) of the original Southern River Complex vegetation has some.

Both complexes are below the 10% threshold level specified by the EPA as needing effective protection, and the general 10% effective protection target adopted in Bush Forever (Government of Western Australia, 2000), though Bush Forever does, in the case of the Forrestfield complex, specify a minimum of 5%. Bush Forever's Policy Measures for Implementation states that there will be a general presumption against clearing bushland containing Threatened Ecological Communities or representation of vegetation complexes of which less than 10% currently remains on the Swan Coastal Plain portion of the Perth Metropolitan Region.

4.1.3.2 Vegetation Units

Vegetation assessment, condition assessment, and rare flora searches of the study area were conducted through field surveys in March, April, July and September 2002 (Weston, 2002). The full report regarding the terrestrial vegetation and flora by Weston (2002) is included as Appendix D.

The system used for describing vegetation types is from Keighery (1994), and Bush Forever (Government of Western Australia 2000, Vol. 2, p. 493). The six-point scale used by Weston (2002) for assessing vegetation condition from Keighery (1994), Trudgen (1991) and Government of Western Australia (2000, Vol. 2, pp. 493-494) is:

1. Pristine — No obvious signs of disturbance.

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

3. Very Good — Vegetation structure altered, obvious signs of disturbance.

4. Good — Vegetation structure significantly altered by very obvious signs of multiple disturbance; basic vegetation structure or ability to regenerate it is retained.

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

6. Completely Degraded — Vegetation structure not intact; the area completely or almost completely without native species (including 'parkland cleared').

Twenty-five vegetation units were identified and mapped in the study area as shown in Figure 4. The condition ratings of the vegetation are shown in Figure 5.

All of the units, except some of the herbaceous vegetation fringing Wright Lake, have ground layers of pasture and other similar vegetation comprising various alien grasses and forbs (non-woody plant other than a grass, rush or sedge), and in several generally more open areas, the weed-like native rush *Juncus pallidus* (Weston, 2002). Most of this vegetation is symbolised on Figure 4 as Wg.

Other natives in the 'pasture' vegetation are very few and localised. There are individual trees and shrubs, both native and non-indigenous, and small groves and thickets of them over some of this ground layer of alien species. The most common and widely occurring woody native over it is the paperbark *Melaleuca preissiana.* However, *Melaleuca rhaphiophylla*, marri, jarrah, *Eucalyptus todtiana*, woody pear, *Banksia menziesii, Banksia attenuata* and *Jacksonia sternbergiana, Astartea* aff. *fascicularis* and *Acacia saligna* occur in some places. The condition of this vegetation is rated 6, Completely Degraded (to 5, Degraded).

There are a few stands of forests and woodlands dominated by paperbark, eucalypt, banksia and woody pear trees in the south-western corner of the study area and near Wright Lake that have more native species and/or plants in their understories. These stands and their locations are:

- *Melaleuca preissiana* and *Melaleuca rhaphiophylla* Low Closed Forests (Mpr+, Mr+) and *Jacksonia sternbergiana* Low Woodland over *Pericalymma ellipticum – Verticordia densiflora* Low to Low Open Shrubland (JsPe+) in the

proposed conservation and rehabilitation area in the western corner of the study area,

- *Eucalyptus marginata – E. (Corymbia) calophylla* Woodland over *Banksia attenuata – B. menziesii – Xylomelum occidentale* Low Woodland to Low Open Forest (EmcBamX+) next to Cammillo Road southwest of Wright Lake,
- *Eucalyptus* (*Corymbia*) *calophylla* Open Forest to Low Open Forest (Ec+) with *Xanthorrhoea preissii* prominent in the understorey, bordering the eastern fringe of Wright Lake, and
- *Jacksonia sternbergiana – Xylomelum occidentale* Low Open Forest to Low Woodland with *Leptospermum laevigatum* weedy shrubs (JsXWs+), northeast of Wright Lake under the transmission lines.

The condition of the above stands is rated 5, Degraded.

The vegetation fringing Wright Lake is in concentric, merging bands of grasses, sedges, rushes and other herbaceous plants, all of which are inundated when the lake is full (Weston 2002). Its condition is rated Degraded, because it is dominated by a mixture of natives and weeds.

Weston (2002) describes the innermost band as comprising mainly two species of native herbaceous plants, *Cotula coronopifolia* and *Wilsonia backhousei*, and the outermost band as characterised by couch grass (*Cynodon dactylon*) and kikuyu grass (*Pennisetum clandestinum*). The native sedge *Baumea juncea* and the weedy grass *Lagurus ovatus* are also conspicuous in the outer layer but are denser and dominant in the next, second band. The weedy grass *Polypogon monspeliensis* is dominant in the third band, and the native sedge *Bolboschoenus caldwellii* is dominant in the fourth band. Weston also recorded restricted stands of *Arundo donax, Typha ?orientalis* and *Cortaderia selloana* in the fringing vegetation.

Two stands of vegetation in the study area have been given condition ratings of 4 (Good) by Weston 2002 because they have fewer weeds and/or more native species in their understories, and higher densities of them than in other stands of vegetation in the study area. One stand is *Jacksonia sternbergiana – Xylomelum occidentale* Low Open Forest to Low Woodland (JsX+) on the south side of Wright Lake in the area between Cammillo Road and the caravan park. This area had more understorey species, and at a higher density, than anywhere else in the study area.

The other stand in Good condition is *Melaleuca viminea – Melaleuca lateritia* Open Heath (Mv+) northeast of Wright Lake under the power transmission lines. This is the southern edge of a stand which is largely within the Tonkin Highway reserve.

Weston (2002) considers that the study area's vegetation is mainly too degraded and weedy to have particular regional significance for its condition, or for the species of plants it contains. Native vegetation (1) in the south-western corner of the study area (JsPe+, K+, Mr+, Mpr+), (2) under the transmission line north of Wright Lake (Mv+) and (3) next to Wright Lake (JsX+, L) has some local, and possibly regional, conservation significance, because it has native plants in its understorey and occurs nowhere else in the study area (Weston 2002). Some of it (JsPe+, Mv+) is poorly represented in the ten Bush Forever sites shown in Figure 6, while some (JsX+, L) appears not to be represented in them at all (Weston 2002).

4.1.3.3 Floristic Community Types

Given there is so little native understorey and ground layer vegetation left within the study area it is impossible to assign most, if any, of the vegetation to any floristic community type with any confidence (Weston, 2002).

Representation of six Floristic Community Types were tentatively inferred by Weston (2002) to be most likely still to be represented in parts of the study area, though by severely degraded stands. The names given in *Bush Forever* (Government of Western Australia, 2000) for these six and map symbols for the study area vegetation types that may correspond to them are shown in Table 3.

4.1.3.4 Flora

Two hundred and fifty five (255) vascular plant taxa have been recorded in the Champion Lakes study area or very near it (Appendix B1 in Appendix D and Weston pers.comm.). No Declared Rare or Priority flora was recorded within the site (See Section 4.6).

Ninety (90) species of weeds and pasture plants are prominent and abundant in all of the vegetation of the study area, and some are aggressive environmental weeds (Weston 2002 and Weston pers. comm.). Section 4.4 of this report provides the details on the weeds and pasture grasses within the site.

Table 3

Tentative Floristic Community Types

(from Weston, 2002)

Floristic Community Type	Name	Map Symbols
FCT 3b	*Eucalyptus calophylla – E. marginata* woodlands on sandy clay soils	Wg, EcmX?
FCT 4	*Melaleuca preissiana* damplands	Mp, MpJ, Mpr+?, A?
FCT 5	Mixed shrub damplands	Mr+, MrpJ?, Mpr+?, K, K+
FCT 8	Herb rich shrublands in clay pans	Mv+
FCT 10a	Shrublands on dry clay flats	JsPe+
FCT 20b	Eastern *Banksia attenuata* and/or *Eucalyptus marginata* woodlands	EtcMpJsX, EmcBamX+, Ec+?, JsXWs+, JsX, JsX+

4.1.4 Potential Environmental Impacts

Approximately 88% of the project area has been cleared of native vegetation for rural activities. Weston (2002) considers the remaining vegetation within the study area, for the most part, too degraded and weedy to have particular regional significance for its condition or for the species it contains.

There are nearby stands of vegetation types similar to most of those in the study area but which are in much better condition and richer in species, e.g. in and on the other side of the proposed Tonkin Highway extension, under transmission lines west of the study area, in the Allen Road reserve, along Southern River, in the southern corner of the Champion Drive – Lake Road junction, and adjacent to parts of Mustang Road (Weston, 2002).

However, native vegetation (1) in the south western corner of the study area near Southern River (JsPe+, K+, Mr+, Mpr+), (2) under the transmission line north of Wright Lake (Mv+) and (3) next to Wright Lake (JsX+, L) has some local, and possibly regional, conservation significance.

All of the vegetation adjacent to Southern River will be protected within a conservation area and will not be impacted directly. The area under the transmission line north of Wright Lake is also proposed for protection in a conservation/landscape area.
Similarly, it is proposed to retain ~2.63ha of the vegetation fringing Wright Lake. Approximately 1.82ha (~40%) of the Degraded vegetation fringing Wright Lake and in JsX+ is proposed to be cleared. Retention of more of the JsX+ vegetation will be considered in the more detailed planning and landscape design of the boat launch and picnic area.

In the remainder of the site a total of approximately 7.6ha of Degraded to Completely Degraded native vegetation in isolated pockets will be cleared, together with some areas of non-native trees.

Potential indirect impacts to the vegetation to be retained include:

- Temporary alteration to groundwater levels during construction from dewatering);
- Potential spread of weeds and diseases;
- Dust from construction activities;
- Increased use of the dampland by residents and visitors as a passive recreation area;
- Pressure on wetland vegetation through uncontrolled access to the dampland; and
- Increased potential for fire as a result of adjoining development.

4.1.5 Proposed Environmental Management

The proposal retains ~7.4ha of remnant vegetation within the development and has set aside ~21ha for the purposes of a conservation reserve. The proponent commits to preparing a Construction Environmental Management Plan and a Foreshore Management and Revegetation Plan to protect the remnant wetland vegetation proposed to be retained from potential impacts associated with future development, prior to site works and commencement of building development. It is essential that the management of the conservation area:

- maintains and encourages species diversity and ecological processes; and
- maintains and enhances natural landscape amenity.

The areas of vegetation proposed for conservation will be fenced and sign-posted prior to construction to prevent any direct impacts by movement of machinery or vehicles into the area. No soil, plant refuse, other rubbish or plant material not known to be dieback free will be permitted within the conservation areas. It is recommended that the fencing

be erected around the vegetation as soon as possible to exclude stock grazing and to promote natural regeneration of the native vegetation (refer Section 5.4 of Appendix D).

The contractor which is awarded the extension to the Tonkin Highway in this locality, by Main Roads WA, is also likely to conduct the bulk earthworks for the Champion Lakes rowing course as part of the arrangement previously described. The contractor will be responsible for the preparation of a Construction Environmental Management Plan that will address the issues associated with the construction of the course and surrounds.

During construction the contractors will be bound to comply with the Construction Environmental Management Plan which requires strict disease, weed and dust control programs, amongst other issues.

Following construction of the course, access to the conservation areas will be controlled by responsive site planning and access provisions. A network of paths will be located in the existing cleared areas wherever possible. Rehabilitation and revegetation of cleared areas will assist in controlling access to the area and protect the conservation values of the core vegetation.

Revegetation will need to be undertaken with suitable local indigenous species of the Southern River or Forrestfield vegetation complexes as appropriate in each area of the site, as far as is practicable. The proponents will consult with relevant experts to choose methods of revegetation and types and sources of seeds and plants for revegetating.

Laying areas of brush and branches cleared from other areas of the site (that are known to be dieback free) between areas planted will deter access over the planted areas and may assist in regeneration. The proponent will employ professional seed collectors to harvest from existing remnant vegetation to contribute to future rehabilitation and revegetation work. Long-term monitoring of the success of the revegetation and weed eradication program will be undertaken.

There is a risk of fire within the area due to the future surrounding residential and sporting development and the proximity of the conservation area to Tonkin Highway. A strategic firebreak should be retained or placed around the perimeter of the conservation areas and fire hydrants will be positioned in the near vicinity.

Following construction of the development the proponent will develop educational and interpretative materials for pedestrians within conservation areas.

In the remainder of the development area mature trees should be retained wherever possible.

Loss of vegetation within the development will be compensated by:

- fencing and limiting access by humans and stock into the Conservation Category wetland vegetation at Southern River;
- revegetating and restoring the riverine and wetland vegetation as well as having a buffer with the Southern River Vegetation Complex;
- undertaking a weed eradication program at Southern River and in the conservation area adjacent to Wright Lake;
- rehabilitating and restoring part the conservation and vegetation within the boat launch area adjacent to Wright Lake.

A preliminary Landscape Strategy for the site, addressing these issues in principle, is presented as Appendix E. Appendix F provides overarching guidelines for the preparation of management plans for vegetation protection and enhancement.

4.2 Terrestrial Flora – Threatened Ecological Communities

4.2.1 EPA Objective

Maintain the abundance, species diversity, geographic distribution and productivity of vegetation.

4.2.2 EPA Scope of Work

As part of the baseline vegetation studies conduct searches for Threatened Ecological Communities.

4.2.3 Existing Environment

Six floristic community types (FCTs) - 3b, 4, 5, 8, 10a and 20b - are tentatively inferred as possibly being represented in parts of the study area, though it must be acknowledged that these are severely degraded stands (Weston, 2002). The map symbols of the vegetation counterparts of these communities, the distribution of the communities in relation to the Perth Metropolitan Region (PMR), and the reservation, conservation and threat statuses for the six FCTs assigned are shown in Table 4.

Weston (2002) considers that these allocations of reservation and conservation status may now be out of date and have limited value, partly because they are based upon analyses that were done over seven years ago, and partly due to the limitations of the definitions.

Assignments to Threatened Ecological Communities (TEC) categories of Endangered (EN) and Vulnerable (VU) of four of the six floristic community types (*Bush Forever* 2000, Vol. 2, p. 491; English and Blyth 1997) are shown in Table 4. The other two floristic community types are not listed in the Threatened Ecological Community database.

TABLE 4

Floristic Community Types and Threatened Ecological Communities Reservation and Conservation Status

(based on Weston, 2002)

Floristic Community Type	Name	Map Symbols	Reservation and conservation status (Gibson *et al.* 1994)	Distribution (Bush Forever 2000)	Threatened Ecological Community Category (after English and Blyth 1997)
FCT 3b	*Eucalyptus calophylla – E. marginata* woodlands on sandy clay soils	EcmX?, Wg	Well Reserved, Vulnerable	>PMR/N	VU
FCT 4	*Melaleuca preissiana* damplands	Mp,MpJ, Mpr+?, A?	Well Reserved, Low Risk	> PMR/C	---
FCT 5	Mixed shrub damplands	Mr+, MpJ?, Mpr+?, K	Well Reserved, Low Risk	PMR+	---
FCT 8	Herb rich shrublands in clay pans	Mv+	Well Reserved, Vulnerable	> PMR/C	VU
FCT 10a	Shrublands on dry clay flats	JsPe+	Well Reserved, Vulnerable	>PMR/N	EN
FCT 20b	Eastern *Banksia attenuata* and/or *Eucalyptus marginata* woodlands	EtcMpJsX, EmcBamX+, Ec+?, JsXWs+, JsX, JsX+	Poorly Reserved, Vulnerable	PMR+/N	EN

Symbols in last two columns:
>: distribution goes well beyond PMR. +: predominantly in PMR.
N: northernmost location is in the PMR. C: PMR is central in the distribution.
EN: Endangered TEC. VU: Vulnerable TEC.

4.2.4 Potential Environmental Impacts

Due to the degraded nature of the vegetation it was not possible to place the vegetation within the sites into the above floristic community types with any certainty. However, if it is assumed that the assignments given above are correct, Table 5 illustrates the potential environmental impact to these TEC's.

TABLE 5
Summary of Potential Impacts to Threatened Ecological Communities

Floristic Community Type	Approximate Area of Vegetation Retained in Conservation (ha)	Approximate Area of Vegetation Proposed to be Cleared (ha)
FCT 3b	0	0.78
FCT 8	0.14	0
FCT 10a	0.17	0
FCT 20b	1.30	2.60
Total	**1.61**	**3.38**

In the worst case scenario, a maximum of 3.38ha of possible Threatened Ecological Communities in Good to Completely Degraded condition will be cleared. The worst case scenario for FCT 20b, which has the largest potential area, is that 2.6ha of JsX+ adjacent to Wright Lake will be cleared. However it is proposed to retain 1.3ha of the JsX+ vegetation within conservation, and more of this vegetation will be considered for retention during the detailed planning and landscape design of the boat launch and picnic area.

4.2.5 Proposed Environmental Management

The proponent commits to preparing a Construction Environmental Management Plan and a Foreshore Management and Revegetation Plan to protect the remnant wetland vegetation proposed to be retained from construction impacts and from potential impacts associated with future development. It is essential that the management of the conservation area:

- maintains and encourages species diversity and ecological processes, and
- maintains and enhances natural landscape amenity.

The management measures committed to by the proponent are discussed in Section 4.1.5 and can be summarised as:

- fencing conservation areas to limit access by humans and stock;
- comprehensive disease, weed and dust control program during construction (which will be addressed in a Construction Environmental Management Plan);
- revegetating and restoring vegetation with indigenous flora of the Southern River and Forrestfield Vegetation Complex within the conservation areas;
- undertaking a weed eradication program within conservation areas;
- long-term monitoring of the success of the revegetation and weed eradication program;
- retaining strategic firebreaks or placing them around the perimeter of the conservation areas and positioning of fire hydrants in the near vicinity;
- following construction of the development, providing educational and interpretative materials within conservation areas;
- retaining mature trees in the remainder of the development area wherever possible.

A preliminary Landscape Strategy for the site, addressing these issues in principle, is presented as Appendix E. Appendix F provides overarching guidelines for the preparation of management plans for vegetation protection and enhancement.

4.3 Terrestrial Flora – Bush Forever Site No 260

4.3.1 EPA Objective

Maintain the abundance, species diversity, geographic distribution and productivity of vegetation.

4.3.2 EPA Scope of Work

- *Discuss the potential impacts on the recommendations for Bush Forever Site No 260.*

4.3.3 Existing Environment

The Environmental Protection Authority's System 6 report identified areas for conservation and recreation (DCE, 1983). The EPA's System 6 recommendations for the Perth Metropolitan Area have now been superseded by the release of Bush Forever

(Government of WA, 2000), which identifies regionally significant vegetation within the Perth Metropolitan Region. The area bordering Southern River at the south-west corner of the site is recommended for protection in both System 6 and Bush Forever. The study area contains one-third of Bush Forever Site 260 – Southern River and Adjoining Bushland, Westfield. The boundary of Bush Forever Site 260 as it relates to the site is shown in Figure 6.

There are several areas of "Other Native Vegetation" noted on Bush Forever maps within the study area, and the former Conservation Category wetland adjacent to Cammillo Road (see Section 4.8) is also mapped.

4.3.4 Potential Environmental Impacts

All of the vegetation adjacent to Southern River contained within Bush Forever Site No. 260 will be protected within a conservation area and will not be impacted directly.

Potential indirect impacts to the vegetation within Bush Forever include:

- Temporary alteration to groundwater levels during construction from dewatering;
- Potential spread of weeds and diseases;
- Dust from construction activities;
- Increased use of the conservation areas by residents and visitors as a passive recreation area;
- Pressure on wetland vegetation through uncontrolled access to the dampland; and
- Increased potential for fire as a result of adjoining development.

4.3.5 Proposed Environmental Management

The proponent has committed to preparing and implementing a Foreshore Management and Revegetation Plan which intends to result in an overall increase in the area and condition of native vegetation contained within Bush Forever Site No. 260. The Plan, and/or the Construction Management Plan, will require the following elements:

- Weed and disease management during construction, followed by a comprehensive weed eradication program;
- Comprehensive dust management program during construction;
- Control of stock and human access into the conservation area by erection of fencing and construction of access ways;

- Revegetating and restoring the conservation area with appropriate indigenous flora of the Southern River Complex;
- Long-term monitoring of the success of the revegetation and weed eradication program;
- Strategic firebreaks to be retained or placed around the perimeter of the conservation areas and a fire hydrant will be positioned in the near vicinity;
- Following construction of the development, provision of educational and interpretative materials within the area.

A preliminary Landscape Strategy for the site, addressing these issues in principle, is presented as Appendix E. Appendix F provides overarching guidelines for the preparation of management plans for vegetation protection and enhancement.

It is anticipated that any temporary alteration to groundwater levels during construction from dewatering will be managed through a "cell" approach by the contractor, together with seasonal and spatial timing. Each excavation cell would be small to limit dewatering requirements. As each cell is completed, dewatering from the next cell would be discharged to the previously completed and cell regardless of whether it is lined or unlined. This approach is common in excavations of this type, and will be documented in detail in the Construction Management Plan and subsequently approved prior to implementation.

4.4 Terrestrial Flora – Weeds

4.4.1 EPA Objective

Ensure that regionally significant flora and vegetation are adequately protected from the spread of weeds.

4.4.2 EPA Scope of Work

- *Identify any weeds which may potentially cause adverse impacts as a result of implementation of the proposal.*
- *Identify the habitats that are most vulnerable to weed invasion.*
- *Describe proposed management measures to prevent or mitigate the impacts of weed invasion during construction and operation of the facility.*

- *Detail how the management measures will be carried out, and to whose satisfaction this work will be done.*

4.4.3 Existing Environment

Ninety (90) of the taxa listed in Appendix D are alien and were recorded during the field work in the study area. These 90 species are estimated to include more than 75 per cent of the expected established alien flora in the study area (Weston, 2002).

All except eight of the weed species are listed in Scheltema and Harris (1995, pp. 65-141) as [environmental] weeds in the Perth Metropolitan Region. Scheltema and Harris (1995, p.27) classifies weeds according to the extent of their distribution and their invasiveness. Three rankings are used:

Priority 1 – Major Weeds
These are the most serious weeds within their ecosystem, and often affect many reserves or habitats in ways likely to permanently degrade them. Fifteen of the species recorded within the study area are Priority 1 Weeds.

Priority 2 – Nuisance Weeds
Priority 2 weeds are serious weeds which are generally found only in a few locations or ecosystems. Priority 2 weeds are usually found in highly disturbed areas. Ten of the species recorded within the study area are Priority 2 weeds.

Priority 3 - Minor weeds
These are weeds that are having little known effect. They are not yet as serious as and occur in smaller numbers or are less competitive than Priority 2 weeds. Thirty-four of the species recorded within the study area are Priority 3 species.

The Priority ranking (or code) for each species is given in Appendix B1 of Appendix D to this report.

Six of the 90 weed species are on the Agriculture Protection Board's April, 2002 list of Declared Plants, where they are formally declared high priority weeds that are, or may become, agricultural or environmental problems (Hussey *et al.* 1997). These species are *Solanum linnaeanum* (Apple of Sodom), *Zantedeschia aethiopica* (Arum Lily), *Moraea flaccida* (a Cape Tulip; *Moraea miniata* is also a Declared Plant), *Gomphocarpus fruticosus* (Cotton Bush) and *Echium plantagineum* (Patterson's Curse).

4.4.4 Potential Environmental Impacts

Arum Lilies and Cape Tulips are conspicuous and serious environmental weeds in parts of the study area (Weston, 2002). Other plants present or that have potential to become established weeds include the species listed in Appendix B1 of Appendix B, which are given weed Priority codes of W1 or W2, and the larger W3 plants *Acacia longifolia, Gomphocarpus fruticosus* and *Schinus terebinthifolia* (Weston, 2002).

Many of the weeds in the study area propagate by seed, which may be windblown, carried on fur or clothing, eaten or just drop to the ground. Many other weeds in the study area propagate vegetatively, e.g. by stem parts, bulbils or root parts. Propagules of most species may remain viable on or in the soil for many years and are likely to be in soil that is moved from one place to another. Some seeds may be induced to germinate by movement of soil.

4.4.5 Proposed Environmental Management

The objective for weed control will be to minimise degradation to retained vegetation, particularly in the Bush Forever site, resulting from the spread of weeds. To prevent further spread of weeds, no soil should be moved into any bushland area being protected or restored, and soil within such areas should be disturbed as little as possible.

A weed control program within the retained areas will be necessary which will likely include a combination of the four weed control strategies:

1. Hand weeding, pulling or digging;
2. Herbicide wipe, stem injection and cut stump application;
3. Herbicide spot spraying; and
4. Herbicide blanket spraying.

Near Wright Lake and Southern River areas, only “frog-friendly” glycophosate, such as Roundup Bioactive, should be used where necessary.

Weed species *Echium plantagineum, Solanum linnaeanum, Zantedeschia aethiopica, Moraea flaccida, Gomphocarpus fruticosus, Acacia longifolia and Schinus terebinthifolia* should be controlled in the first instance, followed by the Priority 1 and 2 weeds and then, if resources allow, Priority 3 weeds.

When undertaking weed control programs the primary guiding principle is to work from the areas in the best condition to those in the worst condition, and all works should be undertaken in conjunction with a restoration strategy (Bradley, 1988). Any initial weed control will be followed up with annual re-treatment, until such time as the weed species is either eradicated or reduced in area and abundance to the extent that it no longer poses a threat to the ecological integrity of the bushland, and is unlikely to be able to re-establish because of competition from native flora (Ecoscape, 2001).

Management for weed control will be further detailed in the overarching Environmental Management Plan to be prepared for the development, the guidelines for which are presented in Appendix F. Monitoring of the success of the weed control program will also be undertaken annually by the proponent and results be used to update the focus of the program. The program will be designed in consultation with and implemented to the satisfaction of the Bush Forever office (DPI) with advice from Agriculture WA.

4.5 Terrestrial Flora – Disease

4.5.1 EPA Objective

Ensure that regionally significant flora and vegetation are adequately protected from the spread of diseases, including dieback.

4.5.2 EPA Scope of Work

- *Identify any diseases which may potentially cause adverse impacts as a result of implementation of the proposal.*
- *Identify the habitats that are most vulnerable to spread of diseases.*
- *Describe proposed management measures to prevent or mitigate the spread of disease during construction and operation of the facility.*
- *Detail how the management measures will be carried out, and to whose satisfaction this work will be done.*

4.5.3 Existing Environment

The arrival and spread of dieback disease (caused by the root-rot fungus *Phytophthora* spp.) in Western Australia has been catastrophic for the biota of a number of south-west ecosystems (CALM, 2002). The most destructive and widespread species is *Phytophthora cinnamomi.*

An indicator species is a plant species which is reliably susceptible to *Phytophthora cinnamomi*. Approximately 88% of the site is currently cleared and to some degree cannot be readily assessed for disease distribution due to the lack of indicator species.

An area of Jarrah-Banksia woodland vegetation to the north of Wright Lake was assessed as part of the proposed Tonkin Highway Public Environmental Review (BSD Consultants, 2001). This vegetation had many individuals of highly susceptible species and appeared to be mostly dieback-free (BSD Consultants, 2001). Damage likely to be associated with dieback was found further to the north-west and low-lying areas surrounding the vegetation were expected to be extensively infected (BSD Consultants, 2001).

There are three categories used to describe and map *Phytophthora cinnamomi* occurrence*:*

- Uninfested;
- Uninterpretable; and
- Infested.

The site is considered to be poorly assessable for dieback because of the degraded state of the vegetation, the lack of good indicator species and the extent of past disturbance. Given that the majority of the site has been mapped as being seasonally damp or inundated (see Section 4.8), the site is considered to be at a high risk of being infected with dieback. Consequently the entire cleared area within the site is considered to be 'Uninterpretable' and should be considered to be dieback infected due to the seasonal dampness and the significant amount of historical disturbance.

However, the presence of healthy trees of Banksia and woody pear in some of the Champion Lakes vegetation, and the qualified interpretation in BSD Consultants (2001, Fig. 5.1.1, Sheet 1) of the Banksia woodland north of Wright Lake as dieback free, suggest that at least some of the Champion Lakes study area is free of the disease (Weston 2002). Being on sandier, higher, better drained ground than almost all the rest of the study area, three stands of bushland may be dieback-free.
These three stands are:

- the *Eucalyptus marginata – E.* (*Corymbia*) *calophylla* Woodland over *Banksia attenuata – B. menziesii – Xylomelum occidentale* Low Woodland to Low Open Forest (EmcBamX+);

- the *Jacksonia sternbergiana – Xylomelum occidentale* Low Open Forest to Low Woodland (JsX+); and

- the *Jacksonia sternbergiana – Xylomelum occidentale* Low Open Forest to Low Woodland with *Leptospermum laevigatum* weedy shrubs (JsXWs+) (Weston 2002).

4.5.4 Potential Environmental Impacts

As many as 2,000 of the estimated 9,000 native plant species in the south-west are susceptible to, and often killed by, dieback disease (CALM, 2002). The site is deemed to be infected with dieback.

During construction dieback could be spread by:

- Movement of infested soil and plant matter into uninfested areas during clearing and earthmoving activities;
- Movement of infested water into uninfested areas during dewatering and clean-down points;
- Movement of infested soil into uninfested areas on vehicles and construction machinery; and
- Introducing infested soil, mulch and live plants into uninfested areas during planting and rehabilitation activities.

During operation dieback could be spread by:

- Movement of infested soil into uninfested areas by maintenance vehicles and machinery; and
- Movement of infested water or soil unto uninfested areas in recreational craft.

The most significant potential impact will be the exporting and movement of spoil material, which is likely to be infested with dieback. The movement of spoil and traffic may serve to introduce or spread the disease to uninfected areas. All spoil taken from the site will be considered to be dieback infected.

Due to the high levels of disturbance that has occurred within the study area and the damp low-lying nature of the majority of the site, the *Phytophthora cinnamomi* is likely to be already widespread in this area, and the proposal is unlikely to cause any further

significant impact if the correct construction and maintenance hygiene methods are followed.

4.5.5 Proposed Environmental Management

The objective for the management of dieback will be to prevent the disease's possible spread into the two possibly uninfected stands of vegetation that will be retained within the development area (the JsX+ and JsXWs+) or any uninfested vegetation off-site during the transportation of material from the site for the construction of Tonkin Highway.

With regards to off-site impacts, the Tonkin Highway PER (BSD Consultants 2001) indicates that dieback management regimes will be aimed at preventing the spread of dieback beyond the road reserve during construction, by either vehicle or soil movement. Dieback management strategies will be employed by the contractor appointed by Main Roads WA to achieve this aim. Main Roads WA will monitor the performance of the contractors in this regard, and ensure that dieback is managed in accordance with the approved Construction Management Plan.

Management of dieback will be required at both construction and operation stages of the Champion Lakes development. The following guidelines will apply:

- The two areas considered to be dieback free that are to be retained in the development are to be demarcated (and fenced for the period of any construction) with appropriate signage. Vehicle, plant or soil movement into any of these stands which that is not known to be free of infection will not be taken into or dumped in any of them;
- Any plant matter cleared within assumed dieback infested areas must be disposed of in a manner and site selected and approved by CALM;
- All machinery capable of carrying dieback disease from assumed infested to dieback free areas will be cleaned at designated clean-down points;
- Machinery will be inspected prior to commencement of work or prior to movement through any dieback free areas;
- Stormwater and dewatering spoil will be directed away from dieback free areas.

All other areas, including the Tonkin Highway reserve, will be considered to be dieback infested.

Dieback management will be further detailed in the Construction Management Plan to be prepared for the development. Dieback management will be enforced and monitored by the proponent through the establishment of contracts to the satisfaction of CALM.

4.6 Terrestrial Flora – Significant, Declared Rare and Priority Flora

4.6.1 EPA Objective

- *Protect Declared Rare and Priority Flora, consistent with the provisions of the Wildlife Conservation Act 1950.*
- *Protect other flora of conservation significance.*

4.6.2 EPA Scope of Work

- *Identify species of Declared Rare and Priority Flora, if any, which may be directly or indirectly impacted by the proposal.*
- *Identify other species of significance that may be impacted by the proposal and discuss the reason for their conservation significance. These species may include undescribed taxa; new records for the region; species or taxa that are endemic to the region or at the limit of their range; or species confined to specific sites of limited occurrence in the region.*
- *Retain voucher specimens for all significant species and lodge them with the WA Herbarium.*
- *Flora survey work should be undertaken during the flowering season (late winter/spring).*
- *Describe management measures (if any) to prevent impacts on Declared Rare and Priority Flora, and to whose satisfaction the work will be done.*

4.6.3 Existing Environment

No species of Declared Rare or Priority Flora has been recorded within the study area, but two species are considered otherwise significant; *Agonis flexuosa* (peppermint) and *Gyrostemon subnudus* are listed in *Bush Forever* as ‘r’, ‘populations at the northern or southern limit of their known geographic range’, and ‘s’, ‘significant populations’. Weston (2002) indicates that the *Agonis flexuosa* present in the site is not likely to be indigenous in the study area.

None of the plant taxa found in the study area has particular conservation significance on a broad scale, but three species, *Daviesia ?incrassata, Gyrostemon subnudus* and *Hydrilla verticillata*, appear to be very poorly conserved on the Southern Swan Coastal Plain.

Weston (2002) reported that some winter pools in the pastures may provide suitable habitat for the Priority Four aquatic herb *Aponogeton hexatepalus*, and the Priority Four shrub *Verticordia lindleyi* subsp. *lindleyi* is in banksia woodland very near the study area, in the Tonkin Highway extension area north of Wright Lake. Subsequently, Weston found no plants of *Aponogeton hexatepalus* in the potential sites and considered it unlikely that any taxon of Declared Rare Flora or Priority Flora would be found in the study area, except possibly in its western corner proposed for conservation and rehabilitation or in the *Jacksonia sternbergiana – Xylomelum occidentale* Low Open Forest to Low Woodland (JsX+) between Wright Lake and Lake Road.

4.6.4 Potential Environmental Impacts

Populations of *Gyrostemon subnudus* and *Daviesia ?incrassata* population were found within the JsX+ vegetation within the study area. Part of this area (~0.15ha) is proposed to be cleared for the development of a boat launch and picnic area. During the more detailed planning and landscape studies for the boat launch and picnic area retention of more of the JsX+ vegetation will be considered. However, in a worst case scenario the populations of *Gyrostemon subnudus* and *Daviesia ?incrassata* in that stand will be cleared.

Daviesia ?incrassata was also found in the Low Open Forest to Low Woodland (JsXWs+) north-east of Wright Lake under the transmission lines. This area will be retained for conservation.

Hames Sharley (2000) recorded the aquatic plant *Hydrilla verticillata* in Wright Lake. Wright Lake is proposed to be extensively earthworked and consequently it is unlikely that any aquatic plants will be retained.

4.6.5 Proposed Environmental Management

Detailed planning and landscape studies will consider the possibility of retaining a greater proportion of the JsX+ in the detailed design of the plan.

Searches for Declared Rare and Priority Flora on the site were undertaken in September and October, and also earlier in March, April and July 2002.
A preliminary Landscape Strategy for the site, addressing these issues in principle, is presented as Appendix E. Appendix F provides overarching guidelines for the preparation of management plans for vegetation protection and enhancement.

4.7 Fauna

4.7.1 EPA Objective

- *Maintain the species abundance, diversity and geographical distribution of fauna*
- *Protect Specially Protected (Threatened) Fauna and Priority Fauna species and their habitats, consistent with the provisions of the Wildlife Conservation Act 1950.*

4.7.2 EPA Scope of Work

- *Conduct baseline studies to identify existing fauna, including aquatic vertebrate and invertebrate fauna within Wright Lake, likely to inhabit the project area. Establish if Wright Lake provides a significant habitat for waterbirds and other fauna identified.*
- *Discuss the potential direct and indirect impacts of the proposal on the existing fauna and their habitats. Including discussion on the impacts of a reduction in salinity levels of the lake and change to a permanent waterbody.*
- *Identify risks of exotic species and diseases being introduced to the environment and determine the impact that introduced fish or crustaceans may have on any populations of native fauna species present within Wright Lake.*
- *Describe proposed management measures to ensure maintenance of abundance, diversity and distribution of the fauna. Provide guidance on the design of the 'conservation' island proposed to be constructed in Wright Lake on the basis of developing suitable wetland habitat for species present within Wright Lake.*
- *Detail how the management measures will be carried out, and to whose satisfaction this work will be done.*
- *Identify species of specially protected and priority fauna and their habitats, which may be directly or indirectly impacted by the proposal.*
- *Describe management measures (if any) to prevent impacts on Specially Protected and Priority Fauna, and to whose satisfaction the work will be done.*

4.7.3 Existing Environment

A fauna survey of the Champion Lakes project area was conducted by MJ and AR Bamford Consulting Ecologists. A summary of the results of the survey is provided here and the full report and supplement is included in Appendix G. The survey consisted of a detailed site inspection over 6th and 7th March, 2002 to identify fauna habitats and record conspicuous species, and a review of fauna species known to occur in the region in the habitats present within the site. A supplementary study was also undertaken on the 11 September 2002 to identify waterbirds present and to sample the aquatic macro-invertebrates of Wright Lake.

Sources used for the literature review include:

- the WA Museum specimen records from the general region;
- personal observations from previous studies carried out in the area;
- observations on birds in the Perth area from Van Delft (1997);
- observations on reptiles in the Perth area from Bush *et al.* (1995);
- the results of a number of studies on the vertebrate fauna of bushland remnants in the Perth region (eg. Storr *et al.* 1978, Wykes 1991, How 1998, Turpin 1990, Storr and Johnstone 1988, How and Dell 1994, Dell and How 1995 and Johnstone and Storr 1998); and
- species listed for the region in Perth's Bush Forever (Government of Western Australia 2000).

CALM's Threatened Fauna Database was used to determine if any threatened fauna had been recorded in the general region of the study area. The review also accessed waterbird count data available for Wright Lake, in databases maintained by the WA Department of Conservation and Land Management (CALM) and Birds Australia WA Inc.

4.7.3.1 Habitats

Fauna habitats within the site are described as follows:

- Wright Lake: A seasonally inundated, brackish wetland with a margin of sedges and scattered trees. There is little upland vegetation near the lake, with only small patches to the west and south-west. The lake is separated from other parts of the park by Cammillo Road.
- Farmland: Almost all the land between Wright Lake and the Southern River. The habitat consists of pasture with scattered trees. Livestock are present.

- Remnant vegetation: Some remnant vegetation occurs within the farmland between Wright Lake and the Southern River. It is very degraded from grazing but contains some remnant native vegetation, particularly paperbark trees (*Melaleuca* spp.) along a low lying area.
- Southern conservation area: Includes, 1) Southern River weed-invaded riparian zone of paperbarks (*Melaleuca* spp), 2) Woodlands of Marri (*Corymbia calophylla)* and paperbark (*Melaleuca* spp.) that are heavily weed-invaded with little native understorey vegetation. Some weed-invaded areas of heath are also present and parts of the area are seasonally inundated.

Table 6 presents a summary of the fauna species expected within the habitats of the site.

TABLE 6
Summary of Expected Fauna within the Site

Fauna	No. of Families	No. of Species	Common Habitats			
			Wright Lake	Farmland	Rem. Veg.	Cons. Area
Invertebrates	>15	>20	✓	×	×	×
Birds	39	122	✓	✓	✓	✓
Frogs	2	9	✓	×	✓	✓
Reptiles	8	39	✓	✓	✓	✓
Native Mammals	8	14	✓	✓	✓	✓
Introduced Mammals	3	5	✓	✓	✓	✓

4.7.3.2 Invertebrates

There is not currently any site-specific information available on terrestrial invertebrates, however some studies have been conducted on macro-invertebrates of Wright Lake, including a sweep net survey conducted in September 2002. All but three of the species recorded (Appendix G) are typical of freshwater wetlands of the Swan Coastal Plain (Bamford, 2003). However, it has been noted that the composition of the lake's invertebrate fauna changes with seasonal changes in salinity. Species associated with freshwater are abundant when salinity levels are low, but species associated with saline water replace these as water levels fall and salinity increases. As such only some of the species found in Wright Lake would have been sampled in September.

This combination of freshwater and saline species may be considered unusual among wetlands of the Swan Coastal Plain, however other seasonal wetlands such as Forrestdale Lake and to a lesser extend Lake Jandabup, Joondalup and Thomsons Lake display similar salinity characteristics.

4.7.3.3 Birds

Due to the mobility of birds, well over a hundred species could possibly be recorded at the site, but it is considered that only 122 species may make regular use of it, while 42 species were either observed during the site inspection or have been recorded during waterbird surveys (Appendix G).

A high proportion of bird species observed or expected are waterbirds: all ducks, grebes, herons, cormorants, pelican, ibis, crakes, sandpipers, plovers and gulls, but also the Swamp Harrier, Reed-Warbler and Grassbird. Many of these have been counted on Wright Lake during waterbird surveys, including 7 species recorded breeding. Wright Lake is the key waterbird habitat within the study area and while the counts are not exceptional (pooled maximum count of 829), with much higher counts at larger lakes nearby, such as Lake Forrestdale (pooled maximum count of 30,429 Jaensch *et al.* 1988), the lake is of local importance. The number of breeding species is moderate, compared with 18 breeding species at Lake Forrestdale (Jaensch *et al.*, 1988). Nearby Mary Carroll Park has a maximum count of 830 and 11 breeding species (Storey *et al.*, 1993), and tends to act as a summer/ autumn refuge when Wright Lake is dry.

In the September 2002 survey of Wright Lake only seven species of waterbird were recorded (Appendix G), with only the Pacific Black Duck found breeding.

In addition to Wright Lake, Southern River and nearby seasonal wetlands are also likely to be utilised by waterbirds, particularly for breeding, but these areas were dry with no waterbird activity during the site inspection. Areas of pasture are likely to be used by some waterbirds, such as the two ibis species and some ducks. Large trees in paddocks may be used for breeding by some ducks, such as the Australian Shelduck and Australian Wood Duck.

Remnant native vegetation in upland areas is important for dryland birds. Among the species recorded during the site inspection there are some, such as the Splendid Fairy-wren and Inland Thornbill, which are recognised as persisting in the metropolitan region only where native vegetation remains. They were observed only near the Southern River. Linkage of such areas of native vegetation is also important for these species as

they can become locally extinct in small reserves (How and Dell, 1995), and in this respect the project area is effectively part of a larger system linked via Southern River. Other species that are dependent upon native vegetation, such as the honeyeaters, are less reliant on linkages and can access isolated areas of native vegetation.

A number of the bird species observed or expected actually favour disturbed environments such as paddocks and parkland cleared woodland. In contrast with the species dependent upon native vegetation, species of disturbed and degraded environments tend to be widespread at least in the outskirts of Perth.

4.7.3.4 Frogs

Although no frogs were recorded during the site inspection, on the basis of patterns of distribution and the habitats present, all nine species known from the Swan Coastal Plain south of the Swan River are almost certainly present (Appendix G). This reflects the presence of seasonal wetlands and the juxtaposition of Southern River. It is not clear to what extent Wright Lake may be important for frogs, as all local species are intolerant of even brackish water. However, during the macroinvertebrate survey undertaken in September 2002, tadpoles of the genus *Crinia* were identified in 4 of the 5 invertebrate sweeps in the vegetated margins of the lake.

4.7.3.5 Reptiles

Small areas of remnant native vegetation in the Perth region, even when degraded, retain a substantially intact reptile fauna (How and Dell, 1994). Therefore, the project area is expected to support a rich reptile fauna (Table 4 of Appendix G), although this will not be evenly distributed. For example, the Long-necked Tortoise is aquatic and can be expected in Southern River, as well as seasonally visiting wetlands in the area, including Wright Lake. The South-West Cool Skink, Mourning Skink and Tiger Snake are closely associated with riparian habitats around wetlands and may therefore be confined to such areas on the site, such as around Southern River and the margins of Wright Lake.

All remaining species depend upon upland habitats of the site and are therefore most likely to be encountered in the two remnants of upland vegetation near Wright Lake, and close to Southern River. Several of the skink species in particular survive and even thrive in disturbed environments, so may be widespread even in pasture areas. These include the Dwarf Skink and the Bobtail.

4.7.3.6 Mammals

The extant mammal fauna of the site is likely to be poor with only 14 native and 5 introduced species (Appendix G), compared with as many as 16 mammal species that may be locally extinct.

Several of the native mammal species listed as expected, including the Echidna, Honey Possum, Brush-tailed Possum and Western Grey Kangaroo, have been included because they are known from nearby, although the available habitat in the study area appears marginal for them. All rely to at least some extent on native vegetation, although the Grey Kangaroo will forage on pasture and the Brush-tailed Possum occurs in gardens, especially where homes provide access to roof space for shelter.

The remaining native mammal species are the Quenda (recorded), 8 species of bats (2 recorded and 2 possibly present, with the Chocolate Wattled Bat and possibly *F. mackenziei* recorded in Jandakot in March, 2002 (B. Metcalf pers. comm.) and the Rakali. The Quenda requires dense, low vegetation and was recorded amongst dense weeds on the south-eastern side of Wright Lake during the site inspection. It probably occurs throughout the study area where dense vegetation is present. The bats are all tree-roosting species that shelter under bark and in crevices and hollows, and all may forage principally over native vegetation. The White-striped Bat is the only species that regularly forages over open ground and suburbs (M. Bamford pers. obs.). The Rakali may be present along Southern River but could seasonally visit Wright Lake.

A large proportion of the mammal fauna consists of introduced species and several of these were observed during the site inspection. This does not include domestic livestock, such as cattle, sheep and horses that were present in farmland within the study area. Rabbit tracks were observed in several areas of remnant native vegetation and rabbits may contribute to the degradation of this vegetation by burrowing, browsing and through the introduction of weeds. Tracks of either a domestic or feral Cat were observed around Wright Lake, while a Fox was seen near Southern River.

4.7.3.7 Specially Protected and Priority Fauna

The conservation status of fauna species is assessed under Federal and State Acts such as the *Commonwealth Environmental Protection and Biodiversity Conservation Act, 1999* (EPBC Act) and the *WA Wildlife Conservation Act*.

The EPBC Act also has separate listings for migratory and marine species. Migratory species are largely those listed under the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals), the Japan Australia Migratory Bird Agreement (JAMBA) and the China Australia Migratory Bird Agreement (CAMBA).

In Western Australia, the Department of Conservation and Land Management has produced a supplementary list of Priority fauna, being species that are not considered Threatened under the IUCN categories or under the WA Wildlife Conservation Act but for which the Department feels there is cause for concern. Levels of Priority are described in Appendix G.

Species can be considered to be of national or state conservation significance if they occur on any of the above lists. Species not on these lists may be of Regional Conservation Significance if they occur on the edge of their distribution or as an isolated population.

Environmental Protection and Biodiversity Conservation Act

1. Migratory Species

- Wanderer Butterfly *Danaus plexippus* is self-introduced, reliant on introduced plants for food and was present in weed-infested areas near Southern River
- Great Egret *Ardea alba* has been observed on Wright Lake

Migratory birds that are expected to make use of Wright Lake and seasonal wetlands in small numbers, although have not been sighted, are as follows:

- Swamp Harrier *Circus approximans*
- Marsh Sandpiper *Tringa stagnatilis*
- Common Greenshank *Tringa nebularia*
- Red-necked Stint *Calidris ruficollis*
- Long-toed Stint *Calidris subminuta*
- Sharp-tailed Sandpiper *Calidris acuminata*

2. Endangered Species

- Short-billed Black Cockatoo *Calyptorhynchus latirostris* may be a regular visitor to forage on the seeds of Banksias and Woody Pears

WA Wildlife Conservation Act

1. Schedule 1 Species

- Native bee *Leioproctus douglasiellus* is only present on flowers of *Goodenia filiformis*. No individuals of this plant were found within the study area.
- Native bee *Neopasiphae simplicior* is only present on flowers of *G.filiformis, Lobelia tenulor* and *Angianthus preissianus* which were not found within the study area.

2. Schedule 4 Species

- Peregrine Falcon *Falco peregrinus* is not given a high level of significance and is likely to be an infrequent visitor only.

3. Endangered Species

- Short-billed Black Cockatoo *Calyptorhynchus latirostris* may be a regular visitor to forage on the seeds of Banksias and Woody Pears

CALM Priority Fauna

1. Priority 2

- Barking Owl *Ninox connivens* has limited habitat but may perhaps use some of the vegetation along Southern River.

2. Priority 3

- Native bee *Leioproctus contrarius* is only present on flowers from Goodeniaceae and *Lechenaultia stenosepala*. Two species of the Goodeniaceae are present within the site.

3. Priority 4

- Quenda *Isoodon obesulus* is present and probably common where there is dense, low vegetation.
- Chocolate Wattled Bat *Falsistrellus mackenziei* may be present where native vegetation provides roosting and foraging areas.
- Water rat *Hydromys chrysogaster* is likely to occur along Southern River.

The following Priority 4 species are not given high levels of significance and are likely to be infrequent visitors only:

- Freckled Duck *Stictonetta naevosa*
- Square-tailed Kite *Lophoictinia isura*
- Little Bittern *Ixobrychus minutes*

4.7.3.8 Species of Regional or Local Significance

These are species that occur on the edge of their distribution or as an isolated population and include:

- Hooded Robin *Melanodryas cucullata* – observed in habitat similar to the woodland of the site.
- Golden Whistler *Pachycephala pectoralis* – not observed on site but seen in woodland around North Lake.
- Sandhill Dragon *Tympanocryptis adelaidensis* – at the southern limit of their range
- Rosenberg's Goanna *Varanus rosenbergi* – at the northern limit of their range
- Black-headed Tree Goanna *Varanus tristis* – occur at low population densities
- Western Bluetongue *Tiliqua occipitalis* – occur at low population densities
- Narrow-banded Snake *Simoselaps (Vermicella) fasciolata* – occur at low population densities
- Half-ringed Snake *Simoselaps (Vermicella) semifasciatus* – occur at low population densities
- Crowned Snake *Drysdalia coronata* – occur at low population densities
- Worm Lerista *Lerista praepedita* – may persist despite the development as they survive in gardens
- Perth Lined Lerista *Lerista lineata* - may persist despite the development as they survive in gardens
- Honey Possum *Tarsipes rostratus* – unlikely to be present as anything more than a vagrant

4.7.4 Potential Environmental Impacts

In this section, the impacts to the fauna habitats are initially discussed, followed by discussion of potential impacts to fauna associated with these habitats.

4.7.4.1 Wright Lake

The implementation of the proposal will result in Wright Lake being deepened, the area of open water significantly increased, the waterbody would become permanent rather than seasonal, and fresh rather than brackish or saline. The proposal would also result in the creation of a vegetated island as a wildlife refuge, and rehabilitation or introduction of extensive areas of native shoreline vegetation.

Changes to the Wright Lake environment will result in a complex of impacts, both beneficial and deleterious. Making Wright Lake deeper, permanent and with reduced salinity will alter some vegetation and the aquatic invertebrate fauna, which will probably benefit some waterbirds but may disadvantage other species. For example, migratory shorebirds may not visit the lake seasonally because of the absence of extensive shallows as it dries out in summer, although some seasonal shallows have been incorporated into the design. There may be considerable benefit to some other waterbirds, such as ducks, that may be able to use the permanent waterbody as an important summer/autumn refuge when many lakes in the Perth area are dry, which does not exist at present.

Increased boating activity (non-powered) on Wright Lake may increase levels of disturbance of waterbirds, however a significantly larger area of open water and fringing habitat will be available that may mitigate this factor, including a conservation island.

Making Wright Lake permanent will enable it to support the introduced Mosquitofish *Gambusia holbrooki*, which may adversely affect aquatic invertebrates and frogs in the wetland. Accidental introduction of this species is almost inevitable.

The proposed residential area within the development may lead to increased numbers of domestic pets close to conservation areas. Dogs have caused problems for waterbirds through disturbance and predation in other parts of Perth, and cats prey upon small birds and other wildlife. Especially in small reserves, such predation of sedentary species can lead to local extinction and will require management.

4.7.4.2 Farmland

The proposal would result in the farmland area developed for urban land uses.

Developments in cleared areas will have minimal significant impact because such cleared habitat is widespread, and are of little importance for significant fauna. The only

significant impact would be the loss of single large trees used for roosting and/or nesting by species of bats and birds, however these could be replaced by roosting poles within conservation areas and nearshore open water.

4.7.4.3 Remnant Vegetation

Part of the study area is proposed to be rehabilitated for conservation, with a rowing return and broad rowing course also being implemented.

Rehabilitation and revegetation has the potential to create additional habitat and to strengthen the linkage between Southern River and Wright Lake. The proposed canoe trail has the potential to support significant riparian vegetation of conservation value, but the rowing course, being broad and sharp-edged, may be of less value. The extent to which waterbirds would use the rowing course is difficult to determine, and would be species dependent. The rowing return lane is likely to be especially valuable if shallow side-branches and thickets of both low and tall riparian vegetation are created, as proposed but subject to detailed design.

4.7.4.4 Southern Conservation Area

This area is proposed to be retained for conservation (Bush Forever Site No. 260) to provide a link between the Southern River and conservation areas around Wright Lake. This will increase fauna populations and maintain a linkage network that is very important for conservation through the urban landscape.

4.7.5 Proposed Environmental Management

Impacts associated with development around Wright Lake may be difficult to manage and changes to the fauna assemblages will be inevitable. The existing plan does allow for water of different depths and seasonal shallows, and will therefore favour some waterbird species, although the relative abundance of species will likely change.

4.7.5.1 Habitat Replacement

There is potential for beneficial impacts through the creation of habitat, particularly in that part of the project area that is currently cleared and badly degraded. A total of 52.28ha of open water will be created as part of the development, with 21.07ha of adjacent conservation area. The plantings along the rowing course, warm-up lake and

living stream, which will include fringing aquatic plants, will encourage a natural food web to become established.

Currently the site does not have an exceptional waterbird count when compared to Lake Forrestdale (Wright Lake pooled maximum count is approximately 3% of the Lake Forrestdale pooled maximum count). However, there will be provision of some summer shallow feeding areas for migratory wader birds along the living stream/return lane, although these areas are unlikely to be seasonally 'dry'. The permanent water within the site will become a drought refuge for waterbirds.

Any rehabilitation/habitat creation that can be achieved between Southern River and Wright Lake will increase the linkage between these two areas and will therefore improve the ability of fauna to move between them. Habitat creation can include gardens and ornamental planting. Given that the main development area lies between two sites of conservation value, local, native plant species will be used wherever possible to enhance habitat values. Local, native plant species will be used where rehabilitation for habitat creation is the goal, such as around Wright Lake and near Southern River.

4.7.5.2 Wildlife Corridor

The proposal has the potential to improve linkage between Southern River and Wright Lake for fauna, and that will have a flow-on effect to the remnant woodland north of Wright Lake. Such linkage networks through the urban landscape are important for conservation and are discussed in Perth's Bush Forever (Government of Western Australia, 2000). With the development of the Champion Lakes reserve, Tonkin Highway when constructed may act as a barrier for wildlife movement so the need to incorporate wildlife underpasses adjacent to Wright Lake should be considered.

4.7.5.3 Control of Domestic Pets

As noted, increased numbers of domestic pets may present problems close to Wright Lake. Dogs will only be allowed on leads around Wright Lake, while owners of cats will be encouraged to keep them in at night, and preferably at all times. These issues will be discussed within the "Sense of Place" document prepared for future residential areas (outlined in Appendix F).

4.7.5.4 Trapping and Release Program

It is proposed to trap the quendas within the densely vegetated portions of the study area a few weeks before construction begins to impact on these areas. Quendas have a relatively high reproductive rate and are known as effective colonisers with the ability to quickly re-establish in areas of vegetation once a population has been removed, taking as little as two to three months to reach the previous population levels (Dr Peter Mawson CALM 2001 pers. comm.). Trapping must therefore be undertaken as close to construction as possible, and will be an element of the Construction Management Plan.

Any trapped quendas will be arranged to be passed onto CALM to relocate to areas that they intend to recolonise with quendas.

Consideration was given to trapping and relocating other, less mobile, significant species within the site such as the Long Neck tortoises, Chocolate Wattle bat and Water rat. However experience has shown that these species are relatively common and do not relocate well, with a high proportion of deaths after relocation (M. Bamford, pers. comm., 2002).

A large proportion of the significant fauna species that are known or expected to visit the study area are birds. The mobility of birds should enable them to escape direct construction impacts however wherever possible timing of the construction around Wright Lake should avoid periods of peak water levels, from July-August through to October-November which coincides with peak breeding and nesting times.

As Wright Lake is not an important drought refuge in late summer/autumn, the construction activity will have the least impact if it is undertaken over these seasons.

4.7.5.5 Mosquitofish

Once Mosquitofish enter the permanent waterbody they will be effectively be impossible to control. Currently there are no demonstrated methods to selectively control the presence of mosquitofish in a permanent waterbody. However their impact on tadpoles, invertebrates and native fish can be reduced by providing cover via aquatic and emergent vegetation, branches thrown into the water etc.

These management measures will be implemented at the detailed design phase of the project.

4.8 Wetlands

4.8.1 EPA Objective

Maintain the integrity, functions and environmental values of wetlands

4.8.2 EPA Scope of Work

- *Map and describe the significance of wetlands within and surrounding the study area and detail how they may be directly or indirectly impacted by the proposal with a particular emphasis on Wright Lake.*
- *Determine an overall loss or gain of wetland functions and habitats as a result of the development.*
- *Discuss waterbody creation techniques and options.*
- *Discuss whether the development will allow for the retention of some areas of seasonal wetland within the site.*
- *Discuss recreational impacts and how they can be managed.*
- *Provide design criteria and land requirements of the rowing course and seasonal sanctuary wetlands incorporating all necessary requirements (such as the International Rowing Course standards).*
- *Provide details of a Wetland Mitigation Strategy including how this strategy will be implemented.*
- *Detail how the management measures will be carried out, and to whose satisfaction this work will be done.*

4.8.3 Existing Environment

4.8.3.1 Wetland Mapping

There have been several previous studies of the wetlands in the area that have encompassed the subject land.

The Swan Coastal Plain Wetland Atlas (Hill *et al*, 1996) published by the Water and Rivers Commission (WRC) delineated and maps the wetland types and condition of all known wetlands on the Swan Coastal Plain. This data has been updated by the WRC since the release of the wetland atlas, and it is data from March, 2001 that has formed the basis of the wetland mapping within this report (Figure 7).

The WRC's Position Statement on Wetlands provides a general description and management objectives for each of the three different management categories for wetlands: Conservation, Resource Enhancement and Multiple Use (Table 7).

TABLE 7

Wetland Management Categories

(after WRC, 1996)

Management Category	General Description	Management Objectives
Conservation (C)	Wetlands support a high level of ecological attributes and functions	Highest Priority Wetlands. Objective is preservation of wetland attributes and functions through various mechanisms including: • Reservation in national parks, crown reserves and State owned land; • Protection under Environmental Protection Policies; • Wetland covenanting by landowners. These are the most valuable wetlands and the Commission will oppose any activity that may lead to any further loss or degradation. No development.
Resource Enhancement (R)	Wetlands which may have been partially modified but still support substantial ecological attributes and functions	Priority Wetlands. Ultimate objective is for management, restoration and protection towards improving their conservation value. These wetlands have the potential to be restored to Conservation category. This can be achieved by restoring wetland structure, function and biodiversity. Protection is recommended through a number of mechanisms.
Multiple Use (MU)	Wetlands with few important ecological attributes and functions remaining.	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare. Should be considered in strategic planning (e.g. drainage, town/land use planning).

Conservation Category Wetlands

The study area contains approximately 1.75ha of Conservation Category wetland vegetation located on the Southern River in the south-west corner of the proposal area (Figure 7). This wetland was described by Weston (2002, see Appendix D) as consisting of mainly *Melaleuca preissiana – M. rhaphiophylla* Low Closed Forest and *M. rhaphiophylla* Low Closed Forest of Degraded condition. The Conservation Category wetland vegetation extends beyond the study area boundary both to the north into the Tonkin Highway reservation and south of the study area bordering the Southern River.

Resource Enhancement Category Wetlands

The study area contains 59.21ha of Resource Enhancement wetlands (Figure 7) which includes:

- Wright Lake - a sumpland (seasonally inundated basin) comprising 24.06ha of which 19.43ha of Wright Lake is the seasonal wetland bed and 4.63ha is fringing wetland dependent vegetation;
- a proportion (35.02ha) of a large dampland (seasonally waterlogged basin) near the southern part of the proposal area; and
- a small proportion (0.13ha) of a dampland consisting of *M. viminea - M. lateritia* Open Heath in the northern extension arm of the study area.

The majority of the dampland to the south of the site has been extensively cleared and is used for grazing by sheep and cattle. Only four isolated areas of indigenous vegetation remain within the dampland:

1. A small area (approximately 0.96ha) of remnant vegetation lies adjacent to the previous sand mining area in the south-west of the site and consists of *M. preissiana* Low Woodland to Low Closed Forest and *Juncus pallidus* Grassland (Rushland) to Open Grassland (Rushland) of Degraded to Completely Degraded condition;
2. Near Ypres Road is a larger area (approximately 1.41ha) which consists of *Eucalyptus todtiana – E. calophylla* Woodland to Low Woodland over/with *M. preissiana, Jacksonia sternbergiana* and *Xylomelum occidentale* Low Woodlands of Degraded to Completely Degraded condition;
3. A small area of *Kunzea ericifolia* (approximately 0.15ha) is situated close to the Conservation Category wetland to the south-west of the site; and
4. Two small areas situated south of Ypres Road which total approximately 0.48ha which consist of *M. preissiana* Low Closed Forest which are in Degraded to Completely Degraded condition.

Given the lack of ecological attributes of the Resource Enhancement dampland, it is possible to request the WRC to re-evaluate the management category of this wetland. It is noted that the area of this dampland directly west of the road reserve for Allen Road, which is in similar condition to that present within the site, is assigned the Multiple Use Category.

Multiple Use Category Wetlands

There are 36.45 ha of Multiple Use dampland within the study area (Figure 7), with 2.15 ha adjoining the south-west corner of Wright Lake near Cammillo Road. This area contains two residences, outbuildings and established gardens consisting of weeds and trees not native to the area, principally *Eucalyptus calophylla* and *Banksia attenuata*. This area was mapped as Conservation Category but was re-evaluated by the WRC to Multiple Use (8 May, 2002).

The majority of the Multiple Use dampland situated between Cammillo Road and Ypres Road is cleared and is currently used for agricultural purposes, however three isolated areas of remnant vegetation remain in the mapped wetland boundary totalling 3.53ha.

Of the total 96.01ha wetland area mapped by the WRC within the site, approximately 14.51ha (~15%) contains remnant wetland vegetation, all of which is in Degraded or Completely Degraded condition. Including the wetland bed of Wright Lake, the total remaining wetlands of any significant ecological value is approximately 33.8ha (~35%). The remaining 65% of the mapped wetland areas are totally cleared or parkland cleared, and is used for residential or agricultural purposes. These wetlands still have hydrological functions, such as groundwater recharge and flood mitigation, but have limited ecological value.

4.8.3.2 Wright Lake

Wright Lake is a small, seasonal lake with a flat, shallow basin encircled by low dunes with development encroaching close to the lake margins (EPA and WAWA, 1990). The lake has a very important drainage function in this flat, low-lying area, however there is a general lack of data regarding water levels, water quality and wildlife values (EPA and WAWA, 1990).

Weston (2002) described the margins of Wright Lake as containing vegetation bands with the innermost band comprising mainly two species of native herbaceous plants, *Cotula coronopifolia* and *Wilsonia backhousei*, and the outermost band is characterised by couch grass (*Cynodon dactylon*) and kikuyu grass (*Pennisetum clandestinum*). The native sedge *Baumea juncea* and the weedy grass *Lagurus ovatus* are also conspicuous in the outer layer but are denser and dominant in the next, second band. The weedy grass *Polypogon monspeliensis* is dominant in the third band, and the native sedge *Bolboschoenus caldwellii* is dominant in the fourth band. Weston also recorded

restricted stands of *Arundo donax, Typha ?orientalis* and *Cortaderia selloana* in the fringing vegetation.

Hill *et al.* (1996) classify Wright Lake as a sumpland (seasonally inundated basin) of the Mungala consanguineous wetland suite. The Mungala suite is described as containing 340 sumplands and covers 2,944 ha of land on the Swan Coastal Plain on the transition between the Bassendean Dunes and the Pinjarra Plain. The underlying stratigraphy is described as being variable and is usually a complex of sands, clays, calcrete and laterite. Jordan (1986) classifies Wright Lake as an aeolian deflavon hollow characterised by peaty sand, grey to black, fine to moderately sorted sand of lacustrine origin.

Hill *et al.* (1996) ranks Wright Lake as being in the 36 percentile of wetland within the suite group (a wetland with a percentile rank of 100 is the best example of its type of wetland in its particular suite). Consequently it is ranked among the "bottom third" of wetlands of this type.

Anecdotally, an early resident of Zenobia Terrace, Mrs Emily Rigg, recalls that Wright Lake was a permanent waterbody up until 1963-1964. Mrs Rigg has advised that in 1965 Wright Lake started to dry up over the summer months. Another early resident, Mr George Csohany, who also lived on Zenobia Terrace, recalled that water levels in the lake rose to 3 or 4 feet (0.91-1.22m) in the winter, and in the summer the surface of Wright Lake was covered in a white salty crust.

Anecdotal evidence from current local residents suggests the lake is dry for at least 4-5 months of the year, and maximum depth is approximately 0.5m (Hames Sharley, 2000). Data collated by Hames Sharley (2000) appears to support this conclusion with depths ranging from 0m in January to April to 0.5m in October.

High salinities of around $10gl^{-1}$ ($10,000mgL^{-1}$ total dissolved salts; sea water is 35,000 mgL^{-1}) have been recorded both within and below the lake in adjacent groundwater bores, which is unusually saline for a lake this far inland from the coast (Hames Sharley, 2000).

Wright Lake most likely displays elevated salinity through evapo-concentration effects (see Section 5). Due to the lack of historical data for this lake and the hydrogeology of the area, this cannot be determined.

4.8.3.2 Conservation Significance

Wetlands are valuable assets because they carry out a number of important processes or 'functions', either ecological (biological and chemical), hydrological or social (EPA 1993). For wetlands located between Wedge Island and Mandurah there are a number of existing wetland evaluations and studies which provide guidance to the EPA on the relative international, national and regional significance of each wetland.

Wetlands which are nominated by Australia for inclusion in the List of Wetlands of International Importance under the *Ramsar Convention 1971* are considered to be internationally significant. None of the wetlands within or adjacent to the study area are listed or are known to be nominated for Ramsar listing.

Wetlands listed within the Australian Nature Conservation Authority's *Directory of Important Wetlands in Western Australia* and on the Australian Heritage Commission's *Register of the National Estate* list of wetlands are considered to be of national significance. None of the wetlands within or adjacent to the site are listed within either of these registers.

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which came into force in mid-2000, provides protection to matters of national environmental significance. The matters of national significance protected by the EPBC Act include migratory species protected under international agreements.

Fifteen species of birds of national conservation significance are expected to use the site of which eight are listed as migratory under the EPBC Act although only one, the Great Egret *(Ardea alba),* has actually been recorded (Bamford, 2002). The Wanderer Butterfly (*Danaus plexippus)* is also listed as migratory under the EPBC Act and was recorded in weed-infested areas near Southern River by Bamford (2002).

Wetlands generally considered to be of regional significance comprise those included in the:

- System 6 recommendations (EPA, 1983);
- Bush Forever recommendations (Government of WA, 2000); or
- Report on the Investigation into the Environmental Significance of Wetlands and Rivers in the Perth-Bunbury Region (Le Provost *et al*., 1987).

Southern River is recommended for protection in System 6 recommendation M75 and within Bush Forever Site No. 260. Neither Wright Lake nor any of the other wetlands within the site were nominated within these studies.

Southern River and associated wetland vegetation is therefore considered to be of regional conservation value. Wright Lake and the other wetlands within the site are not known to have any regional conservation value but are likely to be intermittently or regularly used by migratory birds of international significance.

4.8.4 Potential Environmental Impacts

4.8.4.1 Design Criteria and Construction Techniques

There are strict design criteria and land requirements for the rowing course stipulated by Rowing Australia Inc, which are required to be met prior to a course being approved for Australian or International standard events. The main requirements are summarised in Table 8, and it is critical to the project that these criteria are achieved and maintained.

No seasonal sanctuary wetlands are proposed as part of the development, however seasonal shallows will be provided at nodes along the rowing return lane. Water quality requirements for permanent freshwater lakes are provided in Section 5.1.

The construction of the rowing course, together with the warm up lake, will require extensive earthworks with excavation and shaping of the waterbody expected to take in the order of 18 months.

The waterbody will be excavated in sections (approximately 10-15 cells) to minimise the potential for dewatering impacts. Dewatering will be carried out in such a way as discharge from the pumps is retained on site and the water quality comprehensively tested. The objective will be to use as much as possible of the water to fill the rowing course and warm up lake. If the water quality is not considered suitable for the rowing course there may be a need to discharge the water to Southern River, or reinjected into the aquifer. Some water may be utilised in the construction of the Tonkin Highway extensions. Further detail is presented in Section 5.1.

Once final design has been developed (likely to be before June, 2003) a Dewatering Program will be developed within the Construction Management Plan, which will determine and manage the potential impacts of dewatering on the vegetation within the conservation areas, surrounding wetlands, Southern River and groundwater quality.

TABLE 8
A Summary of the Rowing Australia International
Rowing Course Requirements

Parameter	Requirement
Course Length	2000m, plus additional areas at start and finish minimum at 2122m, prefer 2222m
Lane Width	8 lanes at 13.5m wide, with 11m on either side of course, totalling 130m
Minimum Depth	If varied, depth 3m. If same, 2m.
Bank Slope	Maximum 1:3, preferred 1:4 to 1:6
Bank Materials	Large stones or wave absorbing materials should be placed along the water line to at least 1m below normal water level
Bank Vegetation	Controlled growth of low height reeds, or other aquatic plants, along edge of bank promoted
Water Quality	Secondary, Refer Section 5.1
Timing Huts	At 500m, 1000m, 1500m intervals

4.8.4.2 Conservation Category Wetland

The Southern River Conservation Category wetland vegetation is proposed to be included in a conservation and rehabilitation area within the Champion Lakes Regional Recreation Park Master Plan, and will therefore will be protected from any direct impacts. A minimum 50m buffer will be provided to the rowing course, however a pedestrian access and some of the rowing starting facilities may be present within the buffer area.

The most significant potential indirect impacts on the conservation area as a result of development will be:

- Increased use of the dampland by residents and visitors as a passive recreation area;
- Pressure on wetland vegetation through uncontrolled access to the dampland;
- Invasion of weeds and possibly diseases through the disturbance of natural habitats;
- Change in hydrology;
- Increased potential for fire as a result of adjoining residential development.

The potential impacts and the proposed management of these impacts are also detailed in Sections 4.4, 4.5 and 5.2.

No net loss of wetland function is predicted in this area (see Table 9).

4.8.4.3 Resource Enhancement and Multiple Use Wetlands

With the exception of Wright Lake, most of the Resource Enhancement or Multiple Use wetlands areas have been cleared or parkland cleared. All are Degraded or Completely Degraded. These wetlands still have hydrological functions, such as groundwater recharge and flood mitigation, but have limited ecological value.

The construction of the rowing course, rowing facilities, warm up lake/return leg and spectator areas will directly impact the majority of the bed of Wright Lake, and a maximum of approximately 60% of the wetland and adjoining vegetation.

The degraded damplands present throughout the site will be extensively modified by the construction of the rowing course and by the construction of the built form of the development. The most significant impacts may be the loss of areas for summer shallow feeding areas within Wright Lake, and the potential loss of Aboriginal archaeological and ethnographic sites (Table 9). Most of the other wetland functions will be retained, enhanced or increased.

TABLE 9
Potential Impacts on Wetland Functions
in the Three Wetland Management Categories

Wetland Function	Conservation Category Wetland (Southern River)	Resource Enhancement Wetlands (including Wright Lake)	Multiple Use Wetlands
Assimilation of nutrients, other pollutants, sediment and litter	No impact and enhanced	Replaced by Water Sensitive Urban Design and Best Management Practices in Drainage	Replaced by Water Sensitive Urban Design and Best Management Practices in Drainage
Food webs	No impact and enhanced	Water quality and depth within Wright Lake and dampland will be altered which will change composition of food web	Existing food web minimal – will be enhanced
Drought refuges for waterbirds	No impact - Currently not a drought refuge	Currently not a drought refuge - will become a drought refuge	Currently not a drought refuge - will become a drought refuge
Provision of some summer shallow feeding areas for migratory wader birds	No impact	Significant reduction in area of summer shallow feeding areas	Currently not a summer shallow feeding area – will be modified to include some shallows
Habitats for plants, animals or communities known to be rare or restricted	No impact	Wright Lake - ~1.82ha of Degraded vegetation and adjoining upland vegetation cleared, ~2.62ha retained Large Dampland – minimum of 0.15ha retained, maximum of 2.92ha of Degraded to Completely Degraded vegetation cleared Northern Dampland – 0.14ha retained	~3.53ha of Degraded to Completely Degraded wetland vegetation cleared
Flood control	No impact	Not applicable	Not applicable
Filtering of nutrients sediments and pollutants in surface runoff from adjoining land	No impact	Replaced by Water Sensitive Urban Design and Best Management Practices in Drainage	Replaced by Water Sensitive Urban Design and Best Management Practices in Drainage
Historical/ archaeological	No impacts	Loss of Aboriginal sites	Loss of Aboriginal sites
Recreation	Enhanced opportunities for passive recreation	Enhanced opportunities for active recreation	Enhanced opportunities for active recreation
Education and Nature study	Enhanced opportunities	Loss of saline wetland environment. Replaced by large permanent, fresh wetland	Enhanced opportunities to study large constructed wetland, evolution and management regime success
Access to wildlife	Enhanced opportunities	Enhanced opportunities although wildlife composition will be altered	Enhanced opportunities
Aesthetic considerations	Enhanced through revegetation/ rehabilitation	Enhanced	Enhanced

4.8.5 Proposed Environmental Management

4.8.5.1 Conservation Category Wetland

The EPA's Guidelines for Environment and Planning (1997) recommend that the wetland's management category and its existing functions should be used to determine how the wetland should be managed. Wetlands of greatest conservation significance such as Conservation category wetlands should be protected from development including draining into or out of and filling and loss of vegetation.

The Conservation category wetland vegetation surrounding the Southern River, located within Bush Forever Site No. 260, will be protected and rehabilitated within regional open space in the development. The EPA has formulated guidelines regarding adequate horizontal separation distances between wetlands and various land uses (EPA, 1997) and recommends a minimum buffer of 50m or 1m AHD higher than the furthermost extent of wetland dependent vegetation, which ever is the largest. 50m and 1m AHD buffers for the Conservation category wetland is shown in Figure 8. A minimum buffer of 50m from the Conservation Category wetland vegetation will be provided in the development to the rowing course.

A management strategy will be prepared to protect the remnant wetland vegetation from potential impacts associated with future development. It is essential that the management of the conservation area:

- maintains and encourages species diversity and ecological processes; and
- maintains and enhances natural landscape amenity.

Access will need to be controlled within the conservation areas by planning a path network. The paths will be located in the existing cleared areas wherever possible. Rehabilitation and revegetation of cleared areas will assist in controlling access to the area and protect the conservation values of the wetland core.

Revegetation will need to be undertaken with suitable local indigenous species of the Southern River and Forrestfield vegetations complexes. Laying areas of brush cleared from other areas of the site between areas planted will deter access over the planted areas and may assist in regeneration.

There is a risk of fire within the area due to the future surrounding residential and sporting development and the proximity of the conservation area to Tonkin Highway. A

strategic firebreak should be retained or placed around the perimeter of the conservation area and a fire hydrant should be positioned in the near vicinity.

The management of weeds and diseases is detailed in Sections 4.4 and 4.5.

Potential hydrological impacts from dewatering operations during construction will be managed in accordance with the approved Construction Management Plan.

4.8.5.2 Resource Enhancement and Multiple Use Wetlands

Given Multiple Use and Resource Enhancement wetlands generally have low to moderate human use and conservation values, the EPA (1997) may consider approving the partial filling of these wetlands and/or use as drainage basins provided:

- The wetland function is retained within the development;
- A wetland is constructed or rehabilitated to fulfil equivalent functions; or
- If the wetland is to be decreased in size there should be an increase in the number of functions created; or
- The additional water enhances the wetland and its functions, and does not lead to a loss of water quality.

Both Wright Lake and the damplands within the property will be extensively modified by the development. However, the project has been designed to fulfil the above criteria through:

- retention of all the Southern River wetland vegetation and some parts of the vegetation surrounding Wright Lake in conservation oriented open space;
- rehabilitation of degraded areas and revegetation within the Southern River Conservation area and preparation of a management strategy to maintain and encourage species diversity and ecological processes; and
- construction of a rowing course which is effectively a large permanent wetland and a "living streams" which will increase the number of wetland habitats by providing areas of permanent and some seasonal open water of varying depths.

4.8.5.3 Wetland Mitigation Strategy

In June, 2001 the EPA released a draft policy framework for the establishment of wetland banking instruments in Western Australia. The draft policy focuses on wetland loss mitigation, by restoring, enhancing, creating or offsetting adverse wetland impact

through the conservation of other wetlands as a form of compensation. In developing this framework the EPA seeks to preserve wetland values and functions and ensure that these are not unnecessarily or 'unavoidably' lost or diminished, irrespective of the type of the proposed development, the size or type of wetland likely to be impacted or magnitude of the wetland impact (EPA, 2001).

The EPA recognises three types of wetland loss mitigation:

- Wetland restoration – re-establishment of a wetland in an area where it historically existed but now only performs no or few ecological functions;
- Wetland creation – construction of a wetland in an area which was not a wetland in the past;
- Wetland enhancement - increasing one or more of the functions of an existing wetland, such as increasing the productivity or habitat value by modifying environmental parameters, such as bathymetry, open water and emergent vegetation (Kruczynski, 1990).
- Wetland conservation – buying equivalent amounts of high quality wetland to mitigate for degradation or destruction of others.

In order to compensate for wetland impacts the proponent commits to implement a Wetland Mitigation Strategy to offset these losses. The objectives for the Strategy will be to:

- Avoid direct and minimise indirect impacts on all Conservation Category wetlands.
- Avoid impacts on Resource Enhancement and Multiple Use wetland vegetation wherever practicable.
- Where Resource Enhancement and Multiple Use wetlands will be impacted, the proponent's objective will be no net loss of Resource Enhancement and Multiple Use wetland values and functions.
- Impacts to Resource Enhancement and Multiple Use wetlands will be compensated by:
    - fencing and limiting access by humans and stock into the Conservation Category wetland vegetation at Southern River;
    - establishing a dryland buffer zone to Southern River from the development;
    - revegetating and restoring the riverine and wetland vegetation as well as the buffer with the Southern River Vegetation Complex;
    - undertaking a weed eradication program at Southern River and the conservation area adjacent to Wright Lake;
    - rehabilitating and restoring the conservation area adjacent to Wright Lake, including the planting of fringing vegetation;

- creating and actively maintaining a large permanent waterbody and living stream to enhance and expand the previous wetland functions and values.

The following wetland functions and habitats (from EPA, 1993) will be established within the development:

Ecological

- Assimilation of nutrients, other pollutants, sediment and litter by water sensitive urban design and best management practices in drainage;
- Food webs – plantings of fringing vegetation along the rowing course, warm-up lake and living stream will encourage a natural food web to become established. Submerged aquatic plants will however not be planted due to the problems experienced at the Penrith rowing facility;
- Drought refuges for waterbirds – by creating a 52.28ha permanent waterbody, which together with adjacent conservation areas totals 73.35ha;
- Provision of some summer shallow feeding areas for migratory wader birds along the living stream/return lane, although these areas are unlikely to be seasonally 'dry';
- Protection of existing vegetation communities near Southern River (~3.35 ha) and Wright Lake (~2.62 ha) considered to be under reserved.

Hydrological

- Flood control functions through behaviour of the rowing course as a retention/storage basin;
- Filtering of nutrients, sediments and pollutants in surface runoff from adjoining land.

Social

- Provision of an Aboriginal Interpretive Centre to display information on Aboriginal heritage and archaeological finds present within the site;
- Significantly expanding the recreational value and uses in the area;
- Education and nature study – the development of the waterbody, rehabilitation areas will provide opportunities for schools and university groups to become actively involved in excursions, monitoring and case studies of the area as occurs at Penrith Lakes Environmental Education Centre;
- Providing greater access to wildlife within the site; and
- Enhancing aesthetic value.

The hydrological regime and ecological composition within Wright Lake will be significantly altered by the construction of the proposed development. However it is considered that the 73.35 ha of permanent wetland and conservation areas proposed within the development will provide different wetland functions and habitats of equivalent value, resulting in no 'net' loss of wetland functions.

Wetland enhancement will be integrated into the overall Landscape Plan (Appendix E), and the area will be subject to constant monitoring and maintenance during the life of the Regional Recreation Park.

Guidelines for the preparation of environmental management plans for the protection of wetlands (and other issues) are provided in Appendices E and F.

5.0 POLLUTION MANAGEMENT

5.1 Water Quality

5.1.1 EPA Objective

- *Ensure that the beneficial uses of surface water can be maintained, consistent with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000).*
- *Maintain or improve the quality of groundwater to ensure existing and potential uses are protected*

5.1.2 EPA Scope of Work

- *Describe how surface water and groundwater quality will be directly or indirectly impacted by the proposal.*
- *Conduct groundwater monitoring to determine the existing groundwater quality beneath the site. Determine groundwater flows.*
- *Undertake monitoring of streamflow into the Southern River and collect baseline data on water quality for the calculation of pollutant loads.*
- *Detail the seasonal baseline data on water quality of Wright Lake.*
- *Calculate possible nutrient and pollutant sources and inputs into Wright Lake and discuss potential management needed to ensure water meets ANZECC Water Quality Guidelines for Fresh and Marine Waters and other applicable water quality requirements such as those required for International Rowing Courses.*
- *Determine the likely pollutant and nutrient inputs into Southern River.*
- *Discuss the potential impacts on groundwater quality including calculating the potential nutrient and pollutant loadings. Model the movement of the salinity plume which may result from the alteration of Wright Lake to accommodate the rowing course. Discuss potential impacts on existing and proposed usage of the groundwater resource.*
- *Determine on-site drainage, irrigation and nutrient stripping requirements, including any sub-soil drainage to protect surface water and groundwater quality.*
- *Determine nutrient management measures for the equestrian, nursery and permaculture facilities and all grassed/garden areas (tennis courts, playing fields, golf course etc).*

- *Discuss Integrated Catchment Management measures that are applicable to the development.*
- *Provide design criteria, area of land required and proposed planting layout for wetland filter proposed within the Master Plan adjacent to the Southern River.*
- *Detail how the management measures will be carried out, and to whose satisfaction this work will be done. Include a description of the long term maintenance required.*

5.1.3 Existing Environment

Nutrient levels in surface water in the vicinity of the proposed development have been historically considered "low" to "moderate" using the classification system outlined in the Swan-Canning Cleanup Program Action Plan (SRT, 1999). This infers that total phosphorus and total nitrogen are in the range of >0.1 < 0.2 mg/L, and >1.0 <2.0mg/L, respectively. Groundwater sampling and analysis undertaken for the project (Section 5.1.3.1) shows nutrient levels are moderate, with localised high levels associated with former and current intensive animal farming. Appendix H presents greater detail on the sampling and analysis program. Hames Sharley (2000) report average groundwater quality measured during the early 1990's also indicates "moderate" nutrient concentrations.

5.1.3.1 Groundwater

Sampling and Analysis Program

Groundwater water quality at the site was determined on three occasions (March, April and June, 2002). Water quality in the Southern River and Wright Lake was assessed in August 2002.

A number of groundwater monitor bores were installed at the site during previous hydrogeological and geotechnical investigations (Wood and Grieve, 1991 and GHD, 2000). Bowman Bishaw Gorham installed an additional four monitoring bores in June 2002. Figure 9 shows the location of the bore network.

Groundwater sampling was undertaken in March, April and June 2002. During each sampling event the electrical conductivity and pH of the groundwater was measured. Samples were collected for the analysis of ammonia (NH_4), total Kjeldahl nitrogen

(TKN), nitrate/nitrite (NO_x), total nitrogen (TN), total phosphorus (TP), filterable reactive phosphate (FRP), and salinity.

Results

Table 10 presents the groundwater analysis results. The groundwater quality parameters at a number of locations within the site exceed the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ 2000) default trigger values (DTV) for freshwater reservoirs and lakes in Southern Western Australia (Table 11) as follows:

- Total Nitrogen as mg-N/L between 1.1 and 80 fold.
- Nitrate and nitrite as mg-N/L between 2 and 2728 fold.
- Ammonia expressed as mg-N/L between 6 and 1500 fold.
- Total Phosphorus between 1.1 and 79 fold.
- Filterable Reactive Phosphorus between 1.2 and 158 fold.

The DTV are used to assess the risk to ecosystems from the adverse effects of elevated nutrient concentrations. This indicates that water bodies constructed outside the natural wetland areas that are in direct hydraulic connection with or are topped up by groundwater could potentially become eutrophic.

The extent of the nutrient, salt and pH plumes within the superficial groundwater was interpolated using the contouring package (Kriging function) within the GMS modelling system. Visualisation tools were used to allow the interpretation of the results.

Nitrogen

Figure 10 shows the interpolated extent of the TN and NO_x concentrations in groundwater in June 2002. The figure shows that the higher concentrations of TN and NO_x are associated with the existing duck farm (Figure 9). The source is likely to be the leaching of nitrogen in the form of NO_x from manure.

Figure 11 shows the interpolated extent of the NH_4 and TKN (organic available nitrogen) concentrations in groundwater measured in June 2002. The highest concentrations of NH_4 and TKN appear to be associated with the duck farm and land formerly used as a piggery. Elevated NH_4 concentrations are often indicative of animal waste disposal.

TABLE 10
Groundwater Quality Analysis Results

Monitor	Ammonia-N			Nitrate-N/Nitrite-N			Total Kjeldahl Nitrogen			Total Nitrogen			Filtered Reactive Phosphate			Total Phosphorus			Salinity			pH
Bore Id	25-Mar	24-Apr	20-Jun	25-Mar	24-Apr	20-Jun	25-Mar	24-Apr	20-Jun	25-Mar	24-Apr	20-Jun	25-Mar	24-Apr	20-Jun	25-Mar	24-Apr	20-Jun	25-Mar	24-Apr	20-Jun	20-Jun
LW1	15	0.04	0.2	0.045	0.015	0.015	19	1.3	1.2	19	1.3	1.2	2	0.06	0.11	2.9	0.01	0.13	320	150	110	5.5
LW2	1.5	1.7	0.18	0.015	0.015	0.49	2.6	2.6	2.3	2.6	2.6	2.8	0.14	0.73	0.47	0.37	0.91	2.7	540	640	520	5.6
LW3	1.3	0.08	0.2	0.015	0.015	0.025	1.3	1.4	2	1.3	1.4	2	0.01	0.01	0.01	0.03	0.12	0.03	110	100	70	5.3
LW4	0.7	0.08	0.2	0.015	0.015	0.015	1	0.2	0.2	1	0.2	0.2	0.01	0.07	0.01	0.05	0.07	0.02	5700	6300	6400	6.5
LW5	2.8	0.09	2	4.4	0.049	5.5	3.9	0.2	0.6	3.9	0.2	6.1	0.71	0.09	0.56	0.75	0.29	0.72	830	800	690	6.3
LW6	1.1		0.3	24.1		27.28	1.4		0.3	24		28	0.02		0.02	0.03		0.06	660		520	5.8
LWPZ1	14	0.06	0.2	14.05	0.015	0.015	15	0.2	0.4	15	0.2	0.4	0.01	0.01	0.01	1.4	0.07	0.04	1600	2900	2400	5.6
B1		0.37	0.3		0.055	1.205		2.1	4.2		2.2	5.4		1.7	2		2.1	2.1		180	150	5.1
B4		0.34	2.1		0.035	3.105		3.1	9.5		3.1	13		2.4	7.9		4.6	7.9		230	290	3.6
B8		0.58	0.8		0.045	0.025		5.1	5		5.1	5		2.8	3.4		4.1	3.4		80	50	5
B12		0.77	0.8		0.015	0.18		3.5	4.8		3.5	5		0.07	0.55		0.67	0.87		930	890	6.2
B15		0.24	0.2		0.015	0.015		0.6	0.7		0.6	0.7		0.01	0.04		0.11	0.05		5400	710	5.8
B16		0.11	0.2		0.015	0.145		0.6	4.4		0.6	4.5		0.01	0.02		0.18	0.78		1700	800	6.2
GERT1			0.2			1.93			0.3			2.2			0.01			0.05			710	7

TABLE 11
Water Quality Default Trigger Values for Freshwater Lakes and Reservoirs in the Southern Western Australia (ANZECC/ARMCANZ 2000)

Water Quality Parameter	Guideline (mg/L)
TN	0.35
NO_x-N	0.01
NH_4-N	0.01
FRP	0.05
TP	0.1
Salinity	200 - 1000

Elevated nitrogen concentrations can also occur under broad acre crops and pasture through the leaching of nitrogen added as fertiliser and/or fixed by leguminous pastures such as lupins and clover. These trends have been previously demonstrated beneath leguminous pastures at Point Grey and Lake Clifton (Bowman Bishaw Gorham, 1999).

Phosphorus

Figure 12 shows the interpolated extent of total phosphorus and filterable reactive phosphate within the site as measured in June 2002. The TP and FRP concentrations were highest in the same area as the high NH_4 and TKN indicating the former piggery may be the source.

The elevated TP and FRP values indicate that there is a potential for wetland eutrophication especially in summer months.

Salinity

Figure 13 shows the interpolated extent of saline groundwater within the site in June 2002. The groundwater salinity beneath Wright Lake in December 2002 was much higher than June 2002 at 28,500mg/L. The high salinity is associated with the discharge of groundwater into Wright Lake and subsequent evaporation leaving salts at the lake surface. Further investigation is required to delineate the salt plume beneath Wright Lake. The WRC WIN database provides some evidence of a saline groundwater plume extending to the northeast of Wright Lake with groundwater total dissolved salts exceeding 1,500mg/L measured in some bores.

pH

Figure 13 shows the interpolated groundwater pH measured in June 2002. The pH measurements indicate moderately acid to neutral groundwater pH within the site. The lowest pH (3.7) was recorded in monitoring bore B4 the vicinity of acid sulfate soil (ASS) sampling location ASS12 (Section 5.7), where sulfidic sulfur and acid concentrations exceeded the accepted action criteria. It is believed that the groundwater acidity may result from the seasonal fluctuation of the watertable exposing PASS material to air for a period during which some oxidation to AASS occurs. The oxidation process is expected to desist when the soil becomes saturated as the watertable rises. Values of pH measured in surface water in Wright Lake in August 2002 were slightly alkaline (~9.5). Values of pH in monitoring bores adjacent to Wright Lake were marginally acid to neutral (6-7).

5.1.3.2 Surface Water Sampling and Analysis Program

In August 2002, two samples of lake water and two samples of river water were collected from Wright Lake and Southern River, respectively and analysed for a range of potability parameters. The results are presented in Table 12 and indicate that total nitrogen in Wright Lake and NO_3 concentrations in Southern River exceed the DTV by up to 4.6 fold an 18 fold, respectively. The water in Southern River is fresh whilst the salinity of Wright Lake would be expected to vary significantly as a result of the evapo-concentration of salts through the seasonal wetting and drying of the lake.

The source of nitrogen into both the Southern River and Wright Lake is likely to be runoff from agricultural fertilisers and the discharge of nutrient enriched groundwater.

TABLE 12
Surface Water Quality Analysis Results

	Ammonia-N	Nitrate-N/Nitrite-N	Total Kjeldahl Nitrogen	Total Nitrogen	Filtered Reactive Phosphate	Total Phosphorus	Salinity	Chlorophyll-a	Phaeophytins	pH
WL1	<0.2	<0.01	1.6	1.6	0.05	0.05	1200	0.00004	<0.00004	9.47
WL2	<0.2	<0.01	0.7	0.7	0.03	0.04	1100	0.00002	<0.00004	9.64
SR1	<0.2	0.18	1.0	1.2	0.04	0.07	160	0.000052	0.000014	8.3
SR2	<0.2	0.17	1.2	1.4	0.04	0.06	340	0.000045	0.000014	8.03

Notes:
WR denotes Wright Lake
SR denotes Southern River
All values in mg/L.

5.1.4 Potential Environmental Impacts

The potential environmental impacts on water quality associated with the construction of an IRC are described in the following sections and summarised in Table 13. The potential impacts and the management of these impacts will depend on whether the IRC is lined or unlined. The preferred option is for a lined IRC. The type of liner used will only marginally affect the potential impacts on water quality and any proposed management (Table 14). The least environmental impact is likely from the installation of a synthetic liner; however, a clay liner would be suitable providing it was constructed to rigorous design criteria.

TABLE 13

Water Quality - Summary of Potential Environmental Impacts

Unlined	Clay Liner	Synthetic Liner
Nutrient rich superficial groundwater could enter the IRC resulting in a higher potential for conditions that result in the development of algal blooms.	A clay liner would isolate the IRC from the surrounding superficial aquifer, however a small degree of exchange between the IRC water and the groundwater would still occur in both directions depending on the water level maintained in the IRC. Absorption and retention of nutrients by the clay liner would be expected.	A synthetic liner would isolate the IRC water from the groundwater. This would allow control over the water quality and significantly reduce the potential for the development of environmental conditions conducive to algal blooms. It is also less likely that a build up of nutrients in the IRC sediments will occur.
Seepage of brackish water will occur into Southern River. If the source water is fresh (>1,000mg/L) this would not be an issue and would potentially restore some environmental flows.	As with the above, a clay liner would not completely prevent the seepage of brackish water. However, the seepage rate would be significantly reduced.	A synthetic liner would prevent the seepage of brackish water.
The water level in the IRC will be harder to maintain at a constant level, which could affect the development of fringing vegetation and the aesthetics of the IRC.	A clay liner would allow better management of the IRC water levels and therefore reduce any potential impacts associated with fluctuating water levels, especially during the establishment of vegetation.	As with a clay liner, a synthetic liner will allow better control on water levels.
An unlined IRC could be vulnerable to any existing, unforeseen or accidental contamination occurring within the superficial aquifer.	A clay liner should prevent any vulnerability of the IRC to groundwater contamination, providing the integrity of the liner is maintained.	A synthetic liner will prevent any vulnerability of the IRC to groundwater contamination, providing the integrity of the liner is maintained.
Fringing vegetation will have to be tolerant of brackish conditions.	Fringing vegetation will have to be tolerant of brackish conditions.	Vegetation within the IRC will have to be tolerant of brackish conditions. However, fringing vegetation planted outside of the liner may not have to be tolerant of brackish conditions.

5.1.4.1 Nutrients and Contamination

Nutrient concentrations in groundwater exceed the ANZECC/ARMCANZ (2000) trigger values. These values are used to assess the risk to ecosystems from the adverse effects of elevated nutrient concentrations. Concentrations exceeding the triggers indicate that water bodies constructed outside the natural wetland areas that are in direct hydraulic connection with or are topped up by groundwater could potentially become eutrophic especially in summer months. It is anticipated that top up water quality will comply with the trigger values as the proposed source is the Yarragadee aquifer. Combined with the continual mixing of the waterbody that will be required during the operation of the IRC significant dilution of the existing high nutrient groundwater is anticipated.

Potential sources of nutrients and pollutants into Wright Lake, the future IRC and Southern River include the former piggery and the existing duck farm. Potential contaminants associated with these activities could include trace metals, pesticides, nutrients, phenols, nonyl phenols, solvents, detergents and hydrocarbons.

5.1.4.2 Salinity

Groundwater beneath the existing Wright Lake was tested in December 2002 and found to be highly saline (28,500mg/L). Therefore it is feasible that a saline plume already exists beneath Wright Lake which is moving in the direction of regional groundwater flow (north east). There is a lack of monitoring data to the northeast of Wright Lake and whilst there is some evidence in the WRC WIN database of brackish bores, it is largely unknown as to whether a saline plume already exists. It is also difficult to accurately determine the impact on the Canning River as there is little information as to the nature of the hydraulic connection between the Canning River and the superficial aquifer.

The presence of an unlined IRC would result in a dilution of the existing groundwater salinity over time.

Solute transport modelling using the MT3D model was undertaken to assess whether the saline groundwater identified beneath Wright Lake, would be affected by the construction of an unlined IRC.

The MT3D simulation indicates that a brackish groundwater plume would be generated from an unlined IRC assuming the concentration of top up water was 3,000mg/L. The salinity of water entering Southern River in 25 years time would be approximately

2,500mg/L (Figure 14). Over an entire year the predicted plume is likely to be diluted by 20 fold by river water, however, in summer months little dilution is expected. In summer, the brackish water may impact riparian vegetation and water-based flora and fauna that are not salt tolerant.

5.1.5 Proposed Environmental Management

Water quality within the IRC is of paramount importance from rowing, amenity, marketing, lifestyle and irrigation perspectives.

This section addresses the following:

- Monitoring and management of water quality.
- Preliminary water quality performance criteria.
- Poor water quality contingency options to be implemented in the event that performance criteria are not met.

Table 14 presents a summary of options for the management of the water quality issues presented above (Table 13). These management options will all be addressed in a Drainage, Nutrient, Irrigation and Water Quality Management Plan (DNIWQMP) which will also provide the contingency plans associated with the different options.

The preferred option is to construct a lined waterbody, which will effectively isolate the IRC from the surrounding superficial aquifer. This will reduce the impacts of the seepage of brackish water (used to fill and top up the IRC) and prevent the entry of nutrient rich superficial groundwater into the IRC.

To eliminate the problem of the seepage of brackish water from an unlined waterbody, reverse osmosis (RO) with brine treatment to remove salts from any brackish water abstracted to fill and top up the IRC would be required. It is unlikely that RO would be implemented as the operating and maintenance costs are very high.

TABLE 14
Water Quality - Summary of Management Options

Potential Environmental Impact	Management Option - Lined IRC (Preferred Option)	Management Option - Unlined IRC
Nutrients	• Regular ongoing monitoring of water quality parameters. • Minimise the potential for eutrophication. • Regular monitoring of the stormwater that may be discharged into the IRC.	• Regular ongoing monitoring of water quality parameters. • Minimise the potential for eutrophication. • Maintain a positive head on the IRC compared to the surrounding aquifer to prevent ingress of nutrient rich groundwater. • Regular monitoring of the groundwater and stormwater that may discharge into the IRC.
Contaminants	• Isolate the IRC from potentially contaminated superficial groundwater through the use of a liner. • Regular ongoing monitoring of water quality parameters. • Regular monitoring of the stormwater that may be discharged into the IRC.	• Maintain a positive head on the IRC compared to the surrounding aquifer to prevent ingress of nutrient rich groundwater. • Regular ongoing monitoring of water quality parameters. • Regular monitoring of the stormwater that may be discharged into the IRC.
Salinity	• Isolate the IRC from the superficial groundwater through the use of a liner, preventing the seepage of brackish water into Southern River. • Regular ongoing monitoring of water quality parameters. • Maintain a relatively constant water quality by regularly releasing brackish water and re-injecting it into either the Yarragadee or Leederville aquifers (to be determined on the basis of further hydrogeological studies). • Modelling would be undertaken to assist the design and location of injection well/s.	• Install a reverse osmosis (RO) plant with brine treatment to remove excess salts prior to the adding the water to the IRC. Salinity would be maintained at less than 1000mg/L eliminating any down stream environmental impact from the release of brackish water. • Regular ongoing monitoring of water quality parameters.
Vegetation	• Select salt tolerant species for use as fringing vegetation and within the IRC. • Regular monitoring of vegetation condition and applicable water quality parameters.	• Regular monitoring of vegetation condition and applicable water quality parameters.

5.1.5.1 Nutrients

As indicated above, each component of the development will require the preparation of a Nutrient Management Plan (NMP), as part of the overall DNIWQMP. This will be conducted under the Landscape Strategy and umbrella philosophies for the project's environmental management plans as detailed in Appendices E and F respectively and will include but be not limited to:

- Isolation of the IRC from the superficial aquifer.
- Regular ongoing monitoring of water quality including temperature, salinity, pH, inorganic and organic contaminants, nutrients and biological parameters.
- The management of the potential for eutrophication.
- Utilisation of nutrient rich groundwater for irrigation of POS.
- Interception, collection and recharge of stormwater runoff from roads and buildings to the IRC. Regular monitoring of the stormwater will occur to ensure the water quality is suitable for recreational purposes.
- Development of contingency plans.

The DNIWQMP will nominate a monitoring schedule and contingency in the event that unacceptable nutrient levels are detected in the IRC and groundwater.

The specific objectives of an NMP will be to:

- Minimise nutrient application to the development area
- Minimise nutrient export from the development area via runoff and leaching.
- Attempt to achieve water quality within the IRC and in water discharging into Southern River that complies with ANZECC Water Quality Guidelines for Fresh and Marine Waters and other applicable water quality requirements such as those required for International Rowing Courses.

The plan will be developed to the satisfaction of the WRC and will address but not necessarily be limited to the following design criteria and guidelines:

- Minimise fertiliser use for landscaped areas by reducing extent of exotic vegetation cover and irrigated landscaped areas.

- Determine fertiliser requirements to minimise nutrient applications - identify areas of site to be fertilised including quantity, duration, frequency and method of application.

- Eliminate or minimise fertiliser applications adjacent to the rowing course and return lane.

- Amend soils with phosphorus binding substances where practicable.

- Use slow release fertilisers.

- Use low fertiliser requirement plants.

- Determine the dilution of nutrients through the use of top up water.

- Address fertiliser requirements including the use of nutrient rich groundwater for irrigation to reduce fertiliser requirements.

Preliminary Water Quality Performance Criteria

Monitoring results will be compared with performance objectives, including established guidelines for aquatic ecosystems in ANZECC (2000) and the requirements of Rowing Australia and the Health Department. Whilst a useful and necessary yardstick, previous experience indicates that many wetlands on the Swan Coastal Plain (natural and constructed) do not achieve ANZECC's relatively conservative water quality criteria.

Davis *et al.* (1993) gathered a considerable amount of water quality data as part of a study conducted to determine wetlands classification on the basis of water quality and invertebrate community data. Davis *et al.* (1993) noted that wetlands with total phosphorus concentrations of less than 165µg/L showed low to moderate nutrient enrichment.

They subsequently proposed this total phosphorus concentration as being a reasonable criteria to avoid or minimise associated excess algal growth in wetlands.

Insufficient data was collected during the Davis *et al.* (1993) study to suggest a limit for total nitrogen, however it was noted that where the ratio of TN:TP was greater than 17, wetlands on the Swan Coastal Plain were considered to be "phosphate limited".

Townley *et al*. (1993) consider that that both nitrogen and phosphorus are required to be in excess to cause algal blooms, and a ratio of 17:1 was established from the requirements of the photosynthesis reaction.

The ANZECC (2000) Australian Water Quality Guidelines for Fresh and Marine Waters provides guidelines of 0.005 - 0.050 mg/L TP and 0.1 - 0.5 mg/L TN.

The results of future water quality monitoring of the IRC can usefully be compared to the total phosphorus criteria suggested by Davis *et al.* (1993), as this data was based on measured data from Western Australian wetlands and hence is directly relevant. Davis *et al.* (1993) did not suggest a total nitrogen limit, and consequently the ANZECC threshold could be applied in this case. In any event, the creation of a waterbody the size of the Champion Lakes course will have an extremely large assimilative capacity (assuming source groundwater is relatively nutrient free), and on-going monitoring will determine predictive algal growth based on nutrient concentrations of as the project proceeds.

Further performance objectives for the system may be defined as achieving water quality that does not result in unacceptable environmental, aesthetic or health problems. Therefore, performance criteria for water quality in the system will also include the following broad objectives:

- Water should be of a quality to avoid the creation or promotion of frequent or excessive algal blooms within the system.

- Floating materials including algal mats and/or scums, oil slicks, and litter, should be avoided.

- Water should not emit unpleasant odours.

- Water should be capable of supporting diverse fringing and submerged vegetation and associated aquatic fauna and waterfowl.

- The microbiological quality of the wetland should not preclude occasional human immersion.

Contingency Options for Poor Water Quality

In the event that monitoring and/or visual observation indicates unacceptable water quality within the project area, contingency options and remedial action undertaken by the Proponent may include:

- The identification of the pollution source through sampling and analysis.

- The elimination of the source of pollution (if possible).

- Physical collection and/or harvesting of plant material as required.

- Use of water for irrigation (rather than superficial aquifer) and replenishment with nutrient-free groundwater.

- Physical aeration or other design alteration (for example water current creation) to avoid anaerobic conditions and promote circulation.

- Implementation of biological or chemical water or sediment treatments as necessary under excessive symptoms when rowing is scheduled. These control methods would not be conducted without approval from the relevant authorities.

It is not proposed to discharge water to nearby river systems in the event of algal blooms.

If pollution is identified within the project area from sources within the catchment but outside of the project area, the project manager will notify the City of Armadale.

In terms of the potential for excessive macrophyte (bottom-rooted aquatic plants) growth, Rowing Australia water quality guidelines apply to this form of nuisance in terms of impediment to rowers. Weed growth has been recorded as a problem in both the Penrith Lakes and Nagambie courses, however this has largely been due to initial

complacency in monitoring infestations, and because the courses are connected to river systems which can easily introduce aquatic weeds.

Conversely, the Champion Lakes project will include vigilant monitoring of this element in the water quality monitoring program from the very outset. Further, the lake is essentially a "closed" system, and introduction of aquatic weeds can be more closely controlled.

Further to the above assessment, a strong commitment has been made to implement best management practice water quality management at the site. In part, this will involve the construction of detention facilities to pre-treat stormwater and remove suspended material. The removal of suspended material is a significant mechanism by which artificial wetlands remove nutrients.

A possible source of nutrients is surface runoff from the surrounding turf, directly into the lake. At the time of construction, the proponent has committed to the preparation of a NMP for the irrigated turf areas. The NMP will recommend the use of soil and turf leaf tissue analysis to determine appropriate fertiliser application rates to ensure that nutrients are only applied on an "as needed" basis.

5.1.5.2 Salinity

Providing the re-establishment of ecological features surrounding the IRC is undertaken using species that are insensitive to significant variations in groundwater salt concentrations, salinity is unlikely to be a major issue within the IRC, especially an IRC lined with a synthetic liner.

It is proposed that the water requirements for the IRC will be met by abstracting groundwater from the Yarragadee aquifer. The quality of Yarragadee water is unknown but it is suspected to be brackish (Davidson 1995). Consequently, in a lined IRC evaporation during summer will result in some evapo-concentration of salts.

Management options will be assessed as part of the DNIWQMP and are expected to include:

- Discharge of brackish water back into an aquifer. Either the Leederville or Yarragadee aquifer could be used depending on the results of the hydrogeological assessment recommended in Appendix H. Based on the current understanding of the

salt contents in these aquifers, recharge of brackish water is unlikely to affect the overall salinity of either aquifer. The volume to be re-injected is small compared to the volume flowing though the aquifers.

- Discharge of brackish water into the Southern River remains an option but would only be considered during winter peak flows to maximise dilution. If an aquifer injection well/s is installed then there would be no requirement to discharge into Southern River. Modelling would be required to assist in the design and location of injection wells.

- Desalination of the brackish water using reverse osmosis (RO) with brine treatment to remove salts as a solid for offsite disposal is an option that could be used prior to filling or topping up the IRC. Use of RO would remove the requirement to discharge any saline water into rivers or aquifers. However, the construction and ongoing operational costs of RO would appear prohibitive.

5.2 Groundwater Quantity

5.2.1 EPA Objective

Maintain the quantity of groundwater to ensure existing and potential uses are protected

5.2.2 EPA Scope of Work

- *Conduct detailed hydrogeological monitoring to determine current water balance for the site and to model changes to water balance.*
- *As part of this assessment undertake detailed soil/geology investigations over the proposal area including the lake bed. Determine extent and thickness of clay or other low permeability strata.*
- *Discuss the variation in lithology and hence aquifer characteristics over the site.*
- *Determine hydraulic conductivity and hydraulic head differential between the proposed waterbody and the water table.*
- *Determine groundwater recharge rate.*
- *Discuss lining requirements for the Wright Lake and International Rowing Course.*
- *Discuss the potential changes in the superficial aquifer and other hydrogeological implications as a result of development.*

- *Calculate quantity of water needed to be inputted into the overall development over the course of a year. Discuss water supply options and water balance.*
- *Discuss the feasibility of accepting stormwater from other adjoining developments.*
- *Liaise with WRC regarding possible groundwater abstraction and determine the feasibility and impacts of this abstraction on local and regional hydrogeology.*

5.2.3 Existing Environment

5.2.3.1 Hydrogeology and Regional Groundwater Flows

The proposed IRC is located between the Southern and Canning rivers within the Pinjarra Plain landform. The local superficial deposits and lake sediments have been investigated by Wood and Grieve (1991) and GHD (2002). Figure 15 shows a cross section of the superficial aquifer at the IRC site as presented by Wood and Grieve (1991). The IRC site comprises a number of shallow ridges with the land generally falling towards the north where Wright Lake is located. Elevations vary from 22 to 27mAHD, the Quaternary to late Tertiary sediments of the superficial formation comprising the first 15 to 25m.

In a regional geological perspective, the proposed IRC site is located on the extensive sedimentary deposits of the Perth Basin, which has been described by Playford *et al* (1976). The regional hydrogeology has been described by Davidson (1995). More detail on the regional and local hydrogeology is presented in Appendix H.

Three main aquifer formations are found in the region as follows:

- Superficial Formation.
- Leederville Formation.
- Yarragadee Formation.

The unconfined Superficial Formation, which comprise the Bassendean sands and Guildford clays unconformably overlays the Cretaceous Wanneroo Member of the Leederville Formation. In the vicinity of the IRC this unit consists of sandstones, siltstones and shales and is ~50m thick where it conformably overlies the Mariginiup Member, also of the Leederville Formation. The intersections of the deeper aquifer formations are strongly inclined in the vicinity of the IRC, with the precise depths not fully defined. The Leederville aquifer in the area is reported to be a discharge area and to have transmissivities of less than $100m^2$/day (Davidson 1995). Water from the Leederville aquifer is expected to be fresh to slightly brackish depending on depth. The salinity is expected to be above that normally utilised for drinking water purposes.

The Yarragadee Formation is the most extensive stratigraphic unit and in parts of the study area underlies unconformably the Mariginiup Member of the Leederville Formation or the Gage Formation and South Perth Shale. Structurally, the Darling fault separates these sedimentary formations from the archaic elevated Darling Plateau. In the south eastern portion of study area, the lesser Serpentine fault extends to the Darling fault. In this area, the Yarragadee Formation has been eroded away and the older Cattamarra Coal Measures underlie the Leederville Formation. Davidson (1995) indicates that water from within the Yarragadee aquifer especially in the vicinity of the IRC is likely to be slightly brackish, however fresh water is expected within the Cattamarra Coal Measures to the southeast.

Regional superficial groundwater flows in the Jandakot flow net discharge in an east to north easterly direction into the Forrestdale Main Drain and the Southern River. Regional groundwater contours as determined from the steady state groundwater model are presented in Figure 16.

5.2.3.2 Localised Superficial Groundwater

A number of groundwater monitor bores were installed at the site during previous hydrogeological and geotechnical investigations (Wood and Grieve 1991 and GHD 2000). Bowman Bishaw Gorham installed an additional four monitoring bores in June 2002 to complement those already existing. Figure 9 shows the locations of the monitoring bores. Localised groundwater contours were interpolated from the groundwater level monitoring at the site (Table 15) and surrounding areas undertaken in June 2002 (Figure 17), using the capabilities of the GMS modelling system.

5.2.4 Potential Environmental Impacts

The Water and Rivers Commission has provided initial advice regarding the feasibility of utilising groundwater in the vicinity of the site as an IRC top up water supply (Appendix I). In response to this advice, the potential environmental impacts were assessed by undertaking groundwater flow and seepage modelling as detailed in Appendix H and summarised in the following sections.

5.2.4.1 Groundwater Modelling

To determine the impacts of the proposed development on groundwater heads, other groundwater users and groundwater dependant ecosystems, groundwater flow modelling

was undertaken using Modflow (McDonald and Harbaugh, 1988). In addition seepage modelling using the Seep2D model, solute transport model using MT3D and urban water balance modelling were undertaken.

TABLE 15
Measured Groundwater Levels

Bore Id	mGDA94		Groundwater Level (mAHD)			
	Easting	Northing	19Feb02	22Mar02	19Apr02	19Jun02
LW1	404448	6446359	20.956	20.81	21.067	21.564
LW2	404769	6446655	22.161	21.999	22.205	22.797
LW3	405052	6446851	22.598	22.354	22.688	23.382
LW4	405708.7	6447499	-	18.788	18.798	19.565
LW5	405453	6447353	22.44	22.3	22.601	23.234
LW6	405399	6447099	22.416	22.08	-	22.994
LWPZ1	406117	6447713	-	18.003	18.133	18.821
B1	404476	6446397	21.122	20.954	21.19	21.675
B4	404718	6446575	22.308	22.085	22.243	22.79
B8	404994	6446858	22.585	22.366	22.761	23.391
B12	405271.6	6447150		21.916	22.035	22.858
B15	405449	6447397	21.024	21.024	19.582	20.332
B16	405557	6447434	22.585	22.49	22.78	23.428
GERT1	406390.3	6448274	-	-	-	21.731
STGEO1	406302.2	6447938	-	-	-	22.658
KIN1	406078.7	6447450	-	-	-	23.53
KIRK1	406155.5	6447320	-	-	-	20.702

Conceptual Groundwater Flow Model

The conceptual model was developed based on the information provided from the Perth Region Aquifer Modelling System (PRAMS) supplied by the WRC in conjunction with Davidson (1995). All three major aquifers were modelled. The following section describes the conceptual model (Figure 18).

The top layer of the model represents the unconfined superficial aquifer that consists predominantly of the Bassendean sands and incorporates the three main surface hydrological features (Forrestdale Lake, the Canning and Southern Rivers). The rivers are depicted as drains to allow the drawdown impacts from abstraction to be assessed.

The second layer of the model represents the Leederville aquifer. Within the model domain the flow dynamics of the Leederville are strongly associated with those of the overlying superficial aquifer (especially within the Armadale superficial flow net). Flow directions are predominantly towards the west with components to the north and north-east.

The third layer of the model represents the Yarragadee aquifer. Groundwater flow within the Yarragadee is predominantly to the west with components towards the north.

The model domain (Figure 19) covers an area of 13.7 km (6439700m N – 6454300m N) by 14.8 km (392300m E – 407100m E), incorporating all known boreholes within the Superficial, Leederville and Yarragadee Formations as suggested by the Water and Rivers Commission (WRC). Each cell within the model area is 100m by 100m resulting in 148 columns, 137 rows and a total of 20,276 cells per layer. The model consists of one unconfined layer; two confined layers and incorporates topographical, geological, climatic and hydrogeological data. The hydrogeological data utilised was taken from area extracted from PRAMS (WRC, 2002) and Davidson (1995) on the advice of the WRC (Table 16).

TABLE 16
Aquifer Properties

Aquifer	Data	Parameter Value	Data Source
Superficial	Topography (mAHD)	-	PRAMS-WRC
	Water levels (mAHD)	Levels measured in 2002	WIN-WRC
	Base Aquifer (mAHD)	-	PRAMS-WRC
	Transmissivity, T (m^2/d)	100 – 1000	Davidson
	Porosity, ∅	0.2	Davidson
	Specific Yield, S_y	0.2	Davidson
	Recharge, q	5 – 20% mean annual rainfall	Davidson
Leederville	Water levels (mAHD)	-	Davidson
	Base Aquifer (mAHD)	-	PRAMS-WRC
	Transmissivity, T (m^2/d)	100	Davidson
	Porosity, ∅	0.25	Davidson
	Storage, S_S	0.0001	Davidson
Yarragadee	Water levels (mAHD)	-	Davidson
	Base Aquifer (mAHD)	-	PRAMS-WRC
	Transmissivity, T (m^2/d)	1000	Davidson
	Porosity, ∅	0.25	Davidson
	Storage, S_S	0.0001	Davidson

Calibration

Steady-state model calibration was achieved by adjusting the hydraulic conductivity and recharge parameters until predicted heads match observed heads as closely as possible.

Calibration of the steady-state model was undertaken in consultation with the WRC and a variance of 1.6m ($R^2 = 0.77$) was accepted as being as good as could be expected given the general lack of observed data, especially within the Armadale flow net. Within the portion of the model domain in which the IRC would be constructed, the field measured groundwater levels are about 1m higher than the regional levels provided by the WRC and used as the starting heads in the model. Regardless of the starting value used, the magnitude of the predicted drawdowns will be similar.

The steady-state groundwater model for the 3 layers over the modelled domain indicates that travel path times would range up to approximately 3,000 years for the superficial aquifer to transverse the whole area as compared to 30,000 to 40,000 years for the Leederville and Yarragadee aquifers. These long travel path times are a result of low hydraulic heads across the model domain to drive flow, as well as low transmissivities of the Leederville and Yarragadee aquifers close to the Scarp. Figure 19 shows the conceptual cross-section A – A'.

IRC Water Requirements

The total surface area of water is estimated to be 52,300m^2 (52.3hectares) at an assumed depth of 3.5m and therefore would require 2.31GL (Gigalitres) of water to fill. Taking mean annual rainfall and pan evaporation (Epan) for Perth as 869 and 1,744mm respectively, the annual evaporation deficit (875mm) multiplied by the waterbody surface area would lead to a potential loss of 0.458GL per year. Generally a factor of 0.8 times Epan is used to estimate actual evaporative loss (pers. comm. Prof. M Sivapalan, Centre for Water Research, University of Western Australia). Using a factor of 0.8 the estimated evaporative loss is 0.376GL per year. Therefore the expected and worse case water requirements for the development include:

Expected Use (0.79GL/year)

- 0.366GL/year using 0.8 x Epan
- 0.19GL/year to dilute salts in the IRC.
- 0.15GL/year to irrigate POS.
- 0.01GL/year for a white water park.
- No seepage from the IRC.
- A contingency of 10%.

Worse Case Use (1.42GL/year)

- 0.706GL/year using 1.5 x Epan.
- 0.34GL/year to dilute salts in the IRC.
- 0.15GL/year to irrigate POS.
- 0.01GL/year for a white water park.
- 0.09GL/year seepage from the IRC.
- A contingency of 10%.

Based on these numbers two water use regimes were modelled as follows:

- An expected case regime using 0.79GL/annum in addition to the 2.1GL required to initially fill the IRC.

- A worst-case regime using 1.42GL/annum in addition to the 2.1GL required to initially fill the IRC.

It should be noted that these water use regimes could be reduced through the utilisation of stormwater and grey water from the proposed urban catchment. Water from these sources could yield between 3% and 7% of the total IRC water requirements, if required water quality standards are met.

Scenario Testing

A comprehensive list of scenarios[1] was developed and tested that included abstracting water from each different aquifer as well a combination of aquifers as follows:

- Scenario 1 – filling of the IRC from the superficial aquifer and the predicted impacts after the first year.

- Scenario 2 – filling of the IRC in the first year together with the total expected water use regime over the following 24 years from the superficial aquifer.

- Scenario 3 - filling of the IRC in the first year together with a worst-case total water use regime over the following 24 years from the superficial aquifer.

- Scenario 4 - filling of the IRC from the Leederville aquifer and the predicted impacts after the first year.

- Scenario 5 – filling of the IRC in the first year together with the total expected water use regime over the following 24 years from the Leederville aquifer.

- Scenario 6 - filling of the IRC in the first year together with a worst-case total water use regime over the following 24 years from the Leederville aquifer.

[1] Scenario modelling does not account for any water treatment or disposal. Only the impacts of abstraction are predicted and assessed. In this instance, groundwater flow modelling is unaffected by the water quality and the predicted drawdowns are the same whether the groundwater is saline or fresh.

- Scenario 7 - filling of the IRC from the Yarragadee aquifer and the predicted impacts after the first year.

- Scenario 8 – filling of the IRC in the first year together with the total expected water use regime over the following 24 years from the Yarragadee aquifer.

- Scenario 9 - filling of the IRC in the first year together with a worst-case total water use regime over the following 24 years from the Yarragadee aquifer.

- Scenario 10 – filling of the IRC in the first year together with the total expected water use regime over the following 24 years from the Yarragadee aquifer and the irrigation of POS from the superficial aquifer.

- Scenario 11 – filling of the IRC in the first year together with a worst-case total water use regime over the following 24 years from the Yarragadee aquifer and the irrigation of POS from the superficial aquifer.

- Scenario 12 - filling of the IRC in the first year and together with the total expected water use regime over the following 24 years from the Leederville aquifer and the irrigation of POS from the superficial aquifer.

- Scenario 13 – filling of the IRC in the first year and together with a worst-case total water use regime over the following 24 years from the Leederville aquifer and the irrigation of POS from the superficial aquifer.

- Scenario 14 – filling of the IRC in the first year together with the total expected water use regime for the following 24 years with water obtained equally from all three aquifers.

- Scenario 15 – impact on local groundwater and surface water hydrology after 25 years with no top up water, if an unlined IRC was constructed.

- Scenario 16 – impact on local groundwater and surface water hydrology after 25 years of an unlined IRC using the total expected water use regime obtained from the Yarragadee aquifer with an additional amount of 100ML/year abstracted to account for seepage losses and maintain the IRC at a constant level. The scenario includes irrigation of POS from the superficial aquifer.

Steady State Simulations

The steady state model results provided the initial heads for the transient simulations. Figure 16 shows the steady state groundwater levels for the superficial, Leederville and Yarragadee aquifers. The difference in groundwater heads between the superficial and the Leederville is small, generally less than 1.5m. The head differences are both negative and positive indicating both discharge from the Leederville to the superficial within the portion of the model domain that will contain the proposed IRC, and recharge of the Leederville from the superficial over the Jandakot mound. The head difference between the Leederville and the Yarragadee shows recharge from the Leederville to the Yarragadee beneath the Jandakot mound and discharge within the vicinity of the IRC.

Transient Scenario Simulations

Table 17 summarises the predicted drawdown response for each scenario. Predicted drawdowns for the scenarios that cause the least drawdown impact on the Southern and Canning Rivers after 25 years are as follows:

- Scenario 9 (Figure 20).
- Scenario 10 (Figure 21).
- Scenario 16 (Figure 22).

Of the scenarios with a lined IRC, scenarios 8 and 10 provide the best results. Scenario 8 assumes no water is abstracted from the superficial aquifer for the irrigation of POS. It is unlikely that POS water requirements would be met by the Yarragadee aquifer as the water is likely to be too brackish for irrigation, hence scenario 8 can be discounted.

Whilst a drawdown of up to 0.5m is depicted on Figure 21 (Scenario 10), it is within the normal seasonal fluctuation in groundwater levels and within the calibrated model error of 1.6m as agreed with the WRC. This represents an annual drawdown of 0.02m per year, which is not significant and should not affect groundwater dependant ecosystems (GDEs). It is understood that whilst the WRC have not officially set a drawdown criteria for the maintenance of GDEs, a value of <0.2m per year should be acceptable (Ray Freond 2003, pers. comm). The modelling has also been conducted in a conservative manner to ensure any potential impacts are identified and it is likely that the real impact would be less. Further hydrogeological investigations combined with a refined localised model would be required to further predict the drawdown affect of scenario 10.

Scenario 16 (unlined) involving the abstraction of water from the Yarragadee aquifer to maintain an unlined IRC at a constant level will create a groundwater mound beneath the IRC, which offsets any drawdown impact from abstraction. However it is likely that unless the desalination of the brackish Yarragadee water is undertaken, the scenario will be unacceptable as the result of the salt plume that would potentially affect the Southern River (Section 4.7.2 of Appendix H). Saline seepage would not be an issue from the scenarios involving a lined IRC.

The scenarios that have the greatest impact on the rivers all involve abstraction from either the superficial or Leederville aquifers. Abstraction from the superficial aquifer results in the greatest impact. A combination of the superficial and Leederville abstraction also results in predicted drawdowns that would be considered excessive and detrimental to environmental flows or GDEs. Appendix H discusses the results of the scenario testing in greater detail.

It should be noted that the modelling does not account for the preferred management option to inject brackish water from the base of the waterbody into either the Leederville or Yarragadee aquifers as a way of limiting the build up of salts within the IRC (Section 5.1.5.2). This would reduce drawdown impacts on these aquifers. The amount of water injected would be small compared to the overall aquifer storage and flow through volumes and therefore the water quality of either aquifer is unlikely to be affected.

5.2.4.2 Seepage Modelling

The Seep2D model simulates the steady state two-dimensional seepage of water from the floor and walls of a waterbody. A constant head equivalent to 3.5m of water was assigned within the waterbody. The hydraulic conductivity (K) of the surrounding aquifer was assigned a value of 8m/day and the clay liner was assigned a K of 0.1m/day[2].

Heads corresponding to the water level in the lake and the surrounding groundwater were assigned and the groundwater seepage velocity and shape of the resultant watertable determined.

The 2D seepage modelling undertaken for both a clay-lined and unlined IRC predicts that the loss into the down gradient portion of the superficial aquifer is 60ML/year and 90ML/year.

[2] The relatively high K value of 0.1m/day was used in the model as the specifications for the liner were not available at the time of modelling. The actual K value is likely to be at least 2 orders of magnitude lower and therefore the amount of seepage is likely to be significantly lower.

TABLE 17
Predicted Drawdowns from Model Scenarios

Scenario	Years	Aquifer	Total Water Use per year	No. Bores	Abstraction per Bore (m^3/day)	Drawdown on Southern River (m)	Drawdown on Canning River (m)
1	1	SUP	2,310 ML	3	2,110	0.2 - 1.75	0
	1	LEED	0	0	0		
	1	YARRA	0	0	0		
2	2 to 25	SUP	790 ML	3	721.5	0.5 - 1.5	0.3 - 0.9
	25	LEED	0	0	0		
	25	YARRA	0	0	0		
3	2 to 25	SUP	1,420 ML	3	1,297	0.2 - 3	0.2 - 1.5
	25	LEED	0	0	0		
	25	YARRA	0	0	0		
4	1	SUP	0	0	0	0.25 - 1	0
	1	LEED	2,310 ML	3	2,110		
	1	YARRA	0	0	0		
5	25	SUP	0	0	0	0.2 - 1	0.2 - 0.8
	2 to 25	LEED	790 ML	3	721.5		
	25	YARRA	0	0	0		
6	25	SUP	0	0	0	0.5 - 2	0.5 - 1.5
	2 to 25	LEED	1,420 ML	3	1,297		
	25	YARRA	0	0	0		
7	1	SUP	0	0	0	0	0
	1	LEED	0	0	0		
	1	YARRA	2,310 ML	1	6,330		
8	25	SUP	0	0	0	0.2 – 0.4	0.2 – 0.4
	25	LEED	0	0	0		
	2 to 25	YARRA	790 ML	1	2,165		
9	25	SUP	0	0	0	0.2 – 0.71	0.2 – 0.7
	25	LEED	0	0	0		
	2 to 25	YARRA	1420	1	3,891		
10	1	SUP	150 ML	1	411	<0.2	0
	1	LEED	0	0	0		
	1	YARRA	2,310 ML	2	3,165		
	2 to 25	SUP	150 ML	1	411	0.2 – 0.5	0.2 – 0.5
	25	LEED	0	0	0		
	2 to 25	YARRA	640 ML	1	1,754		
11	2 to 25	SUP	150 ML	1	411	0.2 – 0.9	0.2 – 0.8
	25	LEED	0	0	0		
	2 to 25	YARRA	1,270 ML	1	3,480		
12	1	SUP	150 ML	1	411	0.2 - 1	0
	1	LEED	2.31 GL	2	3,165		
	1	YARRA	0	0	0		
	2 to 25	SUP	150 ML	1	411	0.2 - 1.2	0.2 - 0.9
	2 to 25	LEED	790 ML	2	1082		
	25	YARRA	0	0	0		
13	2 to 25	SUP	150 ML	1	411	0.2 - 2	0.2 - 1.6
	2 to 25	LEED	1,740 ML	2	2,384		
	25	YARRA	0	0	0		
14	1	SUP	770 ML	2	1,055	0.2 - 1	0
	1	LEED	770 ML	1	2,110		
	1	YARRA	770 ML	1	2,110		
	2 to 25	SUP	264 ML	1	723	0.2 - 1	0.2 – 0.8
	2 to 25	LEED	264 ML	1	723		
	25	YARRA	264 ML	1	723		
15	25	SUP	457 ML	0	0	0.2 - 0.5	0.2 - 0.75
16	25	SUP	150 ML	1	411	0.25	0.25
	25	LEED	0	0		0.25	0.25
	25	YARRA	1,740 ML	1	2,438	2.0	2.0

5.2.4.3 Salt Transport Modelling

The objective of the salt transport modelling was to assess whether the saline groundwater identified adjacent to and beneath Wright Lake would be affected by the construction of the IRC. The salt transport modelling assumed an unlined IRC as this option would result in the greatest mobilisation of salt and would have the potential to cause the greatest down gradient impact.

The solute transport model MT3D was used to simulate the movement of the potential saline groundwater plume that would develop if in an unlined IRC filled with brackish water at a concentration of 3,000mg/L was constructed. A transient Modflow flow solution for scenario 16 was used as the base model with the water level in the IRC maintained at a constant head of 21.5mAHD over 25 years. The daily abstraction volume from the Yarragadee aquifer was increased by 275m^3/day (100ML/year) to account for seepage losses from an unlined IRC. A transient solute transport simulation was run over a total period of 25 years. It was assumed that:

- The salt plume comprised conservative ions and was predominately NaCl.
- No chemical transformations, absorption or other losses occurred during transport.
- The salt concentration under Wright Lake was of the same magnitude as the estimated concentration in the IRC.

The MT3D simulation indicates that the saline groundwater plume will reach the Southern River within 25 years (Figure 14) at concentrations up to 2,500mg/L. The discharge area is likely to be small compared to the entire length of the river and considerable dilution is likely. The estimated daily superficial groundwater discharge into the Southern River is 5,900m^3/day. A conservative estimate of daily seepage from the IRC into Southern River is 275m^3/day. Therefore the potential dilution is of the order of 20 fold. However, river flows only occur in winter and during the summer months the only discharge would be the brackish water from the IRC. Currently, over the entire length of the river, the potential daily salt load at a discharge of 5,900m^3/day assuming a salt concentration of 250g/m^3 (the estimated average salt concentration in the river), is 1.5 tonnes per day. A seepage discharge from an unlined IRC of 275m^3/day at a salt concentration of 2,500g/m^3 would result in an additional salt load of 0.69 tonnes per day, an increase of approximately 30%.

An unlined IRC could increase the mobilisation of the existing saline plume beneath Wright Lake towards the Canning River, depending on the head maintained in the waterbody. Dilution of the existing plume would also occur. If a lined IRC was constructed there would be minimal effect on the existing saline plume as it would be isolated from the superficial aquifer.

5.2.4.4 Water Balance Modelling

Urban water balance modelling was undertaken using a spreadsheet model. The modelling indicated that, whilst stormwater runoff can be captured and transferred to the IRC, the quantity available from the proposed residential area (~13ha) within the site would only contribute approximately 26ML per annum (or 3.3%) of the expected water use[3] (Figure 23, top graph). Regular monitoring of the stormwater would be required to ensure the water quality is suitable for recreational purposes prior to discharge into the IRC. Management of stormwater runoff by recharging it to the superficial aquifer is also a consideration. Modelling has shown that the superficial aquifer can provide sufficient water to irrigate the POS at the site. Recharging the stormwater to the superficial aquifer would prevent the depletion of this resource and provide the potential to recycle any nutrients within the groundwater onto grassed area (Appendix H, Section 6.2).

Grey water from the residential component of the IRC could also be collected, treated (if required) and used as top up water[4]. The production of only 55ML of grey water is predicted, which is 7% of the required water. However, there is a significant cost component to treat grey water to the required water quality standard. Of equal importance, an IRC with treated grey water may have significant constraints as an international sporting facility.

Since the urban water balance modelling was undertaken, it has been suggested that the amount of urban residential development may be increased. Stormwater and grey water from this additional urban area could provide another 3% to 10% of the IRC water requirements.

An urban catchment of approximately 400 hectares is required to provide sufficient stormwater and to provide 100% of the required top up water. Whilst there is enough urban area to the south of the IRC to theoretically provide sufficient water, the collection

[3] Assumes 0.2m of runoff generated per year from an urban catchment including roofs and roads of 13ha.
[4] Assuming the expected water use requirement with grey water from 500 homes each producing 300L per day.

of this water would be expensive and difficult, with the resulting loss of significant flows to the Canning and Southern Rivers.

As new residential development occurs to the north of the IRC, stormwater and grey water could be collected and piped into the IRC, reducing the requirement to abstract water. Figure 23 (bottom graph) shows the predicted IRC water level with input from 400 ha and 200 ha of residential housing and no addition of top up water.

5.2.4.5 Modelling Summary and Conclusions

Groundwater modelling investigations were undertaken to determine the impact on local and regional groundwater levels from the development of the Champion Lakes Regional Recreation Park. Water requirements include top up water for an International Rowing Course (IRC), irrigation of public open space and a white water rafting course.

The data to construct the steady state groundwater model was provided by Water and Rivers Commission (WRC) using the Perth Region Aquifer Modelling System (PRAMS), while additional information was utilised from the report by Davidson (1995). The steady state model parameters and calibration were agreed with the WRC.

The model incorporated three layers to represent the superficial, Leederville and Yarragadee aquifers. Various model scenarios were simulated using an expected (0.79GL/year) and a worst case (1.42GL/year) water use regime. Each scenario was run over a period of 25 years and the drawdown in each aquifer predicted.

Following the testing of a matrix of scenarios, the most appropriate scenario that would have a limited impact on surface water features and other users within the area was taken as a combination of limited abstraction from the superficial aquifer and the bulk from the Yarragadee aquifer.

Results and conclusions from the groundwater modelling investigation are summarised as follows:

- Abstraction of the majority of the required water from the Yarragadee was found to be the best option.

- Water required to irrigate the POS could be sustainably abstracted from the superficial aquifer.

- Abstraction from the Yarragadee would not adversely affect other groundwater users and groundwater dependent ecosystems.

- Abstraction to meet the expected water use regime from either the Superficial or Leederville aquifers is not sustainable beyond one year. Long term abstraction would lead to a significant and unacceptable drawdown of water in the Canning and Southern Rivers.

- Without desalination, an unlined IRC filled and maintained with water abstracted from the Yarragadee aquifer would create a brackish seepage problem into the Southern River (assuming the Yarragadee water was found to be brackish).

5.2.5 Proposed Environmental Management

5.2.5.1 Stormwater

At present stormwater collected within the urban catchment between the Canning and Southern Rivers (largely directly south of the site) discharges into the following drains:

- Second Road Main Drain (discharges into the Southern River).
- Denny Avenue Branch Drain (discharges into the Canning River).
- Rundle Street Main Drain (discharges into the Canning River).
- Westfield Park Main Drain (discharges into the Canning River).

Some stormwater is discharged into Wright Lake from the urban catchment to the northeast. Stormwater runoff is unlikely to be generated from non-urban areas within and to the north and west of the site because of the sandy nature of surface soils.

Existing stormwater flows into Southern River will not alter from present. Stormwater from the proposed Champion Lakes development is likely to be collected and recharged to the superficial groundwater. It is estimated that the quantity of runoff available for recharge will be 26ML/year. This will partly compensate for the pumping of the superficial aquifer for the irrigation of POS. These issues will be addressed in greater detail in the proposed DNIWQMP.

5.2.5.2 Superficial Groundwater Flows

The presence of a lined IRC will reduce the transmissivity of the superficial aquifer between the Southern and Canning Rivers by approximately 30%. This may result in slightly altered flow directions and a possible build up of groundwater on the up-gradient side of the IRC. This build up is likely to be managed through the abstraction of approximately 150ML/year of superficial groundwater for the irrigation of public open space (POS). The affect on groundwater discharge to the Southern River is likely to be less than 10% of the groundwater discharge of 2150ML/year[5] estimated by Davidson (1995). It should be noted that the Southern River flow regime has already been significantly altered through drainage. Prior to drainage, groundwater from the Jandakot mound would have discharged along the entire length of the Southern River. Most of this flow is now intercepted by the Forrestdale Main Drain, which enters the Southern River close to Gosnells.

5.2.5.3 Groundwater Abstraction

Modelling indicated that the best management of groundwater to protect GDEs and other users would be the abstraction of the majority of the required water supply from the Yarragadee aquifer. This would result in low to insignificant drawdowns of around 0.02m per year. As part of any future application for a licence to abstract groundwater, a detailed operating strategy would be prepared, which would include a commitment to install and monitor a series of groundwater monitoring bores within each of the three aquifers.

Monitoring would be undertaken on a regular basis as agreed with the WRC and results compared to the groundwater model predictions. The operating strategy would identify "trigger" levels which if breached would trigger management responses, which could range from reduced abstraction to the requirement to stop pumping.

5.2.5.4 Dewatering

The construction of the IRC will involve a substantial dewatering program. Excavation will occur in sections to minimise dewatering impacts. Dewatering will be carried out in such a way as discharge from the pumps is retained on site and will not be directed into

[5]Davidson (1995) estimates the discharge into rivers and lakes from the Armadale superficial flow net to be 5,900m^3/day (2,150ML/year), using flownet aquifer hydraulics.

any of the proposed conservation areas, or the buffer for wetland vegetation adjacent to Southern River.

Dewatering water will be comprehensively tested for nutrients, microbiological and standard contaminants. If the water meets the desired quality criteria for secondary recreation contact it will be used to partly fill the IRC. If the dewatering is not suitable for filling the IRC it may be pumped into an infiltration basin or discharged into the Southern River. Discharge into the Southern River will only occur as a last resort if the water quality will not cause significant impact to riverine water quality.

Once final design has been developed (likely to be before June, 2003) a Dewatering Program (including a requirement for a groundwater abstraction licence) will be developed as part of the Construction Management Plan, in co-ordination with Main Roads WA, which will propose strategies to minimise the potential impacts of dewatering on the vegetation within the conservation areas, surrounding wetlands, Southern River, Canning River and groundwater quality.

5.2.5.5 Other Water Sources

Other water sources are discussed in Section 2.0 of Appendix H. Options canvassed include:

- Superficial aquifer.
- Leederville aquifer.
- Yarragadee aquifer.
- Scheme water.
- Water trading.
- Urban runoff and grey water.

The preliminary assessment presented in Appendix H, shows that the most environmentally and technically feasible option is abstraction from the Yarragadee aquifer. Regardless of the final option adopted, long-term management will be required to maintain water of a sufficient quality.

5.2.5.6 Water Conservation Measures

Water conservation measures are recognised as important design elements and will be applied within the development. These include (but are not necessarily limited to) the following:

- Promote use of plant species, which have low water and fertiliser requirements.
- Utilise local native species in landscaping.
- Consider the collection and transfer of road stormwater drainage to the IRC.
- Promote landscape treatments sympathetic to climatic conditions and prevailing site conditions – soil types, topography, environment, wetlands etc.
- Utilise "cluster or clump" plantings to provide useable shade areas and better use of reticulated water in preference to single item or symmetrical planting regimes.
- Irrigate grass and garden areas at appropriate time so as to reduce evaporative loss and minimise transpiration losses.
- Ensure that irrigation regime is responsive to prevailing weather conditions.

The umbrella philosophy and guideline criteria for the preparation of a future Environmental Management Plan to address drainage and water management issues is included as Appendix F.

5.2.5.7 Recommended Further Work

Given that there is a lack of good hydrogeological and hydro-chemical data, it is recommended that the following work be undertaken:

- A preliminary desktop study to estimate the cost of investigations, testing, installation and operation of a Yarragadee production bore.
- Application to the WRC for an exploration licence to drill a test hole into the Yarragadee aquifer.

- Undertake hydrogeological investigations to the satisfaction of the WRC including:

  - Characterisation of the hydraulic properties of the superficial and Yarragadee aquifers in the vicinity of the proposed IRC.

  - Test drilling.

  - Pump testing.

  - Geophysical logging.

  - Preparation of a hydrogeological report.

- Revise modelling on the basis of the results of the hydrogeological investigation and construct a localised model to further assess the potential drawdown impacts on the local groundwater and surface water hydraulics if applicable.

- Prepare a comprehensive water management strategy that addresses pending issues of water quality, quantity and the management of water discharges into existing watercourses.

- Apply for an abstraction licence, which would include an operating strategy and ongoing monitoring commitments.

5.3 Noise

5.3.1 EPA Objective

Protect the amenity of residents from noise impacts resulting from activities associated with the construction and operation of the proposal by ensuring that noise levels meet statutory requirements and acceptable standards.

5.3.2 EPA Scope of Work

- *Using information on existing sporting facilities, conduct a noise study to estimate noise levels associated with the development and extrapolate to existing and proposed residences and noise sensitive premises in the area. Take into account the*

proposed extension of Tonkin Highway adjacent to the development within this study.

- *Determine if noise is likely to exceed significant levels.*
- *Discuss the proposed management measures which will be implemented to ensure that the noise levels meet acceptable standards established in consultation with the DEP.*
- *Discuss construction impacts on nearby residents, including the transport of raw material to the site and onsite construction operations.*
- *Detail how the impacts will be identified, maintained and managed to meet statutory requirements and acceptable standards established in consultation with the DEP.*

5.3.3 Existing Environment

A noise assessment for the site was conducted by Herring Storer Acoustics, the full report of which is provided in Appendix J. The report considers noise emissions from the site to:

1. neighbouring existing residences to the north and east of the study area; and
2. the proposed residential area within the study area.

The report also considers noise that will be emitted from the future Tonkin Highway extension. Compliance of these noise emissions with the *Environmental Protection (Noise) Regulations 1997 (as amended*) is reported.

5.3.4 Potential Environmental Impacts

There are several sources of noise associated with the project which have the potential to impact noise sensitive premises. These include noise from:

- Construction activities;
- Rowing and whitewater events;
- Tonkin Highway; and the
- Commercial Area.

5.3.4.1 Noise Emissions from Construction Activities

During construction, noise emissions from this site will be generally due to earth moving equipment. Noise received at the existing residence from construction equipment will need to comply with the requirements of the *Environmental Protection (Noise) Regulations 1997* and specifically Regulation 13 “Construction sites”.

The majority of earth to be excavated from this site will be carted from the site via access to the northern side of the site (i.e., on opposite side to existing residence) therefore, noise impact on the existing residences will be minimal.

5.3.4.2 Noise Emissions from Recreational Activities

Noise emissions from spectators at an event are exempt from the Regulations. Noise emissions from the actual event, participants and a PA system are required to comply with the Regulations.

The only potential impact that will be of concern during an event is noise emissions from the PA system. Noise emissions from the rowing events themselves will be minimal and are likely to be masked by the crowd noise.

No power boats are usually associated with the races. Power boats are only proposed to be used on the rowing course intermittently for regular maintenance and monitoring, and consist of dinghies with small outboard motors.

Noise associated with the pumps required to generate white water or to circulate water around the course will be required to comply with the Regulations.

Noise emissions from training sessions carried out in the early morning (i.e. before 0900 hours on Sunday or Public Holiday or before 0700 hours on any other day) will need to comply with the assigned night period noise levels. Noise emissions from any coaches, power boats or megaphones will need to comply with the Regulations.

5.3.4.3 Noise Emissions from Tonkin Highway

Noise received at the north east end of the proposed residential area from vehicles travelling along the Tonkin Highway is expected to exceed the DEP acceptable criteria by approximately 1dB(A).

5.3.4.4 Noise Emissions from Commercial Areas

The critical noise sources from the convention centre are mechanical services and music generated within the convention centre.

5.3.5 Proposed Environmental Management

5.3.5.1 Noise Emissions from Construction Activities

To ensure that noise emissions from construction activities comply with the regulations, a Construction Management Plan will be developed for this site.

5.3.5.2 Noise Emissions from Recreational Activities

Noise emissions from the PA system will be managed by using a larger number of small speakers carefully positioned along the course. The area which will be most affected by a rowing regatta are the existing residences located to the north east of the finish line. For any large regattas that are going to involve the use of an extensive PA system and possible entertainment after the regatta, a Regulation 18 "Venues used for sporting, entertainment purposes" will need to be obtained for the event to allow noise emissions to exceed the assigned noise levels.

To reduce the possibility of any complaints from any future residences, memorials should be considered for new residential titles to provide a warning that the area is subject to noise generated at the rowing course. These include early mornings from boat crews and coaches, boats with megaphones, and during regattas.

Noise emissions from white water generating pumps will be controlled by placing them in acoustic enclosures or at a suitable distance from the residential area. Consultation will occur with the Department of Environmental Protection Noise Officers to determine appropriate treatment for the proposed type and number of pumps.

5.4.5.3 Noise Emissions from Tonkin Highway

To manage noise emissions from Tonkin Highway, additional noise control is required for residences in the north-east of the proposed residential area or residences will need to be located approximately 25 metres further back from the proposed highway.

5.3.5.4 Noise Emissions from Commercial Areas

Mechanical services are likely to operate during the night period so noise received at neighbouring premises will need to be less than 30 dB(A). To manage this, the location

of any mechanical services within the commercial areas will be located adjacent to other commercial premises and on the furthest side of the building from any residences.

To comply with the Regulations, noise received at a residence from music generated within the convention centre will need to comply with a noise level of around 25 dB(A). Therefore, the construction of the convention centre will be such that it contains the music. The greatest problem in controlling noise breakout from function rooms will be noise emanating from the roof, windows and doors. To reduce noise emissions from the function rooms, general guidelines for construction are provided within the full noise report in Appendix J.

Herring Storer (2002) recommends that the sporting fields be relocated to between the commercial area and the residential area to provide a buffer between the convention centre and the residences. This option can be considered in the future detailed planning and design of the development, but it is expected that the current layout will be preferred.

5.4 Public Risk and Safety

5.4.1 EPA Objective

Ensure that risk is managed to meet the EPA's criteria for individual fatality risk off-site and the Department of Minerals and Petroleum Resources' requirements in respect of public safety.

5.4.2 EPA Scope of Work

- *Establish if there are any risks associated with the construction and operation of the proposal from the high pressure gas pipeline and power transmission lines.*
- *Discuss potential risks and setback distances required from the pipeline in accordance with previous EPA assessments.*
- *Detail how the risks, if identified, will be managed and to whose satisfaction.*

5.4.3 Existing Environment

5.4.3.1 High Pressure Gas Pipeline

A 20m gas pipeline easement is located along the western edge of the future Tonkin Highway, approximately 60m from the western edge of the Champion Lakes development and 275m from any proposed residential development at its closest point. The easement currently contains the Dampier – Bunbury Natural Gas Pipeline (DBNGP), which is 660mm in diameter and has a Maximum Allowable Operating Pressure (MAOP) of 8.5MPa.

5.4.3.2 Power Transmission Lines

A Western Power transmission corridor containing two 330KV transmission lines is located along the western edge of the development area. The proposal has been developed to ensure that the existing transmission line towers are located within designated conservation and parking areas to minimise the potential risk to the public.

5.4.4 Potential Environmental Impacts

5.4.4.1 High Pressure Gas Pipeline

Changes in land use adjacent to pipeline easements may result in the risk posed by these changes exceeding the EPA criteria for individual risk of fatality and may subsequently affect the overall risk to the public (EPA, 2000a). Off-site individual risk is the risk of a certain outcome to an individual at a specific location, with outcomes measured in terms of fatality, injury or exposure level (EPA, 2000b). The current off-site individual risk criteria established by the EPA are listed in Table 16.

TABLE 16
Off-site Individual Risk Criteria (EPA, 2000b)

Type of Development	EPA Criteria (Fatalities per year)
Residential Areas	1 in 1,000,000
Sensitive Developments (hospitals, schools, child care facilities etc)	0.5 in 1,000,000
Industrial Facilities	50 in 1,000,000
Non-industrial Activity or Active Open Spaces	10 in 1,000,000
Commercial Developments	5 in 1,000,000

When considering proposals that involve changes to land uses adjacent to high pressure gas pipelines, the EPA seeks to ensure that not only can the individual risk criteria for

adjacent land uses be met, but also that ALARP (As Low As Reasonably Practicable) requirements can be achieved such that:

- Risk mitigation measures are implemented;
- Separation from the pipeline is achieved; and
- Management of the pipeline and the easement is modified to account for any changes. (EPA, 2000a)

High pressure gas transmission pipelines are defined as pipelines with a MAOP above 5MPa, and subject to the requirements of AS 2885.1 Pipelines – Gas and Liquid Petroleum (Part 1: Design and Construction). Under the requirements of Guidance Statement 50 (EPA, 2000a), any proposal involving a pipeline with a MAOP greater than 5MPa, where the separation distance from the centre line of the pipeline to the adjacent land use is less than 300m, must be referred to the EPA for consideration.

Two detailed Quantitative Risk Assessments (QRA) have previously been conducted within Western Australia for residential development proposals located adjacent to existing high pressure gas pipelines. These were a land development at Kogolup adjacent to the Parmelia pipeline, and also the development at Ellenbrook that is adjacent to both the Parmelia pipeline and the DBNGP. Both assessments resulted in a reduction of the 300m separation distance, based on the incorporation and implementation of protection measures (EPA, 2000a). Separation distances for each development are provided in Table 17.

At Ellenbrook, the assessment considered two high pressure gas pipelines operating in adjacent easements; the Parmelia pipeline (350mm diameter, 5.6MPa MAOP) and the DBNGP (660mm diameter, 8.5MPa MAOP). As demonstrated in Table 15, the agreed separation distance for this scenario was 60m to residential uses, whilst the agreed separation distance from the DBNGP was 45m. This separation distance was established using pipeline protection measures such as concrete footpaths over the pipeline, signage, use of pine bollards etc. In the buffer area between the pipeline and residential development, functional areas and mounding were created to provide walk trails, bicycle paths, BMX tracks and public open space.

The EPA has indicated (EPA, 2000a) that developments in comparable situations to these that incorporate equivalent management measures will generally be regarded as acceptable without further risk assessment.

Given the greater separation distance of 275m between the DBNGP and residential areas in the Champion Lakes development, and the implementation of mitigation measures as further detailed in Section 5.4.5, the individual risk from implementation of the proposal is therefore considered to be low.

TABLE 17
Minimum Separation Distance from the Centre Line of the Gas Pipeline to the Adjacent Land Use (EPA, 2000a)

Development	Type of Development (Individual Risk of Fatality)	Separation Distance
Kogolup – Parmelia Pipeline	Sensitive Developments (0.5 in 1,000,000)	96m
	Residential Areas (1 in 1,000,000)	32m
Ellenbrook – Closest Pipeline	Sensitive Developments (0.5 in 1,000,000)	200m
	Residential Areas (1 in 1,000,000)	60m
Ellenbrook – DBNGP	Sensitive Developments (0.5 in 1,000,000)	160m
	Residential Areas (1 in 1,000,000)	45m

The EPA also considers that the location of facilities that result in the congregation of large groups of people for relatively short periods of time may constitute an unacceptable risk to society (EPA, 2000a). The proposed rowing course is intended to host a variety of activities from local rowing competitions to international events. Spectator areas have been provided within the proposal to cater for such activities.

Societal risk attempts to quantify the likelihood of a given number of fatalities that may occur as a result of the high pressure gas pipeline bursting or exploding. Societal risk acceptance criteria proposed for use in Western Australia have been adapted from the *Kwinana Cumulative Risk Analysis*, prepared in 1995 for the Department of Minerals and Energy.

The criteria for acceptable societal risk are based on the individual fatality risk criterion of one in a million ($1x10^{-6}$), with an arbitrary tenfold reduction in likelihood for each

tenfold increase in the potential number of casualties. The magnitude of the societal risk is influenced by the number of people exposed to the risk and the duration of the exposure (e.g. spectators at rowing events), as well as other factors such as the prevailing wind direction (which influences the direction of drift of gas clouds).

If the Ellenbrook example is considered, then the individual fatality risk criterion of $1x10^{-6}$ is achieved at 45m from the DBNGP. Within the Champion Lakes development, large gatherings of people are likely to occur within the spectator areas during rowing events. The spectator stands are approximately 60m from the DBNGP whilst the remainder of the spectator areas are a minimum of 120m from the pipeline. These separation distances are substantially greater than the 45m required to achieve the $1x10^{-6}$ individual risk criterion at Ellenbrook. Therefore it is considered that the societal risk to spectators at rowing events is acceptable.

It should also be noted that the $1x10^{-6}$ individual risk criterion is based on permanent home occupancy whilst the incidence of spectators at rowing events will be intermittent, and as such the risk of exposure to casualties will also be intermittent.

On the basis of this it is therefore considered that the proposal is able to meet the EPA's individual risk criteria.

Due to the location of the Tonkin Highway easement between the DBNGP and the Champion Lakes development, there are not anticipated to be any risks to the pipeline from construction of the proposal.

5.4.4.2 Power Transmission Lines

The environmental risks associated with construction of the proposal in proximity to the development are:

- The potential impacts of electromagnetic fields (EMFs) on the amenity and health of residents;
- The risk of Earth Potential Rise (EPR) on the Rowing Course; and
- The risk of electrocution during construction.

There is a perceived risk relating to EMFs and the potential impacts on general well being. Whilst there is no conclusive evidence that EMFs do not endanger the health and well being of residents living in proximity to transmission lines, the World Health Organisation (WHO) has established guidelines for safe exposure limits. The National

Health and Medical Research Council (NHMRC) of Australia have subsequently adopted these as interim guidelines (*Interim guidelines on limits of exposure to 60/60 Hz electric and magnetic fields*). The recommended limit in the NHMRC guidelines for exposure to EMFs for up to 24 hours per day is 1000 milliGauss (0.1 milliTesla). Western Power has previously advised that it designs and operates all its power lines in accordance with these guidelines (EPA, 2002).

In its evaluation of a proposed transmission line from Pinjar to Cataby (Western Power, 2001), Western Power found that at maximum, worst case operating conditions the proposed 330kV transmission line was expected to produce a maximum EMF of just over 5 milliGauss within the corridor and just under 1 milliGauss along the edge. These values are substantially less than the levels recommended by the NHMRC for continuous exposure, and are unlikely to be substantially increased by the presence of two lines within the corridor. Exposure levels at the closest residences will therefore be well below current guidelines and pose no risk to the health and amenity of residents within the development.

EPR occurs where transmission lines are not properly isolated and a path is provided for a voltage impulse, whether from lightning or a power fault, to rise up from the grounding system. EPR has the potential to compromise the safety of people in the vicinity of the power lines during fault conditions (http://www.powerpulse.net/powerpulse/archive).

EPR effects on the proposed rowing course were examined by Corrpro Companies Australia Pty Ltd (2002). A full copy of this report is provided in Appendix K.

Consideration of the potential for EPR assumed that there were no metallic fences constructed parallel to the power lines and that all fixed structures associated with the rowing course were positioned well outside the zone of influence around each of the power poles. The study found that whilst soil voltages rose under fault conditions at distances greater than 30m from the power lines, levels were still within safety guidelines. Voltage gradients over the waterbody would be significantly lower than the adjacent banks due to its lower resistivity, although the gradients would be affected by seasonal variations and residual ground salinity.

Given that voltage gradients will be within existing safety guidelines it can be determined that there will be no risk to residents or the general public as a result of EPR.

Potential risk of electrocution is present during construction if equipment is operated under, or in close vicinity to the power transmission lines, or if equipment touches the lines during the movement of plant.

5.4.5 Proposed Environmental Management

5.4.5.1 High Pressure Gas Pipeline

The separation distance between the DBNGP and the proposed residential area within the Champion Lakes development is 275m at the closest point, which is substantially greater than the 60m separation distance agreed for Ellenbrook. The land between the pipeline and the residential area will include the future extension of the Tonkin Highway, parking facilities, conservation areas, the rowing course and associated waterways, and spectator areas. This infrastructure and open space areas can be considered as equivalent protection measures to those incorporated into the Kogolup and Ellenbrook developments. On this basis it is considered that the proposal is able to meet the EPA's individual risk criteria.

The societal risk to spectators at rowing events will fall below the individual risk fatality criterion of 1x10-6 at the spectator areas and is therefore considered acceptable. No further mitigation measures to reduce societal risk are considered necessary.

5.4.5.2 Power Transmission Lines

EMF emissions will be well below NHMRC guidelines and as such will not impact on the health and amenity of residents and the general public. Any rise in soil voltages adjacent to the power lines as a result of EPR will still be within safety guidelines.

The main risk associated with the location of the power lines will be that of electrocution to construction personnel. To minimise this risk, the proponent will agree safety guidelines with Western Power prior to the commencement of construction. Such guidelines may include:

- Imposing height restrictions on plant and equipment working under and in close proximity to transmission lines to reduce the risk of induced current; and

- Limiting the movement of plant and personnel under the transmission lines.

5.5 Light Overspill

5.5.1 EPA Objective

The EPA's objective in relation to light is to manage potential impacts from light overspill and comply with acceptable standards.

5.5.2 EPA Scope of Work

- *Predict likely light overspill to proposed and existing residences.*
- *Discuss impacts on existing and future residences and detail how light overspill, if identified, will be managed and to whose satisfaction.*

5.5.3 Existing Environment

Lighting is proposed for the whitewater centre and is being considered in the long term for the rowing course. Lighting may be required for some of the outdoor sporting facilities and for security lighting.

5.5.4 Potential Environmental Impacts

As the detailed planning for the area has not been completed, the distance of any lighting towers to the residences at this stage has not been determined. However, given the proximity of the rowing course and whitewater centre to existing and proposed residences, the issue of light overspill is likely to require definitive preventative measures. Light overspill refers to the flow of light spilling outside of the location boundary.

With inadequate control light overspill can be sufficient to provide a serious nuisance and disturbance to surrounding land users. The level of glare associated with direct viewing of the floodlights also may cause discomfort and annoyance to the viewer.

The potential impacts of the lights to drivers on adjacent roads and any traffic signalling systems also needs to be considered.

The impact of lighting on the hatching of marine turtles has been recognised and documented in the formal assessment of several projects by the EPA. However potential impacts of lighting on tortoises in Western Australian wetlands seem largely unstudied or documented.

Long Necked Tortoises are considered likely to be present in Wright Lake and Southern River. Dr Mike Bamford, an ecologist in Western Australia for 21 years, is not aware of any findings that have shown that lighting affects the Long Necked Tortoises in the same way as the marine turtles. Dr Bamford considers that this may be due to Long Neck tortoise hatchlings emerging at any time of day or night, rather than almost exclusively at night like marine turtle hatchlings. Bamford notes that the Long Neck tortoises seem to be thriving and reproducing in urban wetlands, such as Lake Monger, that are surrounded by lighting. Bamford considers the proposed Tonkin Highway a greater concern for the tortoise population in relation to road kills.

5.5.5 Proposed Environmental Management

The obtrusive effects of outdoor lighting are best controlled by appropriate design. Australian Standard AS4282-1997 on the Control of the Obtrusive Effects of Outdoor Lighting sets out guidelines for control of the obtrusive effects of lighting and provides recommended limits for the relevant lighting parameters to contain these effects to tolerable levels for various surrounding land uses.

The design of the lighting systems in the Champion Lakes Regional Recreation Park will be undertaken in accordance with AS4282-1997 and the recommended limits.

5.6 Dust

5.6.1 EPA Objective

Protect the surrounding land users such that dust and particulate emissions will not adversely impact on their welfare and amenity or cause health problems in accordance with EPA's Guidance Statement No 18 Prevention of Air Quality Impacts from Land Development Sites.

5.6.2 EPA Scope of Work

- *Determine how construction activities can be managed to reduce dust impacts on existing residences.*
- *Refer to the EPA's Guidance on Prevention of Air Quality Impacts from Land Development Sites.*

- Detail how the management measures will be carried out, and to whose satisfaction this work will be done.

5.6.3 Existing Environment

Dust and particulate emissions will be generated throughout construction of the project, in particular during excavation of the insitu lake material and general cut and fill activities.

5.6.4 Potential Environmental Impacts

The potential for dust nuisance will be highest in summer, when dry soil conditions and strong south-westerly prevailing winds will carry dust towards residential areas to the north-east of the site. The closest residences are located 20-25m from the boundary of the Champion Lakes development.

5.6.5 Proposed Environmental Management

The short-term impacts of dust from construction will be managed according to industry best practice and in accordance with all applicable government regulations.

Dust arising from construction works and bare ground will be controlled so as to comply with the requirements of the EPA's EIA Guidance No. 18: *Prevention of Air Quality Impacts from Land Development Sites*.

Where necessary in dry soil conditions, dust will be controlled by a combination of wind fencing, site watering and surface stabilisation (e.g. hydromulching). A water source with storage will be established to provide adequate water to maximise tanker efficiency.

Areas where earthworks have been completed will be stabilised promptly by such means as mulching, sealing or revegetation, as appropriate. No vegetation debris or other material generated during construction will be burned on site. Vegetative material will be recycled on site.

Minimum dust management is expected to be necessary in winter when the soil is damp. However, dust suppression techniques employed during the drier months will be available throughout the year as a contingency measure if required.

The developer will ensure that provision is made, and responsibility accepted, for dust control in all contracts issued for site works.

Management measures specific to the construction phase will be detailed in a Construction Management Plan. Dust management will be carried out to the satisfaction of the City of Armadale.

5.7 Acid Sulfate Soils

5.7.1 EPA Objective

Plan and manage development that may potentially impact on acid sulfate soils to avoid adverse effects on the natural and built environment and human activities and health.

5.7.2 Existing Environment

5.7.2.1 Investigations

A preliminary acid sulfate soil investigation was undertaken by Bowman Bishaw Gorham in May 2002, to assess the extent and characteristics of Potential Acid Sulfate Soils (PASS) and/or Actual Acid Sulfate Soils (AASS) within the study area (Appendix L).

The investigation of Wright Lake, which occupies approximately 25ha (or 20%) of the development footprint, had to be excluded from the assessment program because the Department of Indigenous Affairs was unable to approve access within the program schedule. Approval to disturb the lake bed has since been forthcoming and a second phase of investigations commenced in December 2002.

The phase 1 investigations (May 2002) involved the examination of insitu soil characteristics at a total of 7 locations within the proposed excavation corridors of the rowing channel and return lane for the then preferred Option 1B (See Figure 1, Appendix L) design layout to a maximum depth of 6m. It was agreed with WRC that the results would be submitted when they were available. After the investigations were undertaken the design option significantly changed, the management implications of which are taken account of under 5.7.4. The soil profile characteristics were logged and measurements undertaken of field pH_F and peroxide pH_{FOX} at 25-50cm intervals down

the soil column at each location. Phase 2 investigations within Wright Lake were commenced in December 2002. The results from the Phase 2 investigation will not be available in time for the release of the PER.

Based on the results of the field program, a total of 30 selected oven-dried samples were submitted for laboratory analysis using the Peroxide Oxidation Combined Acidity and Sulfate (POCAS) and Chromium Reducible Sulfur (CRS) test methods, which are the standardised tests, adopted by the NSW and Queensland governments for the assessment of acid sulfate soils. Analytical results were compared with relevant field identification assessment criteria and acid sulfate soil management plan action criteria. Groundwater pH was also investigated in June 2002 at several monitor bores located remotely from the ASS sampling locations to provide an indication of baseline acidity within groundwater.

5.7.2.2 Existing Conditions

79 of the 85 samples subjected to field testing (or 93% of total) exhibited pH_F and pH_{FOX} results, which were not indicative of PASS or AASS. The equivalent laboratory pH results showed relatively poor correlation with the field data, but nonetheless also confirmed the very low incidence of PASS within the sampled soil horizons.

Positive field tests were obtained for 6 samples (or 7% of total), which showed pH_F and pH_{FOX} results indicative of the presence of PASS. Recorded pH differences (between pH_F and pH_{FOX}) for these samples ranged from 0.7 and 3.8, providing a negligible to significant indication of the presence of PASS.

With the exception of sample ASS12-1, no other field peroxide pH_{FOX} values were recorded less than 3, which are generally considered as the pH value below which PASS may be strongly suspected. Laboratory pH results similarly indicated the presence of PASS at a single location in sample ASS12-1.

Of the 30 soil samples selected for analysis based on field test observations, only 1 sample (ASS12-5) exhibited analytical results representative of PASS. In this case, the peroxide oxidisable sulfur level showed good correlation with the chromium reducible sulfur result, which confirms the significant sulfidic potential of the soil at this location. Albeit sample ASS12-1 showed high total potential acidity and a significant pH drop on oxidation, this was not reflected in the sulfur trail. Further confirmatory analysis using the chromium reducible method showed that the soil was not a PASS material, with the

observed acid generation being attributed to organic matter rather than sulfide. The presence of organic acidity in ASS12-1 was consistent with the peaty nature of the soil recorded at this location. Calcium and magnesium test results indicated that all soils have minimal self neutralising capacity.

At location ASS12-5, sulfidic sulfur and acid concentrations exceeded the accepted action criteria adopted in the Queensland guidelines when PASS disturbed at a site requires management (i.e. $S_{CR}+S_{TAA}>0.03\%$ and $S_{CR}+TAA>18$ moles H^+/tonne). The observed exceedences for ASS12-5 were of the order of 2.4-fold the respective guideline values for coarse textured and loamy sands, thereby triggering a requirement to prepare an Acid Sulfate Soils Management Plan (ASSMP) in support of any future dewatering and excavation programs.

Groundwater monitoring results indicate slightly acid to neutral groundwater pH within the site as a whole (Figure 13). The lowest pH was recorded in the locality of ASS sampling location ASS12, where observed sulfidic sulfur and acid concentrations exceeded the accepted ASSMP action criteria. It is believed that existing groundwater acidity may result from the seasonal fluctuation of the watertable exposing PASS material to air and consequent conversion to AASS in this location. The oxidation process is expected to desist when the soil is re-saturated following watertable rebound in the winter months.

5.7.3 Potential Environmental Impacts

Although PASS is essentially benign while they remain in an anaerobic state, their disturbance through excavation or drainage works, can present serious potential risks to aquatic ecosystems and the built environment, through conversion of reduced inorganic pyritic sulfides to sulfuric acid. This can lead to adverse changes in the quality of soil water, groundwaters and surface waters. The generation of acidic leachates, combined with the release of significant levels of sulfate and potentially toxic elements such as aluminium, manganese, arsenic and cadmium can cause serious and long-lasting environmental damage.

Design and implementation of a comprehensive ASSMP should ensure that that no unacceptable effects will occur to human health or the environment from the disturbance of soils within the proposed development area. The main components of the ASSMP are outlined in section 5.7.4.

5.7.4 Proposed Management

The ASSMP will provide a framework of practical and achievable monitoring and control strategies, within which dewatering and bulk excavation activities can be guided to avoid potential impacts associated with the disturbance of acid sulfate soils.

The ASSMP will include details of:

- Proposals for further investigation to develop more accurate data on the extent, depth and characteristics of any acid sulfate soils, having due regard to the outcomes of the preliminary investigation carried out in May 2002 and the spatial variation between a previous option and the preferred conceptual design. In particular, future investigations undertaken in support of the preparation of the ASSMP will seek to (1) delineate the lateral and vertical extent of PASS material in the locality of ASS12; (2) investigate the spatial and vertical distribution of PASS and/or AASS in the lake sediments of Wright Lake and (3) investigate the presence and characteristics of PASS within those areas now earmarked for excavation following the significant redesign of the earthworks layout from Option 1B.

- Proposed prevention, minimisation and mitigation strategies for controlling environmental impacts caused by dewatering and excavation operations, including, but not limited to:
  - treatment and use of any excavated material (including strategic burial considerations);
  - treatment of acidity;
  - containment strategies to manage site runoff and infiltration;
  - techniques for managing watertable height; and
  - if appropriate, management of any existing acidity and contamination being produced.

- Proposed monitoring programs for surface waters and groundwaters and remedial measures to mitigate potential impacts caused by disturbance of PASS.
- Implementation responsibilities for environmental management.

- Reporting requirements and auditing responsibilities to ensure that agreed performance objectives are met, including quality assurance considerations.

- Contingency measures to rectify any deviation from the agreed performance standards.

For the purpose of this document and the management of PASS, it could be assumed here that the entire bed of Wright Lake contains PASS. If this were the case, which appears unlikely based on preliminary groundwater pH readings, then all PASS would be managed, as required, in accordance with the relevant ASSMP to be approved by the regulatory authorities.

At present, the preferred management option for any PASS recovered from below Wright Lake is strategic reburial below the liner of the IRC, beneath the permanent watertable, to maintain anaerobic conditions in the long term.

As noted previously sampling for PASS from Wright Lake has been precluded due to access restrictions. The lake currently contains approximately 600mm of water, and if approvals were received to allow sampling prior to summer 2002/03, this would require a barge-mounted drill rig at considerable cost.

Given that no earthworks will occur within the site until at least July, 2003, and that the proponent has committed to manage any PASS and AASS irrespective of the volume of soils generated, it is considered reasonable to conclude that the final determination of whether PASS do occur below Wright Lake be conducted when the lake is dry, most likely in February or March 2003.

If PASS is identified by the forthcoming sampling regime, then they will be managed in accordance with the Construction Management Plan, and ASSMP, as approved by the regulatory authorities.

5.8 Contamination

5.8.1 EPA Objective

To ensure that soil quality is at an acceptable standard compatible with the intended land use, and consistent with appropriate criteria.

5.8.2 Scope of Work

A poultry farm, piggeries, orchards and market gardens have historically operated within the site and several abandoned landfills are located within and adjacent to the site. The Department of Environmental Protection (DEP, 2001) *Contaminated Sites Management Series* identifies horticulture, animal based industries and landfills as Potentially Contaminating Land Uses.

A preliminary assessment for potential contamination has been undertaken in accordance with the DEP (2001) *Contaminated Sites Management Series*. The Preliminary Site Investigation (PSI) scope of work was agreed with the DEP (pers comm. A. Ralston, 18 September 2002) prior to commencement of the investigation. The PSI is presented in Appendix M and summarised below.

The objectives of the PSI were to identify areas and sources of potential contamination within the site and to determine the requirement for further investigations to confirm the contamination status of the site.

The following scope of work was undertaken to achieve the above objectives:

- A review of historical aerial photographs taken between 1948 and 2002 held by the Department of Land Administration. Copies of the relevant photographs are presented in Attachment A of Appendix M;

- A chain of title search to identify past owners, as presented in Attachment B of Appendix M;

- Consultations with past and present City of Armadale personnel and councillors;

- Consultations with the Explosives and Dangerous Goods Division of Department of Mineral & Petroleum Resources regarding historical dangerous goods storage facilities including fuel storage tanks. No past or present licences or permits were identified within the site;

- Consultations with other persons knowledgeable of historical site activities including:

    - William and Mary Clare, Lots 13, 14, 15, 1 and 2 Lake Road

- Simon Ellies, Lots 11 and 12 Lake Road
- Donelle Zaurs, Lot 1 Cammillo Road
- Gilbert Goodwin, (offsite) caravan park owner/proprietor
- Ludmilla Dostal, former caravan park owner/proprietor
- Richard Dostal, son of former caravan park owner/proprietor
- Alf Della-Vedova, neighbouring property owner
- Bill Epps, WAPC, owner of Lots 107 & 108
- Mike Gilliam, Kelmscott School Farm Manager
- Rob Liebeck, Kelmscott School Farm Teacher in-charge
- M Csohany, (offsite) 14 Zenobia Terrace
- George Csohany, (offsite) Zenobia Terrace, written recollections
- Emilia Csohany (offsite) Zenobia Terrace, written recollections
- Dave Ballard, (offsite) 16 Zenobia Terrace
- Lenie Muilenburg, (offsite) Caretaker, Church of Kelmscott
- Kim Fletcher, historian for Armadale/Gosnells area
- Daniel Goussac, Wesfeeds poultry feed nutritionist

- Site inspections to confirm the areas and sources of potential contamination identified from the above investigations and to search for other signs of potential contamination;

- Identified areas and sources of potential contamination and the associated contaminants of concern based on information gathered from the aforementioned investigations; and

- Assessed the requirement for further investigations to confirm the contamination status of the site.

5.8.3 Existing Environment

Soils at the northeast end of the site around Wright Lake are mapped as white to pale grey fine to medium grained sand of eolian origin underlain by yellow sand (Jordan, 1986). Large areas of pale grey to brown clayey sand that is silty in part are present through the central western part of the site, interspersed with pockets of white to pale grey sand. Sandy clay to clayey sand of the Guildford formation is present along the central and southeast site boundaries. A cross section of lithological units is detailed in PER Appendix H, Figure 3.

A preliminary acid sulfate soil investigation was undertaken to assess the presence and characteristics of Potential Acid Sulfate Soils and/or Actual Acid Sulfate Soils within the site. PER Section 5.7 provides a summary of the investigation, which is presented in PER Appendix L.

As discussed in previous sections, regional groundwater flows north-northwest toward Wright Lake at the northern end of the site and south-southwest toward Southern River at the southern end of the site.

5.8.4 Potential Environmental Impacts

The PSI has identified the following areas of potential contamination:

- Six historical orchards and market gardens;
- A livestock yard;
- Two piggeries;
- A poultry farm;
- Uncontrolled fill at three locations within and adjacent to the site;
- Existing and demolished residential buildings and onsite sewage disposal systems; and
- A small residential automotive workshop.

The areas of potential contamination identified within the site are summarised in Table 18 and shown on Figure 24.

The risk of significant contamination occurring at the identified areas appears low but cannot be discounted without additional examination. Consistent with State guidelines, further investigations are proposed to assess the contamination status of the site, the associated environmental risks and the requirement for remedial action.

5.8.5 Proposed Environmental Management

Consistent with DEP guidance, it is proposed to assess potential contamination at the identified areas using the staged approach recommended in the *Contaminated Sites Management Series* (DEP, 2001) as shown in Figure 25. The next assessment phase will be an initial sampling and analysis program to assess the presence, nature and magnitude of contamination at the identified areas of potential contamination.

TABLE 18
Areas and Sources of Potential Contamination

Potential Source	Key Potential Contaminants	Location
Orchards & Market Gardens	• Pesticides • Trace metals • Nutrients	Lot 13 Lake Road Lot 14 Lake Road Lot 15 Lake Road Lot 3 Cammillo Road Lot 11 Lake Road Lot 1 Lake Road Area Lot 90 Pt 5
Grazing & Pasture	• Pesticides • Nutrients	Area Lot 90 Lot 4 Lake Road Area Lot 90 Pt 5
Piggeries	• Pesticides • Metals • Nutrients • Petroleum hydrocarbons • PAH	Lot 1 Cammillo Road Lot 11 Area Lot 90 Lot 4
Poultry Farm	• Pesticides • Trace metals • Petroleum hydrocarbons	Lot 13 Lot 14 Lot 15 Lot 1 Lake Road
Uncontrolled Fill	• Pesticides • Trace metals • Asbestos	North shore Wright Lake Southeast edge Wright Lake North of Ypres Road & east of Lake Road
Residences	• Pesticides • Nutrients • Pathogens	Lot 1 Cammillo Road. Lot 2 Cammillo Road. Lot 3 Lake Road (near Cammillo Road) Lot 6 Lake Road near the current Caravan Park Lot 11 Lot 1 Lake Road (corner Ypres Road) Lot 3 Lake Road Lot 13 Lot 107 Lake Road Lot 108 Lake Road Area Lot 90
Domestic Workshop	• Trace metals • Petroleum hydrocarbons • Solvents	Lot 108

6.0 SOCIAL SURROUNDINGS

6.1 Mosquitoes and Midges

6.1.1 EPA Objective

Protect health, welfare and amenity of existing and future residents.

6.1.2 EPA Scope of Work

- *Determine the potential for increasing habitat and breeding grounds for nuisance mosquito and midge populations for the proposed and existing residential areas based on expected water quality within Wright Lake and the rowing course.*
- *Discuss methods of mosquito and midge control which can be implemented as part of the design and in subsequent management. Refer to EPA's Guidance No 40 on Management of Mosquitos by Land Developers.*

6.1.3 Existing Environment

Insects with aquatic larvae that breed in wetlands and may impact surrounding human populations include mosquitos and non-biting midges. Mosquitos are known to present serious health risks to humans through acting as transmitters of a number of diseases in Western Australia including Ross River virus, Barmah Forest virus and Australian encephalitis. Both mosquitoes and midges can also create severe nuisance problems that may impact on nearby residential areas. Midge and mosquito problems in residential areas tend to develop around wetlands that have an open waterbody and a very small buffer of vegetation. Factors which affect the abundance of these insects are:

- Whether the wetland is permanent or seasonal;
- Variation in the surface level of the exposed water table in the wetland; and
- The width and density of buffer vegetation.

The problem is due in part to excessive nutrient inputs which support a large phytoplankton biomass on which the larvae feed. Midge and mosquito problems are rare in wetlands that are not nutrient-enriched where there is existing vegetation (Davies and Lane, 1995)

Adult midges are passive fliers, dependent on prevailing winds and therefore dense fringing vegetation has a capacity to act as a barrier between the emergence of the adults from the wetland to nearby houses. A vegetated buffer also screens residential lighting, an attractant to adult midges. A buffer zone also provides habitat for predators including spiders and dragonflies (Davies and Lane, 1995). Vegetation also acts to absorb nutrients, provide shade which decreases water temperature and subsequent growth of algae and larvae and produce tannin which reduces algal growth (Pinder *et. al.*, 1992).

The length of the life cycles of midges, and thus the rate of population growth, is highly dependent upon temperature and food availability (Pinder *et. al.*, 1992). Larval midge densities have been found to rise immediately following a steep rise in algal abundance over the spring/summer months. The maintenance of nutrient levels to ensure algal blooms do not occur forms an integral part of controlling populations of midge larvae. It is expected that the deep water (3.5m minimum) proposed within the rowing course will keep the water temperature lower than the shallow wetlands located on the Swan Coastal Plain.

Constructed wetlands, although initially 'artificial', may "evolve" and become complex ecosystems with a variety of flora and fauna including mosquitoes and midges (Russell 1999). The construction of the lake and rowing course has the potential to introduce mosquito and midge populations without appropriate control and management.

In the EPA Guidance Statement No. 40 Management of Mosquitos by Land Developers the EPA encourages the adoption of mosquito control measures which maintain healthy wetland ecosystems and minimise the physical alteration of foreshore areas or wetlands. The use of water sensitive urban design principles is also encouraged to ensure appropriate management of urban stormwater run-off. Physical, chemical and biological control methods are recommended for management of mosquito populations. Public education is also an important element in mosquito management. On-going monitoring programs are recommended for assessing the effectiveness of a control program for up to five years after the completion of the development, after which time consideration should be given to handing this responsibility to the relevant LGA.

6.1.4 Potential Environmental Impacts

The potential for increased habitat and breeding grounds for nuisance mosquito and midge populations within the site is minimal for the following reasons:

- Water quality will be maintained for primary contact levels as detailed in Section 5.1, which includes low nutrient levels that are not favourable for mosquito and midge growth;
- The course will be oriented in line with the prevailing wind, allowing for production of surface waves and disturbance to larvae;
- The water will be mechanically aerated in locations within the warm up lake which will reduce larval survival by disturbing the surface and preventing the formation of stagnant areas which are conducive to mosquito and midge breeding;
- There will be large areas of deep (3.5m), open water and appropriate edge treatments to limit potential breeding locations;
- Appropriate vegetation species will be selected for edge planting;
- A large, dense vegetation buffer varying between 15-60m wide will be planted between the course and the nearest residences in the direction of the prevailing wind (north-east from the development);
- A complete wetland food web will be promoted, which will enhance mosquito predators, through maintenance of water quality within the water bodies;
- Implementation of WSUD BMP's within the development will further reduce the suitability of the lake and rowing course as mosquito breeding grounds;
- To minimise shallow areas, the slopes have been engineered to be as steep as possible whilst also maintaining Rowing Australia rowing course design requirements and public safety standards.

6.1.5 Proposed Environmental Management

Nuisance proportions of mosquitos and midges will be prevented through the methods of mosquito and midge control discussed above, which are in accordance with the EPA Guidance Statement No. 40 Management of Mosquitos by Land Developers.

Details of further mosquito and midge control, management and monitoring programs will be provided in a Mosquito and Midge Management Plan to be prepared as part of the overall Champion Lakes Environmental Management Plan (see Appendix F).

6.2 Aboriginal Culture and Heritage

6.2.1 EPA Objective

- *Ensure that changes to the biological and physical environment resulting from the proposal do not adversely affect cultural associations with the area.*
- *Ensure that the proposal complies with the requirements of the Aboriginal Heritage Act 1972.*

6.2.2 EPA Scope of Work

- *Establish whether any sites of Aboriginal archaeological and/or ethnographic significance may be impacted. This should be done in consultation with local Aboriginal communities and native Title claimants.*
- *Lodge investigation reports of archaeological and ethnographic surveys with the Aboriginal Affairs Department.*
- *Obtain any permits or Ministerial approvals required under the Aboriginal Heritage Act 1972, including a section 18 permit from the Minister for Aboriginal Affairs.*

6.2.3 Existing Environment

The *Aboriginal Heritage Act 1972* defines Aboriginal sites and provides for the preservation of places and objects customarily used by, or traditionally important to Aborigines, and prohibits the concealment, destruction or alteration of any Aboriginal sites.

McDonald, Hales and Associates conducted an Aboriginal Heritage survey of the proposed Champion Lakes development in November and December 2001. A summary of these surveys is provided below, with the full reports provided as Appendix N.

6.2.3.1 Ethnographic Sites

One ethnographic site has previously been recorded within the Champion Lakes PDA. This site, which is the Southern River (Department of Indigenous Affairs (DIA) Site Id 3511/S02601), is located in the southwestern corner of the development area and is listed on the DIA Permanent Register as a mythological site associated with the Waugal.

According to Aboriginal people from Armadale, this river system was formed by the creative actions of a Waugal, who still inhabits it and thus guarantees the flow of water. The site appears on the DIA digital database as a 10km by 2km rectangular grid, covering the southern half of the PDA.

Fifteen Aboriginal consultants representing five family groups and/or organisations were consulted during the recent ethnographic field survey. Only one new ethnographic site, being Wright Lake, was identified during the survey. Wright Lake has spiritual significance to some of the Aboriginals consulted during the survey although the ethnographic consultants were unable to establish the nature of this significance during the recent survey. It is also understood that the Swan Valley Nyungah Community consider the lake to have spiritual significance and have cited their intentions to have the Lake listed as an Aboriginal site on the DIA Register.

6.2.3.2 Archaeological Sites

Six archaeological sites (sites 4346, 17242, 18,663, THMR-2, THMR-3 and THMR-4) have been previously recorded within, or immediately adjacent to, the proposed development area.

Sites 4,346 and 18,663: Reported in 1974 and formerly listed as separate components of a single site (previously known as S00756a and b). The sites are located approximately 100 metres apart on the western and northern margins of Lake Wright and both consist of stone artefact assemblages. The assemblages at both sites are similar in that they consist primarily of quartz debitage.

Although the location details provided in the original site report are now considered 'unreliable' (Department of Indigenous Affairs file note), it is likely that both sites are located within Pt Lot 102 between the Tonkin Highway Reservation and the Municipal Boundary.

Site 17,242 (Ypres Road, Westfield): This site, reported in 1991, is located on vacant land previously owned by Kelmscott Senior High School. The site comprises an artefact scatter encompassing an area of approximately 50m² contiguous with an elevated dune ridge adjacent to swampy ground. The dune ridge itself has been disturbed as a result of excavations undertaken for drainage, rubbish disposal or sand quarrying.

The site is located entirely within the Wright Lake Parks and Recreation Reserve.

Tonkin Highway-Mundijong Road Scatter #2 (THMR-2): This site consists of a sparse scatter of quartz artefacts recorded over a 20m² area in the vicinity of a sandy firebreak. The firebreak runs in an east-west direction along the lower slopes of a gentle sandy rise adjacent to a small seasonal wetland and is located approximately 250 metres west of Gertrude Avenue, Gosnells.

The site appears to be located between the proposed Tonkin Highway Reservation and the northern boundary of the development area.

Tonkin Highway-Mundijong Road Scatter #3 (THMR-3): Consists of a small cluster of quartz artefacts over an area measuring approximately ten by 15 metres. The site is located on a de-vegetated exposure on the upper slope of low dune ridge, approximately 250m west of Gertrude Avenue and 120m north of Zenobia Crescent, Gosnells.

The site appears to be located between the proposed Tonkin Highway Reservation and the northern boundary of the development area.

Tonkin Highway-Mundijong Road Scatter #4 (THMR-4): Consists of a sparse cluster of quartz artefacts recorded over an area approximately 40m by 20m. The site comprises a total of 11 artefacts and is located approximately 75m north-west of Lake Wright and approximately 100m west of the corner of Lake View Terrace, Gosnells.

This site is distinct from other sites previously recorded along the margin of Wright Lake (i.e. sites 4,346 and 18,663) due to the degree of physical separation between the scatters and gross differences in assemblage composition. It is located within the proposed Tonkin Highway Reservation, adjacent to the northern boundary of the proposed development area.

Attempts were made during the archaeological assessment to examine all of the previously recorded sites, however it was not possible to relocate sites 4,346 (Kelmscott Lake North) or 18,663 (Kelmscott Lake West). This was attributed to several factors, including poor ground surface visibility and the general lack of precision in the original site report.

A brief inspection of site 17,252 (Ypres Road, Westfield) revealed that the extent of the site is much greater than originally reported, encompassing a minimum area of 150m² (as opposed to the 50m² previously reported). A considerable quantity of archaeological material was noted at this location, including a range of flaked stone artefacts made with

quartz, fossiliferous chert, mylonite and silcrete, grinding material and quantities of late nineteenth/early twentieth century European bottles, ceramics and butchered bone. Owing to the size and complexity of the site, no additional recording was undertaken during the survey.

In addition to the previously recorded sites, three new archaeological sites (Champion Lakes Field Site 1-3) and two isolated artefacts (Champion Lakes Isolated Artefact 1 and 2) were identified during the archaeological surveys (Table 19).

All the stone artefact clusters were located in relatively elevated locations overlooking wetland complexes or other drainage features (e.g. Southern River) and occurred in areas that had been subject to past disturbance. This suggests that there is considerable potential for additional material to occur within other (less disturbed) areas of the development area.

6.2.4 Potential Environmental Impacts

Under Section 17 of the *Aboriginal Heritage Act 1972*, it is an offence to:

- Excavate, destroy, damage, conceal, remove or in any way alter an Aboriginal site; or
- Assume the possession, custody or control of any object on or under an Aboriginal site,

unless these acts occur under the authorisation of the Registrar of Aboriginal Sites under Section 16, or the consent of the Minister for Aboriginal Affairs under Section 18, of the Act.

The proponent will therefore apply for Section 18 clearance during development of the proposal as further outlined below.

TABLE 19

New Archaeological Sites Located During the Aboriginal Heritage Surveys

Site No.	Environment	Dimensions	Visibility % and type	Site condition/ potential
CL-01	Hollow excavated into low dune ridge in cleared paddock; wetland c.50 m to NE	30m (N-S) x 32m (E-W)	>75% within excavated hollow; <25% across adjacent vegetated area	Disturbed by excavation of hollow; potential for additional material across adjacent grassed areas along dune ridge.
CL-02	Hollow excavated into low dune ridge in cleared paddock; wetland c.50 m to NE	60m (N-S) x 50m (E-W)	>75% within excavated hollow; <25% across adjacent vegetated area.	Disturbed by excavation of hollow; potential for additional material across adjacent grassed areas along dune ridge.
CL-03	Firebreak running adjacent to Lot 212 Lake Road	4m (N-S) x 52m (E-W)	>75% on track	Heavily disturbed by grading; potential for additional material across adjacent vegetated areas.
CL-ISO-01	Low dune ridge in cleared paddock	N/A	<50% across dune ridge	Possible additional material across the more densely vegetated areas of dune ridge.
CL-ISO-02	Firebreak running along the slope of a dune ridge; small wetland approximately 30 m to N.	N/A	>75% on track	Possible additional material across the more densely vegetated areas of the dune.

6.2.4.1 Ethnographic Sites

Implementation of the proposal will impact on both the existing and the newly identified ethnographic sites. However, it appears that the existing site is related to the Southern River, which will be protected from the development by a Conservation/Rehabilitation area that incorporates a 50m buffer to the Southern River vegetation. Therefore it is considered that the impact on the existing ethnographic site will be negligible. However, a Section 18 clearance may still be required for those works between the Conservation area and the eastern edge of the site.

Wright Lake will be substantially modified by the implementation of the proposed development, which will result in the disturbance of this ethnographic site. Should the Swan Valley Nyungah Community be successful in having this site listed on the DIA Register then it will be necessary to obtain Section 18 clearance to disturb this site.

6.2.4.2 Archaeological Sites

Implementation of the preferred option for the development of the Champion Lake Regional Recreational Park will result in the disturbance of newly recorded sites CL-01, CL-02, CL-03 and the newly identified isolated artefacts.

Previously recorded sites 4,346, 18,663, 17,242 and THMR-4 will also be disturbed by implementation of the proposal¸ whilst THMR-2 and THMR-3 will be retained in the conservation area at the eastern end of the development area.

Sites 4,346 and 18,663 have previously been assessed as requiring additional archaeological investigation (Edwards and McDonald 1999). MRWA was previously granted consent to disturb these sites under Section 18 of the *Aboriginal Heritage Act 1972*, however this consent was conditional upon further archaeological research being undertaken. A new Section 18 application will therefore need to be lodged by the current proponent to disturb these sites.

The full extent, nature and archaeological potential of Site 17,242 cannot currently be determined on the basis of existing investigations and further archaeological examinations are considered necessary to enable an appropriate management strategy to be developed.

Sites CL-01 and CL-02 (as currently defined) are considered to have little further archaeological potential owing to their small and homogenous stone artefact assemblage and past disturbance activities. Nevertheless, there is potential for additional archaeological material to be present in the less disturbed areas adjacent these scatters and as such works in the vicinity of these sites will need to be monitored during development.

Sites THMR-2, THMR-3 and THMR-4 have previously been assessed as having little further archaeological potential (Edwards and McDonald 1999). The two isolated artefacts identified by the current survey (CL-ISO-01 and CL-ISO-02) have been comprehensively recorded and also have little further archaeological potential.

6.2.5 Proposed Environmental Management

The proponent has received clearance under Section 18 of the *Aboriginal Heritage Act 1972* to remove both previously and newly recorded sites located within the PDA that will be impacted by development (Appendix N).

The proponent will undertake further archaeological investigations which may include, but not be limited to:

- Surface recording, mapping and collection of archaeological material; and
- Archaeological excavation and/or sub-surface evaluation.

Any works will be undertaken by a suitably qualified archaeologist issued with a valid permit in accordance with Section 16 of the Act. Aboriginal community representatives will also be consulted and involved in any archaeological investigations.

All construction and operating personnel will be apprised of the requirements for dealing with Aboriginal heritage areas prior to the commencement of construction activities, and will also be made aware of their responsibilities under the *Aboriginal Heritage Act 1972.*

A qualified archaeologist and relevant Aboriginal people will monitor earth disturbing work during the excavation of Wright Lake and the general development area. Should a suspected aboriginal site be located during construction activities, all work in the vicinity of the area will cease immediately. The DIA will be advised of the find and consulted with respect to management options. Work in the area will not resume until such time as the site has been professionally assessed.

The proponent has committed to plan and develop an Aboriginal Interpretive Centre as part of the Champion Lakes Regional Recreation Park. Such a centre would be established in partnership with the relevant Aboriginal groups and will provide information and education opportunities on local Aboriginal heritage and culture. The centre will also display salvaged material from the site.

In addition, a strategy will be developed which will encourage the employment of aborigines within the centre and throughout the Champion Lakes development.

6.3 European Culture and Heritage

6.3.1 EPA Objective

- *Ensure that changes to the biological and physical environment resulting from the proposal do not adversely affect cultural associations with the area.*
- *Ensure that the proposal complies with the Heritage of Western Australia Act 1990.*

6.3.2 EPA Scope of Work

- *Establish whether any sites of European significance may be impacted including places which may be on the Western Australian Heritage Register and Places Database.*
- *Discuss what measures will be taken to ensure that any significant places are not significantly affected by implementation of the proposal.*

6.3.3 Existing Environment

The following organisations were consulted on possible European Heritage within the site:

- Australian Heritage Commission;
- Heritage Council of Western Australia;
- National Trust of Australia (WA);
- City of Gosnells; and
- City of Armadale.

These sources did not reveal that any European Heritage is present within the site.

Mrs Emily Rigg and Mr George Csohany were early residents of Zenobia Terrace adjacent to Wright Lake, and provided information and written transcripts of their recollections of the area. Ms Rigg or Mr Csohany did not identify any areas of significant European Heritage within the site.

6.3.4 Potential Environmental Impacts

There are no sites of European Heritage present within the site and therefore no potential environmental impacts.

6.3.5 Proposed Environmental Management

Environmental management is not required as there are no European Sites present.

7.0 SUMMARY OF COMMITMENTS

1. Construction Environmental Management Plan

Contractors and the proponent will prepare a Construction Environmental Management Plan which addresses:

- Weed and Disease Management;
- Comprehensive Dust Management Program;
- Control of stock and human access into the conservation areas by erection of fencing and construction of access ways;
- Fire management including retention or placing of strategic firebreaks around the perimeter of the conservation areas;
- Quenda Relocation Program;
- Dewatering Program to determine the potential impacts of dewatering on the vegetation within the conservation areas, surrounding wetlands, Southern River, Canning River and groundwater quality;
- Timing of construction around Wright Lake to avoid wherever possible periods of peak water levels, from July-August through to October-November which coincides with potential for peak bird breeding and nesting times;
- Construction Noise Management Plan.

2. Construction Environmental Management Plan

The proponent and contractors will implement the Construction Environmental Management Plan.

3. Foreshore Management and Revegetation Plan

The proponent will prepare a detailed Foreshore Management and Revegetation Plan which addresses:

- Comprehensive Weed Control Program;
- Revegetating and restoring conservation areas with appropriate indigenous flora of the Southern River and Forrestfield Complex;
- Creation of habitat and wildlife corridors;
- Control of vehicle, stock and pedestrian access;
- Permanent fencing and public facilities;

- Water conservation and harvesting principles (Commitment 6);
- Soil and plant source material hygiene;
- Fire management including provision of fire hydrants;
- Provision of educational and interpretative materials within the area;
- Long-term monitoring criteria to determine the success of the revegetation and weed eradication program;
- Progress and Compliance reporting;
- Timing and implementation schedule.

4. Foreshore Management and Revegetation Plan

The proponent will implement the Foreshore Management and Revegetation Plan.

5. Wetland Mitigation Strategy

The proponent will implement a Wetland Mitigation Strategy which:

- Avoids direct and minimises indirect impacts on all Conservation Category wetlands where practical.
- Avoids impacts on Resource Enhancement and Multiple Use wetland vegetation wherever practical.
- Where Resource Enhancement and Multiple Use wetlands will be impacted, the proponent's objective will be no net loss of Resource Enhancement and Multiple Use wetland values and functions.
- Impacts to Resource Enhancement and Multiple Use wetlands will be compensated by:
  - fencing and limiting access by humans and stock into the Conservation Category wetland vegetation at Southern River;
  - establishing a dryland buffer zone to Southern River from the development;
  - revegetating and restoring the relevant part of the riverine and wetland vegetation as well as the buffer with the Southern River Vegetation Complex;
  - undertaking a weed eradication program at Southern River and the conservation area adjacent to Wright Lake;
  - rehabilitating and restoring the relevant part of the vegetation adjacent to Wright Lake within conservation areas;
  - creating and actively maintaining a large permanent waterbody and living stream to enhance and expand the previous wetland functions and values.

6. Overall Drainage Nutrient Irrigation and Water Quality Plan

An Overall Drainage, Nutrient, Irrigation and Water Quality management plan (DNIWQMP) will be prepared for the Champion Lakes development as a whole site which will include:

- water conservation and harvesting principles (Commitment 6);
- determination of flushing requirements, associated impacts and management options;
- a monitoring schedule; and
- contingencies in the event that unacceptable nutrient levels are detected in the waterbody and groundwater.

7. Overall Drainage Nutrient Irrigation and Water Quality Plans

The proponent will implement or require the implementation of the Drainage Nutrient Irrigation and Water Quality Management Plans.

8. Individual Drainage Nutrient Irrigation and Water Quality Plans

Once detailed planning has been undertaken within each component of the development, a more detailed DNIWQMP will be required to be prepared to demonstrate how water quality will meet required targets set in the overall DNIWQMP.

9. Individual Drainage Nutrient Irrigation and Water Quality Plans

The proponent will require the implementation of the Drainage Nutrient Irrigation and Water Quality Management Plans.

10. Contamination

Potential contamination will be assessed at areas identified in the PSI using the staged approach recommended in the *Contaminated Sites Management Series* (DEP, 2001). The next assessment phase will be an initial sampling and analysis program to assess the presence, nature and magnitude of contamination at the identified areas of potential contamination.

11. Contamination

The proponent will conduct site contamination assessments for areas identified in the PSI.

12. Water Conservation Measures

Water conservation measures are recognised by the proponent as important design elements and will be applied within the development. These include (but are not necessarily limited to) the following:

- Promote use of plant species which have low water and fertiliser requirements.
- Utilise local native varieties in landscaping.
- Consider the collection and transfer of road stormwater drainage to the IRC.
- Consider re-injection of stormwater into the superficial aquifer.
- Promote landscape treatments sympathetic to climatic conditions and prevailing site conditions – soil types, topography, environment, wetlands etc.
- Utilise "cluster or clump" plantings to provide useable shade areas and better use of reticulated water in preference to single item or symmetrical planting regimes.
- Irrigate grass and garden areas at appropriate time so as to reduce evaporative loss and minimise transpiration losses.
- Ensure that irrigation regime is responsive to prevailing weather conditions.

13. Operation Noise

Measures to minimise noise levels from the proposed rowing course will include:

- using a larger number of small speakers carefully positioned along the rowing course;
- Memorials will be considered on new residential titles to provide a warning that the area is subject to noise generated at the rowing course;
- Noise emissions from white water generating pumps will be controlled by placing them in acoustic enclosures or at a suitable distance from the residential area.

14. Light Overspill

The design of the lighting systems in the Champion Lakes Regional Recreation Park will be undertaken in accordance with AS4282-1997 and the recommended limits.

15. Acid Sulphate Soils

Design of an ASS Management Plan (ASSMP). The ASSMP will include details of:

- Proposals for further investigation to develop more accurate data on the extent, depth and characteristics of any acid sulfate soils, having due regard to the outcomes of the preliminary investigation carried out in May 2002 and the spatial variation between Option 1B and the preferred conceptual design. In particular, future investigations undertaken in support of the preparation of the ASSMP will seek to (1) delineate the lateral and vertical extent of PASS material in the locality of ASS12; (2) investigate the spatial and vertical distribution of PASS and/or AASS in the lake sediments of Wright Lake and (3) investigate the presence and characteristics of PASS within those areas now earmarked for excavation following the significant redesign of the earthworks layout from Option 1B.

- Proposed prevention, minimisation and mitigation strategies for controlling environmental impacts caused by dewatering and excavation operations, including, but not limited to:
  - treatment and use of any excavated material (including strategic burial considerations);
  - treatment of acidity;
  - containment strategies to manage site runoff and infiltration;
  - techniques for managing water table height; and
  - if appropriate, management of any existing acidity and contamination being produced.

- Proposed monitoring programs for surface waters and groundwaters and remedial measures to mitigate potential impacts caused by disturbance of PASS.

- Implementation responsibilities for environmental management.

- Reporting requirements and auditing responsibilities to ensure that agreed performance objectives are met, including quality assurance considerations.

- Contingency measures to rectify any deviation from the agreed performance standards.

16. Acid Sulphate Soils

The proponent will implement the Acid Sulfate Soil Management Plan.

17. Mosquito and Midge Control

Mosquito and midge control, management and monitoring programs will be provided in a Mosquito and Midge Management Plan.

18. Mosquito and Midge Control

The proponent will implement the Mosquito and Midge Management Plan.

19. Aboriginal Heritage

The proponent will undertake further investigations which may include, but not be limited to:

- Surface recording, mapping and collection of archaeological material; and
- Archaeological excavation and/or sub-surface evaluation.

A Section 16 permit will be applied for and a qualified archeologist and relevant Aboriginal people will monitor earth disturbing work during the excavation of Wright Lake and the general development of the area.

20. Aboriginal Interpretive Centre

The proponent commits to plan and develop an Aboriginal Interpretive Centre as part of the Champion Lakes Regional Recreation Park. The centre will be used for, among other things, the display of salvaged material. Substantial input into the decisions for the centre will be made by Aboriginal people, particularly those in the Armadale Shire Community.
In addition, a strategy will be developed which will encourage the employment of aborigines within the centre and throughout the Champion Lakes development.

21. Community Education

Information in the form of a 'Sense of Place' document will be provided to all purchasers within the Champion Lakes development advising of:

- Water conservation and harvesting measures including recommended landscaping;
- Water quality issues and need for nutrient management; and
- Dog and cat control.

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