CONSULTATIVE ENVIRONMENTAL REVIEW

CAPE PERON ESTATE, ROCKINGHAM

JULY 1997

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INVITATION

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

Allied Land Company Pty Ltd proposes to establish a residential subdivision within suitably zoned land at Rockingham in accordance with the requirements of the *Environmental Protection Act 1986*. Allied Land Company Pty Ltd has prepared a Consultative Environmental Review (CER) which describes the proposal and its likely efects on the environment. The CER will be available for public review for a period of two weeks, commencing on 7th July 1997 and closing on 3rd August 1997.

Comments from Government agencies and the public will assist 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 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 increasing the pool of ideas and information. If you form a small group (up to 10 people) please indicate the names of all 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 CER 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 proposals in the CER:

- clearly state your point of view
- indicate the source of your information 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 CER.
- If you discuss different sections of the CER, keep them distinct and separate, so there is no confusion as to which section you are discussing.
- 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
- your address
- the date
- whether you want your submission to be confidential.

The closing date for submissions is

Submissions should be addressed to:

Department of Environmental Protection
Westralia Square
141 St George's Terrace
PERTH WA 6000

Attention: Mr Adrian Vlok

EXECUTIVE SUMMARY

1. Allied Land Company Pty Ltd proposes the staged development of a residential subdivision of around 900 lots within an 85.5 hectare parcel of land at Rockingham which is zoned for this purpose under the Metropolitan Region Scheme and the City of Rockingham's Town Planning Scheme.

2. The land is presently undeveloped and comprises gently undulating sand plain previously cleared for agriculture, with scattered remnant stands of natural vegetation and large intervening expanses dominated by grasses and weeds. Three open channel drains which carry local suburban stormwater to Lake Richmond, and two underground sewer pipelines operated by the Water Corporation traverse the site. There are no natural surface water features on the land, however unconfined groundwater underlies the whole of the site at relatively shallow depth in the sandy soil profiles.

3. As a result of the location of the land adjacent to the Lake Richmond Parks and Recreation Reserve, and the high conservation values recognised for Lake Richmond due to its fringing Thrombolite structures, and its importance for waterbirds, the Environmental Protection Authority has determined that the project requires formal assessment under Section 38 of the Environmental Protection Act 1986. The assessment level has been set at Consultative Environmental Review (CER), and guidelines for the assessment have been developed by the Environmental Protection Authority (Assessment 1077).

4. A CER document which evaluates potential project impacts in regard to EPA objectives and policy framework for the environmental factors established by the guidelines, has been produced and is presented here for public comment and assessment.

   Environmental factors for which potential project impacts have been assessed in regard to EPA objectives and policy framework detailed in the guidelines include:

   - Vegetation in existing conservation estate;
   - Fauna and habitat in existing conservation estate;
   - Declared Rare Fauna;
   - Wetlands;
   - Thrombolites;
   - Heritage (indigenous and non-indigenous cultures).

5. The planning elements of the project may be summarised as follows:

Total Land Area	-	85.5ha proposed for subdivision,
Number of Lots	-	approximately 900 at residential code R15,
Open Space	-	10% of the total development including previous stages,
Staging	-	subject to market conditions,
Sewerage	-	fully reticulated, two pump stations with emergency power and storage,
Subdivision Drainage	-	unlined road gullies with piped connection to infiltration/detention basins which can completely hold runoff from storms to 1:10 year recurrence interval with treated overflow piped to existing main drains : roof runoff to infiltration wells,
Main Drainage	-	infiltration/detention of Peter Street Drain and piped overflow to Central Branch Drain, realignment of Southern Branch Drain and Central Branch Drain within swales capable of upgrading to multiple use corridors,
Other Services	-	telecommunications, electricity, water.

6. Assessment of the potential impacts of the project has found that the establishment of the proposed subdivision within the project site in accordance with the planning and engineering design concept identified within this document will not reduce the ability for the EPA's objectives to be met for the environmental factors identified by the guidelines.

The attached Summary Table for the project outlines the environmental factors, EPA objectives and policy gramework, the present status of the environment, potential impacts, proposed environmental management and predicted outcomes.

7. The proponent has put forward a range of commitments for environmental management which are consistent with the requirement to ensure that EPA objectives for each environmental factor may be met.

Summary Table: Consultative Environmental Review - Cape Peron Estate, Rockingham

Environmental Factor	EPA Objective Policy Framework	Present Status of the Environment	Potential Impact	Proposed Environmental Management	Predicted Outcome
Vegetation, Fauna, Habitats and Flora in the Conservation Estate Declared Rare Fauna	*"Vegetation in the existing and proposed conservation estate is not adversely impacted"* *"The EPA considers that there should be representative land systems set aside for the conservation of flora and fauna"* *"Fauna and habitat in the existing and proposed conservation estate is not adversely impacted"* *"Where the proposal could impact on the habitat or behaviour of regionally significant fauna those impacts should be reduced as far as practicable"* *"Protect threatened fauna and priority fauna species, and their habitats consistent with the provisions of the Wildlife Conservation Act 1950"*	(i) The project site does not include but lies adjacent to the Lake Richmond Parks and Recreation Reserve, which has conservation values associated with waterbirds, open water and fringing habitat, Thrombolite structures along Lake Richmond's shores, and is the subject of System 6 Recommendation M106. (ii) Whilst the proponent does not wish to prevent legitimate recreational usage of the reserve, due to public liability risks, public access to the privately owned reserve area is not permitted at present.	(i) The south-eastern portion of the Lake Richmond Parks and Recreation Reserve remains within the ownership of Allied Land Company Pty Ltd. Proposals for development within the reserved but privately owned land would reduce the size and extent of the reserve and could reduce conservation values. (ii) Increased recreational usage of the Parks and Recreation Reserve is likely to increase the risk of physical damage to natural features within the reserve. (iii) The project site is not known to support any declared rare flora or fauna or other species of special conservation value.	(i) No development is proposed for the privately owned land within the Lake Richmond Parks and Recreation Reserve. Planning at the interface of reserve and developed areas will incorporate management access and access control features, located entirely outside of the reserve. (ii) The Proponent will liaise with the City of Rockingham and CALM in regard to improvement and intensification of reserve management as development proceeds. (iii) A Construction Management Plan will be prepared prior to development in order to prevent damage to the reserve and the thrombolite structures from activities associated with construction machinery and personnel.	(i) The project will not directly impact the existing or proposed conservation estate. (ii) Acquisition by the WAPC of the privately owned portion of the Parks and Recreation Reserve will enable public access to this area to take place subject to active and passive management for the purpose of reserve protection.

Environmental Factor	EPA Objective Policy Framework	Present Status of the Environment	Potential Impact	Proposed Environmental Management	Predicted Outcome
Wetlands	*"Wetlands are protected and key ecological functions are maintained. Maintain or improve groundwater and surface water quality flowing into the lake.* *Wetlands identified in Bulletin 685 should be protected and should have their ecological function maintained. Where there is loss of a wetland function then the functions lost should be replaced elsewhere."*	The project site does not include but lies adjacent to Lake Richmond, which is recognised as a wetland with important conservation values and is subject to the Environmental Protection (Swan Coastal Plain Wetlands) Policy 1992.	(i) The discharge of stormwater from the development area to the existing main drains could adversely affect water quality in Lake Richmond. (ii) Land uses which discharge large quantities of nutrients to soil could reduce the quality of groundwater inflow to the lake.	(i) The stormwater management system for the subdivision will contain and infiltrate all stormwater from rainfall events up to 1:10 year recurrence interval, with piped overflow of treated water to the existing main drains for storms of greater intensity. The existing Peter Street drain will be connected to a new infiltration/ detention basin such that for storms of less intensity than 1:10 year recurrence interval, existing stormwater flows from urban areas outside the project site will diminish by 6%. (ii) Land uses within the site will be limited to residential and associated commercial and community purpose uses and will be serviced by reticulated sewer system and pump stations fitted with emerging power and storage facilities.	(i) The quality of surface water flowing into Lake Richmond is not expected to significantly change as a result of the project, whilst for rainfall events of intensity less than 1:10 year recurrence interval the quantity of drainage inflow is expected to reduce by approximately 6%. (ii) Groundwater inflows have been shown to have a small role in Lake Richmond's hydrology and its nutrient loads. Recognising that sewered urban development is not noted as a land use which causes excessive nutrient enrichment of groundwater, the project is not expected to influence groundwater quality such that a significant increase to nutrient levels in Lake Richmond will occur.

Environmental Factor	EPA Objective Policy Framework	Present Status of the Environment	Potential Impact	Proposed Environmental Management	Predicted Outcome
Thrombolites	*"Ensure thrombolite survival and growth is not adversely impacted by maintaining or improving the existing quantity and quality of groundwater and surface water flowing into the lake and preventing physical impacts (crushing)."*	(i) Thrombolite structures are located along the fringes of Lake Richmond within the Parks and Recreation reserve. The thrombolites are not known to occur in other locations on the Swan Coastal Plain. (ii) Whilst the proponent does not wish to prevent legitimate recreational usage of the reserve, due to public liability risks, public access to the privately owned reserve area is not permitted at present.	The thrombolite structures are considered to be at risk from physical damage from members of the public, swamping by sediments from drainage and disturbance around the lake edge, blanketing by dumped rubbish and couch grass invasion.	(i) Stormwater management methods implemented within the development area will not create risk of thrombolite damage due to reduced water quality in drainage input to Lake Richmond. (ii) Planning for the interface of the reserve and developed land will incorporate management access and access control features. (iii) The proponent will liaise with the City of Rockingham and CALM in regard to improvement and intensification of reserve management as development proceeds. (iv) A Construction Management Plan will be prepared prior to development in order to prevent damage to the reserve and the thrombolite structures from activities associated with construction machinery and personnel.	(i) The thrombolite structures will not be at risk from processes associated with project construction. (ii) Aquisition by the WAPC of the privately owned portion of the Parks and Recreation Reserve will enable public access to this area to proceed subject to appropriate active and passive management for the purpose of thrombolite protection.
Heritage (Indigenous and non-indigenous culture)	Comply with statutory requirements in relation to areas of cultural or historical significance.	Survey has determined there are no areas of archaelogical or ethnographic interest within the project site.	As there are no known sites of significance the project does not create risk of potential impact.	Construction contractors will be advised that any unearthing of buried archaelogical materials undiscovered by survey must be immediately referred to the WA Museum.	The project will comply with statutory requirements in relation to indigenous and non-indigenous heritage.

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1.0 INTRODUCTION

1.1 Description of the Land and the Development Proposal

Allied Land Company Pty Ltd (the proponent) has prepared an urban Subdivision Plan for Part Lot 402 Rae Road, Rockingham. The land proposed for development is currently zoned Urban under the Metropolitan Region Scheme (MRS), and Residential under the City of Rockingham's Town Planning Scheme. The subdivision is an extension of land previously developed for urban uses, and forms part of the Comprehensive Development Plan for the Cape Peron Estate. Land in the proponent's ownership in the north west portion of Part Lot 402 includes the south east portion of Lake Richmond and its surrounds, which are zoned and reserved for "Parks and Recreation" under the MRS. This land does not form part of the subdivision proposal and in due course will be acquired by the Western Australian Planning Commission.

Figure 1 depicts the boundaries of land remaining to be developed in accordance with the Comprehensive Development Plan and its relationship to the land reserved for Parks and Recreation under the MRS.

The Environmental Protection Authority has determined that the subdivision, as part of the Comprehensive Development Plan, requires formal environmental assessment under Part IV of the Environmental Protection Act 1986. This Consultative Environmental Review has been prepared to enable formal assessment to proceed.

Following the conferral of approval by the Minister for Environment, approval to implement the subdivision plans will be sought from the Western Australia Planning Commission through the Ministry for Planning.

The land is located approximately 40 kilometres south-west of the Perth Central Business District (CBD), and approximately 1.5 kilometres west of the Rockingham townsite, as shown on Figure 1. The area of land within the Comprehensive Development Plan totals 85 hectares, of which submitted subdivision plans comprise 35 hectares.

The site comprises relatively flat land that may generally be described as sandy terrain with a series of low sandy ridges. Three Water Corporation main drains cross the site but apart from these man made features there are no natural surface water features.

As depicted in Figure 2 the majority of the area proposed for development has previously been cleared for agriculture. This land is currently vacant and unused.

1.2 The Rationale for the Development

The need for this urban development proposal arises from the demand for new housing within the Rockingham area.

The rapid development of urban land uses and the establishment of the necessary community infrastructure can proceed readily within this proposed development area. The land can be developed with a minimum of earthworks, and services such as sewerage, water, electricity and gas can be readily provided throughout the site.

The site is well located in relation to present and planned employment and population centres and will be well served by transport services.

Development of the site will be staged, with the first stage commencing as soon as Government approvals can be obtained.

1.3 The Statutory Approvals Process

A number of Government Authorities will be involved in the decision making process in the course of approving this proposal. These include;

- The Western Australian Planning Commission and the Ministry for Planning;
- The City of Rockingham;
- The Department of Environmental Protection;
- The Water Corporation;
- other servicing authorities consulted by the Ministry for Planning.

This document has the purpose of describing the proposal, evaluating potential impacts with reference to the environmental factors identified by the EPA's guidelines for the assessment and detailing environmental management proposals required to mitigate potential impacts.

The Environmental Protection Act 1986 requires that any development which has the potential to affect the environment must be referred to the Environmental Protection Authority under Section 38 of the EP Act. One of four levels of assessment may be assigned to a proposal by the EPA. These are:

- Informal Review with Public Advice
- Consultative Environmental Review (CER)
- Public Environmental Review (PER)
- Environmental Review and Management Program (ERMP)

This proposal has been assigned a Consultative Environmental Review by the EPA. Guidelines for the preparation of the CER issued by the EPA are contained in Appendix A. Following a review period of 4 weeks when members of the public and government agencies may comment on the CER, the EPA will prepare a report (Bulletin) for public release which will summarise the issues and state whether the project is environmentally acceptable and under what conditions. Anyone can appeal against the content of recommendations of an EPA assessment report.

Before a project may proceed, the Minister for Environment must give approval and will set conditions which must be met by the proponent. Only the proponent can appeal against Ministerial conditions which, once set, are legally binding.

1.4 Public Consultation

Following acceptance of this document by the EPA as suitable for public release, this CER will be available for a period of 4 weeks during which submissions may be made regarding the proposal. Government authorities and local interest groups are also invited to comment. At the conclusion of the public comment period the EPA will consider the proposal together with any public submissions. Public submissions are confidential; however the proponent will be asked to comment on any issues which are raised by the public, and summarised by the EPA.

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2.0 PROJECT JUSTIFICATION

The portion of Lot 402 which is reserved for Parks and Recreation and is the subject of System 6 Recommendation Area M102 is not proposed for development and in due course will be acquired by the West Australian Planning Commission. Figures 3 and 4 confirm that the remaining portion of Lot 402 is zoned for residential uses under the MRS and the City of Rockingham Town Planning Scheme. The proposal is therefore consistent with current planning for the area.

2.1 Regional Planning Aspects

The site of the proposed subdivision is approximately 40kms south of the Perth Central Business District. It is however only around 1.5kms west of the Rockingham Strategic Regional Centre and approximately 2.5kms south-west of the commencement of the Rockingham-Kwinana industrial strip. In addition, the application area is approximately 2.5kms south-east of the Garden Island Causeway and the entrance to the HMAS Stirling Naval base. The site is therefore close to a significant range of employment opportunities.

In addition to its economic role, the Strategic Regional Centre at Rockingham provides civic and cultural facilities. The Strategic Regional Centre also contains a number of recreational opportunities which are augmented by the ocean beaches of Mangles Bay, Shoalwater Bay and Safety Bay, each of which is within approximately 1.5kms of the development area.

The land is also within close proximity of educational opportunities including private schools, public primary schools (Rockingham Beach and Bungaree Primary Schools) as well as the Rockingham Senior High School. All of these schools are contained within the road grid provided by Read Street, Rae Road and Safety Bay Road. In addition, the land is within 3kms of the Rockingham TAFE Campus and within 2kms of the proposed University Campus at Rockingham.

The land has been zoned Urban in the Metropolitan Region Scheme since the inception of the Scheme in 1963. Parks and Recreation Reserve covers Lake Richmond as well as the lake's margins. Subsequent plans to develop port facilities at the base of Mangles Bay led to the inclusion of a Controlled Access Highway reservation for the Garden Island Expressway generally following Rae Road and arcing to the south of Lake Richmond before trending north-

west to Cape Peron. Fisher Street connecting with the Expressway from the north was included within the Region Scheme as an Important Regional Road and its alignment led to the adjustment of the Parks and Reservation Reserve around Lake Richmond. Generally, this reservation was increased. Walker Street from the south was also shown to connect with the Expressway and was similarly included within the Scheme as an Important Regional Road.

More recently there have been further adjustments to the Metropolitan Region Scheme. The Garden Island Expressway has been reduced in status from a Controlled Access Highway to an Important Regional Road. Its alignment has been modified immediately to the south of Lake Richmond to reduce its impact on the lake. Fisher and Hawker Streets have also been deleted as Important Regional Roads from the Scheme.

This brief history of zonings has significance in that the Rockingham South Branch drain was aligned through the development area to skirt around one of the formerly proposed interchange facilities associated with connections to the proposed Garden Island Expressway. This is then the explanation for the drain's alignment.

The Metropolitan Region Scheme has evolved further. A route for a rail extension has been incorporated into the Scheme, also servicing the Rockingham Strategic Regional Centre. This means that the subject land will be close to major public transport infrastructure. Additionally, there is some doubt that the Garden Island Expressway will ever be required and therefore will ever be constructed. Therefore, the Important Regional Road reservation adjacent to Lake Richmond may ultimately be deleted from the Metropolitan Region Scheme.

It is estimated that the current population of the Perth Metropolitan Region is around 1.28 million. The State Planning Strategy estimates that this population will rise to 1.383 million by the year 2001, 1.603 million by the year 2011 and 1.924 million by the year 2026. There is accordingly a continuing demand for housing land within the Region and clearly the subject land is one of the more locationally advantaged sites to accommodate this housing demand. Because of the land's situation, it can also be developed without major investment in public infrastructure and servicing headworks. The locality has access to sewerage, water and power services. Road access is already provided and the population generated by the development can be accommodated within existing schools. In addition, public transport routes currently pass through the locality.

2.2 District and Local Planning Aspects

2.2.1 District Aspects

The development site is located within the City of Rockingham and within the South West Corridor of Perth's urban development. In general, the South West Corridor is confined between the coast on the west and the reserve for the extension of the Kwinana Freeway on the east. The Kwinana-Rockingham industrial strip intrudes into Rockingham from the north and to the south, the municipality extends to the boundary of the Metropolitan Region and the City of Mandurah.

The development of Rockingham generally commenced in the early 1900's along the shoreline of Mangles Bay extending westwards to Palm Beach and subsequently southwards along the shores of Shoalwater Bay and Safety Bay. Much of this development was in the form of holiday homes and weekenders taking advantage of Rockingham's proximity to Perth as well as the protected waters of the various bays. As Perth's population grew and industrial development occurred in the sub-region, Rockingham developed rapidly as a series of dormitory suburbs through the 1960's to the present day. The most popular housing areas tended to be close to the coast with the result that areas further removed from the coast were often developed more recently.

The subject land is located on that isthmus of land between Cape Peron to the north and Point Mersey to the south. This central location has generally resulted in it being the last broadacre area of land to be developed on the isthmus. Rockingham has therefore grown up around the subject land providing it with the locational advantages of proximity to employment, educational facilities, a Strategic Regional Centre, servicing and transport infrastructure.

2.2.2 Local Planning Aspects and Current Zonings

The land is currently zoned for Residential development under the City of Rockingham's Town Planning Scheme and Coded R15. The Council's Scheme and Retail Policies also anticipate the provision of some commercial development at a neighbourhood scale. A proposed primary school along Casserley Road has been deemed to be superfluous by the Education Department and is therefore deleted from planning proposals.

The Council's Scheme generally conforms with the Metropolitan Region Scheme and in particular, respecting the Metropolitan Region Scheme reservations.

The land is fragmented by open main drains which traverse the site. This fragmentation is continued by the alignment of the Garden Island Expressway. Development plans have therefore endeavoured to reduce these fragmenting impacts.

For the most part, the locality is well served with public open spaces. The Stan Twight Reserve off Hennessy Way is developed as a major active recreation area. Further to the east, there is the Bungaree Oval another developed active recreation area. A substantial reserve off Townsend Road and immediately adjacent to the development area is not yet developed for recreational purposes. The subdivision of the Estate will add to the inventory of Recreation Reserves.

As mentioned previously, a site for a primary school on the eastern alignment of Casserley Road has been deleted by the Education Department. Primary school students generated by the new Estate will be directed either to the Bungaree Primary School or the Rockingham Beach Primary School. Because of the relatively close proximity of the Rockingham Senior High School, the entire Estate falls within this school's catchment.

2.3 Summary of Benefits to the Community

The development offers substantial community benefits. It will enable a significant population ultimately in the range of 2,500 to 3,000 people to be housed within close proximity of employment, commercial, community and recreation facilities. The development will also make use of existing public infrastructure in the form of reticulated services, educational facilities and roads. The development can therefore occur at minimal public cost.

If development does not occur in this location, the population which would otherwise be housed at Cape Peron, will be housed in Estates further removed from strategic sub-regional centres and employment locations. This will necessitate more travelling with consequent costs and environmental impacts. In addition, the development of the Estates to accommodate these people will require the construction of more headworks facilities and the development of adequate road systems and extension of public transport routes.

3.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

3.1 Physical Environment

3.1.1 Topography

The subject land is located within a low-lying plain of undulating relict foredunes characterised by parallel ridges aligned NW-SE to WNW-ESE. The site is generally flat, with a typical local relief of 0.5m - 2m between adjacent ridges and swales. The elevation varies across the site from 2m - 4m AHD as shown in Figure 5.

3.1.2 Landform and Soils

The site is located in the Quindalup Dune System in a geomorphic setting known as the Rockingham-Becher Plain. This is a large beachridge system bounded by Garden Island and Cockburn Sound to the north, the Spearwood Ridge to the east, and the Peel-Harvey Estuary to the south (Fairbridge, 1948; Searle *et al.*, 1988).

The Rockingham-Becher Plain is characterised by sand dune ridges and swales which become progressively older and more eroded with distance from the coast. The site is located within the relict dunes approximately 2km from the present shoreline. Diagrams of coastal development presented in Woods and Searle *et al.*, (1988) indicate that this part of the Plain was deposited between 2000 and 4000 years ago (see Figure 6).

The surface soil within the site is comprised of Safety Bay Sand, which is described as white medium grain, rounded quartz and shell debris. The Safety Bay Sand in this area is from 2m - 6m deep and overlies an approximate 20m thickness sequence of Becher Sand (Searle *et al.*, 1988).

3.1.3 Surface Water Hydrology

The site is comprised of permeable sandy soils which do not yield any significant runoff under normal weather conditions and therefore the site does not support any natural surface drainage channels.

Surface water features exist in the form of constructed open drainage channels, operated by the Water Corporation, which traverse the site. These drains are part of the stormwater and groundwater management system established by the Water Corporation over many years to service residential development in the Rockingham region.

Figure 7 shows the location of existing drains, in the context of the catchment they serve, their point of discharge to Lake Richmond, and the outlet drain from Lake Richmond into Mangles Bay to the north-west.

3.1.4 Groundwater Hydrology

3.1.4.1 Regional Hydrogeology

The site is located at the western margin of the Safety Bay Groundwater Mound, an unconfined shallow aquifer which has developed in the superficial sandy sediments.

Stratigraphic transects through the region occupied by the mound presented in Searle *et al.* (1988) indicate the superficial sediments which host the aquifer have a thickness of around 25m and comprise an upper sequence of Safety Bay sand of around 8m thickness, a 16-18m sequence of Becher sand and a six meter sequence of Bridport calcilutite overlying Tamala Limestone.

This mound covers an area of about 50km^2 and is situated with its centre midway between the coast and Lakes Cooloongup and Walyungup (Davidson, 1978). It is almost everywhere an unconfined aquifer, although in some places near Lakes Coolongup and Walyungup there is some confinement by clays.

Groundwater recharge is by direct infiltration of rainfall through the unsaturated sands above the water table. Davidson (1978) used an estimate of 20% of rainfall for recharge in the western parts of the mound. Groundwater discharge is by outflow to the ocean to the west and north and there is downward leakage into the underlying Rockingham aquifer.

Figure 8 depicts the water table contours of the mound, Davidson (1978). The highest groundwater contour occurs in the centre of the mound at 4m AHD. From here groundwater flows east to Lake Walyungup west and north to the ocean.

Davidson (1978) estimated the total quantity of groundwater flow in the superficial aquifer which passes from the mound towards Cape Peron, at approximately 2,300m^3/d (840,000m^3/year).

The water table position fluctuates according to seasonal rainfall, with the highest groundwater levels at the end of winter and the lowest at the end of summer. Figure 9 presents a record of water level for the Water and Rivers Commission Monitor Bore T280, located upgradient of the site, some 1.5km to the east of the project area (see Figure 7 for location). The hydrograph for the period 1975 to 1996 shows an average seasonal water table variation of around 0.6m to 0.8m.

The site is located in the Rockingham Groundwater Area.

3.1.4.2 Groundwater Hydrology of the Site

The site is underlain by around 25m of sandy sediments which are subject to regional groundwater throughflow in a general westerly direction. The water table lies at between 1 and 2m AHD and rises gently to the east at a gradient of less than 0.1%. A long term hydrograph of water table level and seasonal fluctuations is not available for the site. However the hydrograph for T280 to the east is likely to closely describe water table variations within the site. Bore T280 data suggests the water table maxima for the site at Figure 9 might reflect typical winter water table contours at 0.5m to 1.5m AHD from west to east, and summer levels which are lower by 0.6 to 0.8m.

The water table is very flat over the Cape Peron Peninsula and precise determination of the direction of groundwater flow down-gradient of the site is not realistic based on the available data.

A map of maximum water table contours produced by the Water and Rivers Commission (1996) indicates that groundwater throughflow in the southern parts of the site is towards Safety Bay, and central parts of the site towards Lake Richmond, and the northern parts of the site towards Cockburn Sound (Figure 10). Throughflow from Lake Richmond appears to flow westerly to northerly.

Passmore (1967) found that groundwater levels were higher than lake water levels on Lake Richmond's east, south and western flanks close to the lakes edge, indicating groundwater inflow occurs on these sides and outflow from the lake to the aquifer was to the north. However

at the time of data collection the Cape Peron peninsula was less extensively urbanised and the main drainage system not as extensively constructed as was the case when the 1996 maximum water table contours were developed.

A comparison of 1996 maximum water table contours to the 1967 winter water table contours presented in Passmore (1967) suggests an overall water table reduction of around 1m has occurred in the central part of Cape Peron.

3.1.4.3 Groundwater Quality

The best description of groundwater quality for this part of the Safety Bay Groundwater Mound is available from water quality monitoring results for Water and Rivers Commission Monitor Bore T280 (see Figure 7 for location of T280). Table 1 presents a summary of the most recently of available chemical analysis.

The data shows shallow groundwater is slightly alkaline, has high calcium carbonate hardness, relatively low TDS, and low nutrient levels. Review of historical data for this bore, and historical data for a scatter of other bores spread through the area indicate this is typical of local groundwater quality for the central parts of Cape Peron. Appendix B presents examples of groundwater quality records from local monitor bores.

Table 1
Shallow Groundwater Quality at Bore T280 - 6/4/87

Parameter	mg/L	Parameter	mg/L
pH	7.9 units	Chloride	82
Sodium	56	Nitrate	1
Calcium	52	Total Phosphorus	.05
Carbonate	<2	Sulphate	33
Bicarbonate	381	Total Soluble Salts	<671

Source: Water and Rivers Commission, Unpublished records

3.1.4.4 Lake Richmond

Land to the east and south of the site has been progressively drained to support residential development. A series of open channel main drains 2-3m deep and 5-10m wide have been established to carry stormwater and in winter shallow groundwater, away from the residential areas.

Figure 7 depicts the location and extent of the main drainage system and shows Lake Richmond has a total drained catchment of 1,102ha, which will be expanded to 1,273ha. When fully developed Cape Peron Estate will comprise 7.7% of the potential stormwater catchment area of Lake Richmond.

The hydrograph for Lake Richmond water level given at Figure 11 indicates typical water levels variations between 0.3m AHD at the end of summer and 1.3m AHD at the end of winter. The lowest record, from late summer 1993 is -0.5m AHD and possibly indicates the effect of private groundwater abstraction in the Cape Peron area.

Figure 11 also demonstrates that the installation of the outlet drain from Lake Richmond to Mangles Bay in 1968 (Kenneally *et al.* 1987) has set the maximum water level for Lake Richmond at approximately 1.3m AHD.

3.2 Biological Environment

3.2.1 Vegetation and Flora

The remnant vegetation of the site consists of a coastal dune formation that is mapped as Quindalup Vegetation Complex by Heddle, *et al* ., (1978).

The site's remnant vegetation is generally typical of the Rockingham Becher plain dune sequence, although most of the site was cleared for dairy farming and pastoral activities several decades ago. The aerial photograph presented as Figure 2 depicts the distribution of remnant vegetation within the site and may be referred to in conjunction with the following broad descriptions.

Remnant stands which remain within the site include a shrubland of *Acacia* sp. and *Xanthorrhoea* sp. with some remaining natural understorey species in the north-east sector. In the southern sector remnant stands of *Melaleuca raphiophylla* and *Acacia* sp. woodland occur with limited stands of *Xanthorrhoea* and sedgeland dominated by *Gahnia trifida* with occasional *Isolepis nodosa*. This area has been generally degraded by stock, fire, rubbish dumping and off road vehicle usage, and is extensively colonised by weeds and grasses.

Records from the Department of Conservation and Land Management and WA Herbarium rare and endangered flora database indicate that no specimens of Declared Rare Flora (DRF) or Priority species have been recorded from this particular site (Appendix C).

As the Rockingham area is not known to be prospective for DRF based on the absence of any species of DRF from the CALM list of known species with conservation significance no specific searches for DRF or priority flora have been carried out for the site as part of this investigation.

3.2.2 Fauna

The clearing of most of the original vegetation on the site would have also led to the decline or removal of most of the native fauna species and populations. The remaining vegetation on the site is in mostly poor condition. Many of the original species have been replaced by weeds, and habitat is now limited to patches of shrubland and low heath in the north east, low woodlands and limited patches of sedgeland in the south-west, with large intervening areas of open sand plain dominated by introduced weeds and grasses. The habitat value of the site is therefore considered to be low.

The site could be expected to support some mobile species including bird life which utilises open grassland eg. Australian Pipit and birds of prey such as the Nankeen Kestrel and Black Shouldered Kite. Introduced species such as rabbits and foxes inhabit the site and are the subject of management recommendations set out in a Management Plan for existing reserves (Goodale, 1996).

Records from The Department of Conservation and Land Management Threatened Fauna data base have been accessed. These records list species which are declared rare or likely to become extinct (Schedule 1), birds protected by international agreement (Schedule 3), and other specifically protected fauna (Schedule 4).

The records indicate that no threatened fauna have been recorded from the site itself. However, the area may be infrequently visited by two protected bird species (Carnaby's Cockatoo and the Peregrine Falcon). Both of these species range widely across suitable habitat and would not be dependent solely on this site.

In the System 6 report, the Department of Conservation and the Environment listed the Peregrine Falcon as one species which has been observed at Lake Richmond (DCE, 1983).

The most comprehensive data base for fauna which is available locally relates to Lake Richmond and its wetland fringes. This area is located outside of the project site and is not proposed for any development. A summary of fauna known for the wetland is presented here in Section 3.2.3.3.

3.2.3 Lake Richmond

Lake Richmond is located to the north and west of the site and is surrounded by an area of land reserved for Parks and Recreation under the Metropolitan Region Scheme parts of which are vested in the City of Rockingham, and vacant Crown Land. Lake Richmond was placed on the Register of the National Estate Database on 30th June 1992. These portions of the lake and surrounding area which are not presently in private ownership comprise, Reserves C9458, C35176 and C33659 which are vested with the Rockingham City Council for Parks and Recreation.

Lake Richmond is a marine relic situated among the Quindalup Dunes and was formerly part of the southern extension of Cockburn Sound which was filled during the last 4000 years. Two nearby lakes, Lake Cooloongup and Walyungup were also part of this former embayment. Lake Richmond is an elliptical shape approximately 1000m long and 600m across. The water area is approximately 40ha. The water is up to 15m deep and fluctuates seasonally according to rainfall (Kenneally *et al.*, 1987).

3.2.3.1 Water Levels

The first known water level records for Lake Richmond were collected in 1945, with regular monitoring commencing in 1956, and an increase in monitoring frequency from 1978.

Figure 11 presents a plot of the water level measurements provided by the Water and Rivers Commission.

The plot shows winter maximum levels of between 0.9m to 1.2 m and summer minimum levels of between 0.1m and 0.8 m. An unusually low minimum of approximately minus 0.5m was recorded for the summer of 1993. This may be the result of heavy domestic pumping from the superficial aquifer, or may be a false reading or a recording error.

Data presented by Passmore (1967) and reproduced in Appendix D confirms a strong relationship between water levels in the lake and groundwater levels in the surrounding

superficial aquifer, indicating a strong hydraulic connection between shallow groundwater and lake water.

3.2.3.2 Water Quality

The water quality of Lake Richmond has been altered by the addition of urban drainage water which commenced during the 1960's with the construction of open drainage channels which enter the lake at three locations and an outlet drain to Mangles Bay, which was constructed at the north-west end of the lake during 1968 (Kenneally *et al.*, 1987). The salinity of lake water presents the most clear evidence of water quality changes although other water quality parameters also exhibit apparent trends. This section summarises known water quality measurements based on data collected by the Water and Rivers Commission from a depth of 7m at a location in the centre of the lake.

(i) Salinity

The salinity of Lake Richmond fell rapidly after the connection of drains to the lake. The lake is now very fresh with an average salinity of 300ppm (Kenneally *et al.*, 1987). Data presented by Passmore (1967) indicated the lake had salinity of around 2,500mg/L at the end of summer and around 2,000mg/L at the end of winter during the middle 1960's. Depth profiles of salinity indicated the lake was not stratified with respect to salinity or temperature. The salinity of lake water appears to have stabilised in recent years as shown by the graphed data on Figure 12.

(ii) Nutrients

Nitrogen and phosphorus have been monitored in the lake from 1970 to 1986. Data obtained from the Water and Rivers Commission demonstrates that the range of concentrations of total nitrogen was <0.05 - 4.4mg/L and total phosphorus was <0.01 - 1.3mg/L for this period. Figure 13 graphs phosphorus and nitrogen concentrations over recent decades and demonstrates an apparent trend of slightly falling levels with time.

More recently (since 1994) nitrate (NO_3) and phosphate (PO_4) levels have been monitored in Lake Richmond and in drains leading into the lake by the Safety Bay Senior High School. In the inlet drains, levels of nitrate-nitrogen ranged from 0 - 1.28mg/L and phosphorus 0.03 - 0.38mg/L. In the lake levels of nitrate and phosphorus varied from 0 - 0.004mg/L and 0.03 - 0.91mg/L respectively. Appendix E reproduces this data.

(iii) pH

The pH of lake water has been monitored for approximately the last 25 years. Data presented by the Water and Rivers Commission show the pH of lake water is slightly alkaline varying between pH 7.9 and 9.3. Figure 14 plots pH records for lake water.

(iv) Bicarbonate

Bicarbonate ion is believed to be important in the deposition process of thrombolite structures within the lake. Data from Passmore (1967) showed high levels of bicarbonate (carbonate alkalinity of 255mg/L) further confirming a strong hydraulic connection between the lake water and the surrounding superficial aquifer which also has high bicarbonate concentrations (see Section 3.1.4.3). The dissolution of calcium carbonate during rainfall recharge and groundwater throughflow is the source of bicarbonate ions in both the superficial aquifer and Lake Richmond. There are no recent records of carbonate and bicarbonate concentrations in Lake Richmond which have been identified by this investigation.

(v) Calcium

The Safety Bay Groundwater mound is oversaturated with calcium carbonate, as a consequence of rainwater percolation through the calcareous Safety Bay Sands (Passmore 1967). The calcium levels in Lake Richmond however are different to the groundwater levels as calcium is removed from the lake water by algae and other lime-secreting organisms including presumably the thrombolites. Late winter and summer concentrations of 22ppm and 12ppm respectively were reported by Passmore (1967). There are no recent records of calcium concentrations in Lake Richmond which have been identified by this investigation.

The figures from Passmore (1967) contrast to calcium concentrations of around 50mg/L indicated for Monitor Bore T280 which is located upgradient of the site and presents an indication of the quality of groundwater entering Lake Richmond.

(vi) Heavy Metals

Heavy metals have found to be in very low concentrations, well within prescribed limits (Kenneally *et al.*, 1987).

(vii) Bacteria Counts

Bacterial counts and faecal *E. coli* have found to be relatively high, and are attributed to excretions from birds and decaying matter rather than septic tank contamination.

(viii) Suspended Solids

The available data indicates lake water is generally very clear, with suspended solids levels of <1 - 34mg/L.

3.2.3.3 Biota

Vegetation

A detailed vegetation survey around the lake on the site was carried out in February 1996. Eight main vegetation types were identified (Figure 15) and a list of species identified is provided in Appendix F. No rare or priority species were recorded during the vegetation survey of the lake.

The edge of the lake on the south and east is bordered by sedges and rushes for a width of 20 - 30m. This region is dominated by *Juncus pallidus* and *Baumea juncea*. In the south and south-west areas the introduced Bulrush *Typha* sp. has become established but is not dominant.

The area at the southern edge of the lake, west of the drain is known to flood. The vegetation in this areas is comprised of sedges and reeds including *Juncus pallidus, Baumea juncea, Isolepsis nodosa, Lepidosperma* sp, and *Gahnia trifida*. There are also many weeds present in this area. Further to the south the land rises to form a shallow dune which is dominated by wild oats (*Avena barbata*). *Jacksonia furcellata, Acanthocarpus preissii* and *Acacia saligna* also vegetate these dunes.

The south-east corner of Lake Richmond, adjacent to the main drain was damp at the time of survey but this low lying area becomes waterlogged during the winter season. This area has a large stand of *Melaleuca rhaphiophylla* paperbarks with *Acacia rostellifera* forming a dense thicket on the north side of the drain. Adjacent to the stand of paperbark trees Pampas Grass (*Cortaderia selloana*) has invaded the area and has the potential to displace native species. In the south-east region, adjacent to the southern side of the drain is an area dominated by *Xanthorrhoea preisii*. This *Xanthorrhoea* and associated vegetation corresponds to Community type 19, identified in a Floristic Survey of the southern Swan Coastal Plain and is considered a threatened plant community (Gibson *et al.*, 1994).

To the east of the lake is a low dune which is degraded by tracks. The vegetation on the dune is comprised of *Jacksonia furcellata, Acanthocarpus preissii, Acacia saligna, Olearia axillaris, Lepidosperma gladiatum, Spyridium globulosum* and *Leptospermum laevigatum.*

There are large areas in the south east and east sections of the Parks and Recreation reserve which are degraded and dominated by introduced grasses such as common wild oats.

The survey was conducted in the summer when annuals are unlikely to be present. Therefore, the species list is not comprehensive and further surveys during spring may detect additional species.

Fauna

The fauna of Lake Richmond and areas immediately surrounding is primarily composed of birds, 109 species have been seen and recorded at the lake. Migratory wading birds from the Northern Hemisphere visit the lake between April and November each year to feed in the shallow edges. Herons and egrets use these resources all year round. Pacific Black Ducks (*Anas supercilosus*), Black Swans (*Cygnus atratus*), Little Grebes (*Tachy baptus novaehollandiae*), Australasian Coots (*Fulica atra*) nest on the lake and Reed Warblers (*Acrocephalus stentoreus*) and Little Grassbirds (*Megalurus gramineus*) in the surrounding reeds. Birds of prey include the Osprey (*Pandion haliaetus)* and Peregrine Falcon (*Falco peregrinus*) (Department of Conservation and Environment 1981).

The long necked Tortoise (*Chelodina oblonga*) lives and feeds in the lake laying its eggs in the dunes nearby.

Numerous other reptiles have been identified at the lake including; Bobtail Skink (*Tiliqua rugosa rugosa*), Gould's Monitor (*Varanus gouldii*), Racehorse Monitor (*V. tristus*), Fence Skink (*Pogona minor*) and Burton's Legless Lizard (*Lialis burtonis*). Tiger snakes (*Notechis scutatus*) have frequently been observed in the sedgelands and Dugites (*Pseudonaja affinis*) live in surrounding native bushland.

Five species of frogs have been identified as living around Lake Richmond: *Litoria moorei* (Western Tree Frog or Motorbike Frog), *Limnodynastes dorsalis* (Banjup Frog), *Heleioporus eyrei* (Moaning Frog), *Heleioporus psammophilus* (Marbled Burrowing Frog) and *Crinia glauerti* (Glauert's Froglet).

Several species of fish are present in Lake Richmond including the introduced Gambusia (*Gambusia affinus*) and Sea Mullet which enter through the outlet drain. An unidentified mollusc is also found in the lake (Goodale, 1996).

Thrombolites

Lake Richmond contains microbialites-the collective name used to describe all organic-sedimentary structures produced as a result of the growth and metabolic activity of benthic microbial communities. Microbialites include stromatolites, thrombolites, algal nodules and algal biscuits.

Lake Richmond contains a community of thrombolites, which are externally indistinguishable from stromatolites but differ in their internal structure. Thrombolites have a clotted internal structure, unlike stromatolites which are layered. The thrombolites at Lake Richmond ring most of the edge as a result of carbonate precipitation by diatoms and cyanobacteria (*Dichotrix* spp.) (Moore, 1993). The thrombolitic zone at Lake Richmond is approximately 125m wide, and the domed structures are "connected by crust which underlies the mobile sediment and the depressions between individual domes are often flooded and contain mobile sediment and algae" (Kenneally *et al.*, 1987).

A research program under implementation by CALM has identified the Lake Richmond thrombolites as a Critically Endangered Community and is in the process of developing a Recovery Plan for the community. Potential threatening processes identified by early consideration of management requirements include physical damage by members of the public, illegal rubbish dumping on nearby land, swamping by sediments which settle from drainage inputs and growth of couch grass.

Relevant Policies

Lake Richmond is protected by a range of State and Federal policies. The lake and surrounding area, Reserves C9458 and C33659 have legal and administrative status of a Registered Heritage Site with the Australian Heritage Commission.

Two communities within the Lake Richmond Parks and Recreation reserve have been identified as having special conservation significance. The thrombolites have a unique community composition not observed elsewhere in Australia and are considered to be "critically endangered" by CALM. An ecological community is listed as "critically endangered" when it is considered to be facing an extremely high risk of total destruction in the immediate future (CALM, 1997).

The *Juncus pallidus/Baumea juncea* sedgeland community in the dune swales is considered to be a "threatened" community. This community has also been identified nearby at Port Kennedy and Lakes Cooloongup and Walyungup and is conserved as a part of the Port Kennedy Scientific Park and Rockingham Lakes Regional Park.

The System 6 Report (DCE, 1983) and update have identified the lake and areas surrounding for conservation.

Lake Richmond is covered by the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992. This policy provides protection for the lake by prohibiting unauthorised filling, mining, and drainage of the lake, and discharges of industrial effluent into the waterbody.

Native fauna are protected by the Wildlife Protection Act (1956) which prohibits deliberate unauthorised destruction of native fauna.

3.2.4 Marine Environment

The project site forms a portion of the Cape Peron peninsula which is bounded to the west by Shoalwater Bay, to the north by Cockburn Sound and to the south by Safety Bay. Three marine habitats are identified in these areas:

- intertidal high reef platforms;
- subtidal reefs and limestone pavement; and
- seagrass meadows, sandy seafloors and embayments.

Intertidal High Reef Platforms

These platforms provide habitats for a wide range of algal communities which undergo strong seasonal changes. Species zonation across the platforms is controlled by tidal range, exposure to the sun and consequent desiccation. The red alga *Gracilaria* sp. occupies the shallower, more exposed zones and slower-growing genera such as *Sargassum* develop a dense canopy in the deeper areas where desiccation is less extreme.

Some of the reef platforms support large populations of certain animals. The dominant animals include: sea star *Patiriella gunnii,* abalone *Haliotis roei*, whelk *Thais orbita*, chiton *Rhyssoplax torriana* and large turban shell *Turbo torquata.*

Subtidal Reef and Limestone Pavement

Subtidal reefs and limestone pavements attract a wide range of marine plants and animals. Underwater limestone features such as caves and pinnacles harbour a variety of fish, sponges, gorgonians and other invertebrates.

The reefs are dominated by large macrophytes such as kelp *Ecklonia radiata*, which is an important primary producer and provides shelter for the marine communities in the area.

The reefs are particularly important to the fishing industry as they provide settlement sites and nursery grounds for the rock lobster *Panulirus cygnus*.

The subtidal reefs harbour one of the most diverse sponge populations in Australia (CALM and NPNCA 1995).

Seagrass meadows and Sandy Seafloors

Seagrass meadows generally occur on the sandy seafloor inside the coastal reef chain and in sand pockets among subtidal reefs. Seagrasses generally grow in water depths less than 10m. The seagrass meadows (mainly *Posidonia* spp., *Amphibolis* spp, *Halophila ovalis* and *Heterozostera tasmanica*) are important primary producers and provide food and shelter for a diverse assemblage of fish and invertebrates (CALM and NPNCA 1995).

3.3 Aboriginal Heritage

In order to comply with the requirements of the Aboriginal Heritage Act 1972, specialist investigations were carried out to determine whether the site has any special Aboriginal cultural significance in terms of both ethnography and archaeology. The findings of survey and investigations were as follows.

3.3.1 Archaeology

An archaeological survey for aboriginal sites was carried out for the project area by Quartermaine Consultants during May 1997.

The survey involved an investigation of previous research in the area and a systematic field survey of the project area.

The investigation found no previously recorded archaeological sites within the survey area and no archaeological sites were located by the field survey.

The investigations therefore concluded that development may proceed. As a result of the general possibility that undiscovered archaeological materials may be present beneath the site undetected by survey the report recommended that the proponent take adequate measures to inform project personnel of the need to immediately report uncovered material to the WA Museum.

3.3.2 Ethnography

An ethnographic survey of the project area was carried out by Rory O'Connor during May 1997. Consultation with Aboriginal elders from the Winjan Progress Association followed by site survey with the elders indicate no areas of significance within the areas proposed for residential development.

Survey found that Lake Richmond to the west of the project area was a site of general significance to the aboriginal elders. This general significance derives from:

- the use of wetlands as food and water resources before European settlement;
- the shores of wetlands were used as camping places before European settlement; and
- the wetlands are current areas of spiritual significance.

The area of general significance was considered to consist of the lake itself and its immediate surrounds along the length of its shores.

The survey found that housing or other development should not be permitted to disturb the lake or its immediate surrounds, but did not identify any ethnographic constraints to development within the area proposed for development.

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4.0 PROJECT DESCRIPTION

4.1 Project Components

4.1.1 Urban Residential Densities

The application area of the Subdivision Plan which was previously submitted for planning approval covered 34.8864ha and proposed the creation of 320 residential lots, 2.4624ha of Commercial components and 3.4786ha of open spaces within a 35ha portion of the total zoned landholding of 85.5ha. Residential lot sizes ranged from around 550m^2 to 1012m^2. As discussed, the land is Coded R15 and under this coding, the minimum lot size is 550m^2 and the minimum average is 666m^2.

The Consultative Environmental Review guidelines has however been applied to the total development area not subject to current approvals. This area measures approximately 85.5126ha and the overall plan showed approximately 900 lots.

A new development plan which has been prepared for the site as part of ongoing planning is shown at Figure 16 - Modified Development Plan. It covers the same area (85.5126ha) discussed above and is likely to produce a similar lot yield.

4.1.2 Public Open Space

The plan lodged for subdivision approval showed 3.4786ha of open space, of which 1.2184ha was shown as lake associated with the Rockingham Central Branch Drain. Council's policies only credit 25% of the lake area as public open space and consequently, the provision credited against the 10% requirement measures 2.5648ha.

The overall plan showed a further 1.5755ha of land to be provided as open space, of which 0.3ha was lake compensating flows along the Peter Street Main Drain. The credited area was therefore 1.3505ha making up the balance of open space required to meet the standard 10% provision from the total development area (previous development plus proposed development).

The modified plan shows a total of 5.6611ha of open space, of which drainage lakes occupy 1.6368ha. As 75% of the lake area is not credited as open space under Council's policy the open space contribution is reduced from 5.6611ha to 4.4335ha, which exceeds the 10%

requirement. This will be adjusted back at the detailed design stage. Under the modified plan, public open space is divided into six reserves compared with two under the former design.

One area of open space measuring 2,799m^2 is added to the Townsend Road public open space compensating land lost to accommodate a drainage facility within the existing reserve. This facility may take the form of a lake or alternatively, could be a dry basin contained within a landscaped depression.

The Rockingham Central Branch drain is shown to be located within a broad strip of public open space capable of being developed as a multiple use corridor containing the existing open drain within a swale. To the far west of the site there is a 1.7912ha parcel of open space containing a large lake capable of storing flows from the Peter Street Main Drain as well as taking stormwater from the development area. This reserve is in effect an extension of the existing Eldon Street reserve.

The remaining three open space areas are generally relatively small reserves containing drainage facilities in the form of lakes. It is expected that they will be developed as landscaped lakes providing a passive recreational function in addition to meeting drainage requirements.

The interface with the Region Open Space has been given particular attention. Where practical, road frontage has been provided along this interface. However north of the Rockingham Central Branch drain, there is a narrow strip of land between the Region Open Space and a pressure sewer main which must be retained within a reserve. The sewer main is generally aligned within a prolongation of Fisher Street and the plan shows that this road reserve has been extended to contain the sewer. As a consequence, there is a row of double frontage lots situated between the extended Fisher Street and the Region Open Space. It is proposed that dwellings on these lots front the Region Open Space and in order to prevent the circumstance of there being private lot boundaries common with the Region Open Space, a pedestrian accessway has been aligned along this interface. The proponent envisages special controls being implemented over these lots governing the orientation of dwellings and the construction of boundary fencing ensuring an appropriate interface is provided.

4.1.3 Commercial and Community Uses

A Commercial site is envisaged at the corner of the realigned Rae Road and the Garden Island Highway. This site is central to a catchment generally identified to exist between the Shoalwater Shopping Centre and the Malibu Shopping Centre. At this location the commercial facilities will

be able to "announce" the new neighbourhood and it is anticipated that the development could accommodate 2,000 to 2,500m^2 of retail space, possibly a service station and/or fast foods together with some local offices.

Previous stages of the development led to the provision of a site for community purposes at the corner of Hennessy Way and Swift Court adjacent to the Stan Twight Reserve.

4.1.4 Internal Roads

The road patterns of both the submitted plan and the modified plan are based on the possibility that the Garden Island Expressway will not be constructed from effectively its present location to Cape Peron. The plans therefore cater for the opportunity to discontinue construction as well as allowing for future extension should it be required. In the event that extension is not required, the development is designed so that the Rockingham South Branch Drain which is proposed within the medium strip of the Expressway, can be incorporated into a multiple use corridor occupying the 50 metre wide highway reserve with housing and service roads to either side. In this circumstance, the Expressway would terminate at a roundabout connecting it with Casserley Road to the north and Rae Road to the south.

Casserley Road is shown in both options to extend north from the Expressway to intersect with Townsend Road. It is shown to continue north from Townsend Road to ultimately connect with Bay View Street. Roundabouts allow for the distribution of traffic to the north via Bay View Street as well as Fisher Street in an endeavour to ensure that existing residential roads do not suffer from unduly increased traffic loadings.

The submitted plan shows a neo-traditional design utilising geometric elements such as crescents contrasted with long avenues providing vistas to open spaces and landscaped features.

The local street system of the modified plan is based on catering for the disposal of stormwater through soakage to the groundwater via lakes. These drainage facilities are sited to serve land generally within a 350 metre radius and in order to achieve drainage connections from the outer edges of these catchments to the disposal point, relatively direct road linkages are required. This requirement therefore strongly influences the road pattern of the modified plan.

4.2 Provision of Services

4.2.1 Reticulated Sewerage

The northern part of the land will generally drain via gravity sewers to a pump station near the corner of Bay View and Forbes Streets to the north. The balance of the Estate will rely upon the construction of a new pumping station adjacent to the Garden Island Expressway Reserve and to the north of Hawker Street. Again the subdivision within the catchment of this pumping station will drain to the pump via gravity sewers.

4.2.2 Drainage

An effective stormwater management system has been designed for the site. Design criteria for the system include essential engineering factors and environmental factors important for the site.

The important environmental design criteria and performance features of the system may be summarised as follows:

- partial disposal of stormwater by infiltration, by the collection and conveyancing system,
- partial disposal of stormwater collection from the road system by manholes and gullies which can discharge water to the surrounding soil profile and underlying aquifer,
- construction of stormwater detention structures in the form of unlined lakes in the sandy soils, designed and constructed to retain stormwater inflow and to allow for infiltration losses into the superficial aquifer,
- sizing of the stormwater detention basins to meet the requirements of the Water and Rivers Commission, including the provision of detention volume for 1 in 10 year storms, for recharge to the shallow aquifer,
- for storms of greater than 1 in 10 year recurrence interval, the detention basins surcharge will overflow to the Water Corporation main drainage system,
- discharge structures will include appropriate gross contaminant removal facility.

The components and layout of the stormwater system may be described as follows:

- the Water Corporation Central Branch Drain is retained, and will only be used (by this development proposal) as an emergency overflow route,

- the Water Corporation Southern Branch Drain is to be re-routed along the alignment of the median of the Garden Island Freeway reserve, and linked to the existing Peter Street Drain. In the event that the Garden Island Expressway is not constructed this reserve is then capable of being developed as a multiple use corridor,

- the Water Corporation's Peter Street Drain will be undergrounded on the south side of the Freeway reserve and connected to a new stormwater detention/infiltration structure. In future this drain will only contribute stormwater to Lake Richmond during storms of recurrence interval greater than 1 in 10 years : this offers the benefit of detaining and infiltrating stormwater flow from existing residential areas outside of the Cape Peron Estate boundaries as well as stormwater from the proposed new residential areas,

- the area will be divided into five subcatchments each with detention basins which will contain all storm events up to and including 1 in 10 year intensity, and will only overflow to the Water Corporation Drainage system during larger storms of greater than 1 in 10 year occurrence.

It is important to note that the detailed design works for various elements of the stormwater system remain to be completed. Detailed design of the detention basins will as far as practical apply design criteria which optimise the environmental and social benefits of the water body. This process accommodates the broad principles of Water Sensitive Design and will focus on water quality protection, landscape aesthetics, habitat creation, and passive recreation.

4.2.3 Water

Because the development area is effectively surrounded on three sides by existing housing, water services are available in the general locality and can be extended to the new development in the normal way.

4.2.4 Power and Telecommunications

Similarly, power and telecommunications services are generally available in the locality and will be extended to the new development via underground cabling.

4.3 Project Timing and Staging

4.3.1 Commencement of Development

The proponent intends carrying out subdivision works following the receipt of necessary approvals.

4.3.2 Staging

Currently, available lots in the latest stage of development are accessed via Townsend Road which is linked to Read Street via Swinstone Street. The entrance to the Estate is therefore more or less via a long cul-de-sac. The developers aim to create a through street system from Rae Road to Townsend Road by constructing Casserley Road.

The development of subsequent stages will be dependent upon market conditions.

5.0 ENVIRONMENTAL IMPACTS AND MANAGEMENT

This section of the report discusses the environmental factors identified by the EPA's guidelines for this CER, in terms of the potential impacts of the project and environmental management which will be implemented to mitigate impacts, in order that the EPA objectives can be met.

5.1 Vegetation, Fauna, Habitats and Flora in the Conservation Estate

5.1.1 EPA Objectives and Policy Framework

The CER Guidelines present the EPA's position in regard to several related factors as follows:

"Vegetation in the existing and proposed conservation estate is not adversely impacted"

"The EPA considers that there should be representative land systems set aside for the conservation of flora and fauna"

"Fauna and habitat in the existing and proposed conservation estate is not adversely impacted"

"Where the proposal could impact on the habitat or behaviour of regionally significant fauna those impacts should be reduced as far as practicable"

"Protect threatened fauna and priority fauna species, and their habitats consistent with the provisions of the Wildlife Conservation Act 1950"

These matters are closely related and are logically discussed under a single heading.

5.1.2 Potential Project Impacts

Assessment of potential impacts of the proposal is provided here under several relevant headings.

5.1.2.1 Location and Extent of the Conservation Estate

The Metropolitan Region Scheme identifies the location and extent of the Conservation Estate in the Rockingham Region.

Figure 17 identifies the location of the project site in relation to the onshore conservation estate in the Rockingham area, which is referred to as the Rockingham Lakes Regional Park, as shown on the Metropolitan Region Scheme map dated 16th May 1997.

Figure 17 shows that the site does not physically impinge on the conservation estate area recognised for Lake Richmond.

At Lake Richmond, the proposed conservation estate includes land within the north-western Portion of Lot 402, which is currently in the ownership of Allied Land Company Pty Ltd, but which is zoned and reserved as Parks and Recreation under the MRS, and is the subject of System 6 Recommendation M102.

There is no proposal for any residential development within the Parks and Recreation Reserve/System 6 Recommendation Area and the intended purpose of maintaining this land area for conservation is not directly affected by the proposal.

In due course, the portion of Lake Richmond and the Parks and Recreation Reserve which is presently owned by Allied Land Company Pty Ltd will be acquired by the Western Australian Planning Commission.

5.1.2.2 Indirect Impacts to the Parks and Recreation Reserve

There is the potential for indirect physical impacts to the Lake Richmond Reserve during construction activities near the reserve boundary. These impacts will need to be prevented by active management during the construction phase of the project.

There is also potential for indirect impacts within the Parks and Recreation Reserve as a result of increased recreational pressure from residents of the new estate. These include,

- off road vehicle activity and damage to vegetation;
- pedestrian trampling of vegetation;
- littering and rubbish disposal;
- fire;
- weeds invasion;
- predation and disturbance of wildlife by domestic animals.

Methods of mitigating these potential impacts need to be incorporated within Management Plans for the Parks and Recreation area.

The Thrombolite community which fringes the open water body of Lake Richmond has specific conservation significance and the relationship between potentially threatening processes to this community and the proposed development is discussed separately in Section 5.2 of this document.

Similarly the Holocene Sedgeland community located within the Parks and Recreation reserve has special conservation and protection needs, and management requirements to protect this community are discussed in Section 5.1.3.1 of this report.

Discussion of environmental factors in the CER Guidelines also identified a requirement to examine the effectiveness of the Parks and Recreation Reserve as a "satisfactory ecological buffer for Lake Richmond".

In this regard reference is made to a report to the Australian Nature Conservation Agency which provided guidelines for design of effective buffers for Wetlands on the Swan Coastal plain (Davies and Lane, 1995). The report examined buffer requirements relative to a range of processes.

For ecological processes, the report concluded:

> "An adequate buffer zone for maintenance of ecological processes and major food webs is recommended at 20 to 50m, measured from the outer edge of open water and will therefore include wetland dependent vegetation".

Figure 13 plots the development boundary relative to the parks and recreation area and shows that:

- the south-eastern boundary has a minimum setback from the outer edge of open water of approximately 100m;
- for the southern boundary the setback varies evenly between a minimum distance of approximately 75m to approximately 400m.

The Parks and Recreation reserve therefore meets this specific guideline. Development will be confined to the eastern side of a sand ridge which encircles the eastern edge of the lake and is a physical barrier between the landscape of the lake and its fringing wetland vegetation, and the development area.

5.1.3 Environmental Management

5.1.3.1 Existing and Proposed Conservation Estate

By confining all proposed development within the area zoned for residential uses, the proposal meets the EPA objective of preventing direct impacts to vegetation, flora, habitat and fauna in the existing conservation estate. Road and boundary features which are proposed to manage the southern and south eastern boundaries of the reserve are located fully within the project area, and land allocations to public open space have been located so as to allow potential for carparking areas to be established, and to provide controlled access to the reserve, in accordance with existing management plans.

5.1.3.2 Management of Increased Public Usage

Protection of the Lake Richmond Parks and Recreation reserve from the detrimental processes noted previously as potential indirect effects, requires specific planning at the boundary between the reserve and the future residential areas.

To address this requirement it has been necessary to design the land use interface so that user access to the reserve for legitimate purposes is not constrained, but unwanted practices and processes can be minimised.

The plan of subdivision recognises the reserve for the Garden Island Highway, which presently forms the southern boundary of the Parks and Recreation Reserve, and when constructed would provide a constraint to uncontrolled pedestrian or vehicle access across this part of the reserve boundary.

At the junction between the highway reserve and the project area, the plan of subdivision provides for a public road directly abutting the highway reserve over most of this sector of the boundary. Where the plan does not provide a boundary road, a 3m public access way is

proposed. In combination these features determine that there will be no areas where private residential land directly abuts the reserve, and control of access and active management can be achieved along the full length of the boundary.

Management of the Cape Peron Estate interface using the management boundaries and access facilities described will be able to be integrated with overall management of the Reserve.

The System 6 "Red Book" (DCE, 1983) recommended that the City of Rockingham should prepare a management plan for the area reserved Parks and Recreation in consultation with the Department of Fisheries and Wildlife (now CALM), the Metropolitan Regional Planning Authority (Western Australian Planning Commission) and the local landowners.

A management plan for the Lake Richmond Conservation Reserve has been prepared for the Rockingham City Council and the Kwinana Rockingham Mandurah Branch of the WA Naturalists Club (Goodale, 1996).

The Management Plan is intended to cover all of the land reserved for Parks and Recreation in the MRS, including existing reserves, vacant Crown land and that portion of Lot 402 which remains in the ownership of Allied Land Company Pty Ltd.

The Management Plan identifies active management works which have been carried out over recent years by volunteers working through the WA Naturalist Club and with funding support from the City of Rockingham, the WA Naturalist Club and private fundraising.

Specific management objectives for the Parks and Recreation Reserve which were put forward were:

- *"To maintain and rehabilitate Lake Richmond as an example of coastal wetland*
- *To protect and conserve native plants and animals in their habitat,*
- *To protect and conserve the special features of Lake Richmond Landscape : the Thrombolite stromatolitic structures,*
- *To encourage public use for passive recreation by up-grading paths and other facilities and fencing to sensitive areas,*

- *To increase public awareness of the flora and fauna of Lake Richmond via educational brochures, self-guided and guided walks".*

The proposal for further residential development within Cape Peron Estate will not reduce the ability for management objectives to be met within the Parks and Recreation reserve and will contribute to the implementation of the management plan for Lake Richmond by establishing management control boundaries and access to the reserve. These features will be located entirely within the project area on privately owned land.

As the development proceeds and the local population increases it will be important for active management along the boundary to intensify, and for programs including the protective measures identified in the Management Plan prepared for the WA Naturalists Association to be implemented. Protective measures and processes requiring management identified in the Management Plan included:

- fencing;
- pest eradication;
- weeds;
- feral animals;
- fire;
- rehabilitation and maintenance;
- public use.

Allied Land Company Pty Ltd will liaise with the City of Rockingham and with management staff for the reserve appointed by the City of Rockingham in regard to the implementation of management within that part of the reserve in its ownership, for the period prior to acquisition of this land parcel by the WAPC.

The development plan for Cape Peron Estate also provides for a 2.63ha area of public open space which would surround the Rockingham Central Branch drain, which would be realigned.

This area provides the opportunity for upgrading to a multiple use corridor containing the existing drain in a linear swale, and provides space which would allow the Water Corporation to upgrade the drain to incorporate water quality control devices should this be desired in the future. Carparking spaces for users of the reserve proposed by the Rockingham Lakes Regional Park Plan may also be able to be established in this area as the implementation of the Management Plan Proceeds.

The establishment of fencing around the reserve to prevent vehicular access and control pedestrian transit within desired paths would be the priority as development proceeds and should be considered by the City of Rockingham during review of expenditure for management of the reserve.

5.1.4 Conclusion

Evaluation of potential project impacts indicates that the implementation of the proposal will not reduce the ability for the EPA's objectives to be met. Development within the existing conservation estate is not proposed and therefore protection of land systems, vegetation, flora habitat and fauna in the existing conservation estate can be achieved subject to appropriate attention from the managers of the reserve. The extensions of management initiatives over the full extent of the parks and recreation reserve will be able to proceed when acquisition of the privately owned portion of the reserve by the WAPC has been finalised.

5.2 Lake Richmond

Lake Richmond is the relevant local feature in regard to the wetland and thrombolite factors presented by the EPA. Accordingly, discussion of the factors is grouped and focused towards Lake Richmond.

5.2.1 EPA Objectives and Evaluation Policy

The EPA's position in regard to Lake Richmond was expressed in the CER guidelines as follows:

> *"Wetlands are protected and key ecological functions are maintained. Maintain or improve groundwater and surface water quality flowing into the lake.*
>
> *Wetlands identified in Bulletin 685 should be protected and should have their ecological function maintained. Where there is loss of a wetland function then the functions lost should be replaced elsewhere.*

Ensure thrombolite survival and growth is not adversely impacted by maintaining or improving the existing quantity and quality of groundwater and surface water flowing into the lake and preventing physical impacts (crushing)."

In discussing these factors, certain specific aspects were cited by the guidelines as requiring discussion, as follows:

- the biological status, physical fragility, light requirements, water quality tolerance and carbonate and bicarbonate requirements of thrombolites;

- the water quality of Lake Richmond viz nutrient status, salinity, stratification, pH, light penetration, and turbidity, carbonate and bicarbonate status and inflows in groundwater.

Much of the available background information in regard to these aspects is summarised in Sections 3.1 and 3.2. Further relevant information is given in the subsequent discussion of potential impacts.

5.2.2 Potential for Project Impact

To facilitate discussions of potential project impacts, the management objectives for Lake Richmond set out within the EPA guidelines may be most simply expressed as follows:

- maintain water quality so as to not detrimentally effect existing ecological functions : in the case of Lake Richmond these focus on the use of the wetland and its fringing vegetation by waterbirds, and other aquatic fauna, and the broad water quality target is to maintain nutrient levels so the lake does not experience excessive algal blooms which could reduce water clarity or oxygen content to the detriment of aquatic wildlife;

- specifically ensure that lake water quality meets the requirements of the thrombolite community, in terms of salinity, bicarbonate ion concentrations and light penetration to support photosynthesis;

- protect the thrombolite community from direct physical damage.

The potential for residential development within the site to detrimentally impact on the ability for these objectives to be met is discussed separately in the following sections.

5.2.2.1 Water Quality in Lake Richmond: Nutrient Levels and Inputs

(i) Background

The major sources of nutrient inputs to Lake Richmond currently include surface water inputs through the Water Corporation drainage system, groundwater inflow, and deposition of faecal matter by waterbirds. There will also be a nutrient store in the lake sediments, which might re-release nutrients to the water column under certain circumstances.

Data collected by the Water Authority and evaluated by the EPA (1990) indicates that water quality in the lake is now dominated by the quality of inflowing drainage water. This shift from a groundwater throughflow lake to a lake with hydrology controlled by surface water inputs commenced with the construction of the inlet drains prior to the 1960's and is shown by the data presented by Passmore (1967) and Keneally *et al.* (1987) to have accelerated when the outlet drain was constructed in 1968. Figure 12 shows that by the middle 1970s the salinity of lake water was very similar to the drainage water and showed similar seasonal fluctuations. Figure 13 shows water quality trends for nutrients and Figure 18 shows trends for suspended solids, pH and total dissolved solids.

The importance of drainage into the lake as a component of Lake Richmond's water balance and therefore as a source of nutrient inputs to the lake can be gauged from broad estimates of the relative volumes of lake inputs and outputs, and the lake's volume. Table 2 summarises relevant estimates, whilst Appendix G presents the background calculations.

Table 2
Estimates of Water Balance Elements for Lake Richmond

Water Balance Element	Volume
Lake Volume	5.0×10^6 m^3
Drainage Inputs	1.4×10^6 m^3/annum[1]
Rainfall	340,000m^3/annum
Groundwater Inflow	275,000m^3/annum[2]
Evaporation	560,000m^3/annum

Note:

1 Probable under estimate as groundwater interception is not included

2 Order of magnitude estimate only, but possibly conservatively high

The data presented in Table 2 must be viewed as estimates only, however the estimates present the opportunity to compare the flows at least at the order of magnitude level. In this regard, drainage inputs are one order of magnitude larger than rainfall and one order of magnitude greater than groundwater inflow and would replace lake water within the order of three to four years.

The drainage management strategy for the site proposes the upgrading of the current Peter Street drain (see Figure 7) by directing the current open drain flow to a new stormwater infiltration. Flows from this catchment which totals 78ha, currently discharge directly to the drainage system and join flows in the central branch drain.

Construction of the infiltration basin will reduce these flows so that as for the other parts of the proposed development, drainage inflows to Lake Richmond would occur on average once every ten years from the Peter Street catchment. Stormwater from smaller rainfall events will be discharged to the shallow aquifer through the floors and walls of the infiltration basin.

The Peter Street catchment represents approximately 6% of the total stormwater catchment discharging to Lake Richmond. Therefore for storm events of less than 1 in 10 year recurrence interval, the stormwater inflow volume to Lake Richmond can be expected to reduce by around 6%.

In addition to the hydrological data, the relative importance of drainage and groundwater inflow to the nutrient levels within Lake Richmond can be further gauged by examining the available data for nutrient levels in these sources.

Water quality data describing nutrient levels in drain inlets, Lake Richmond and local groundwater have been collected from a variety of sources, and whilst there is inconsistency in the period of available data, and the suite of measurements taken, the following summaries can be made.

Northern Branch Drain - Safety Bay Senior High School data for nutrient levels in drainage water inputs indicate a range of 0.03 to 0.38 mg/L $P\text{-}PO_4$ and an average of 0.13mg/L $P\text{-}PO_4$, from 7 records collected between 1994 and 1996, from water samples taken from the drain at its point of entry to the lake (see Appendix E).

Lake Richmond - This data base returned nutrient levels for Lake Richmond water with a range of 0.03 to 0.91 mg/L $P\text{-}PO_4$ and an average of 0.26 mg/L $P\text{-}PO_4$, from 5 records collected

between 1994 to 1996, from water samples taken from shallow water at the lake's edge (see Appendix E).

The Water Authority collected 29 lake water samples between 1970 and 1984 and found total phosphorus concentration varied between <0.01 - 1.3mg/L. (Examination of the tabulated data provided at Appendix E suggests an error in data entry such that the cited value of 1.3mg/L was the result for total nitrogen whilst the value for total phosphorus from that sample would have been 0.1mg/L P which is consistent with water quality trends for that time).

The difference between the Water Authority and Safety Bay High School data may reflect different sampling sites. The high school data is collected from the edge of the lake in shallow water where faecal matter from waterfowl could collect. In contrast the Water Authority data is collected from around 7m depth in the centre of the lake.

Shallow Groundwater - Phosphorus levels of 0.07mg/L P-PO_4 and 0.05mg/L P-PO_4 were reported for Monitor Bore T280 located some 1.5km east of the lake for samples collected on 6/4/87 (end of summer) and 8/7/80 (mid winter) by the Water Authority.

Data presented by Davidson (1995) indicate total phosphorus concentrations of <0.03mg/L for the surface of the superficial aquifer upgradient of the Lake Richmond area.

The combination of water balance and water quality data indicate that Lake Richmond water quality in regard to nutrients is dominated by the inflow of drainage water.

Whilst recognising the limited numbers of samples presented by all but the WRC data base, the available water quality figures and the volumetric estimates of flows of water to the lake enable the following broad conclusions to be made;

- Due to its very large comparative volume, incoming stormwater is the major source of nutrients to the lake (no attempt to quantity waterfowl droppings has been made here).

- Lake Richmond is well flushed by stormwater, with an indicative throughput rate of one lake volume per three to four years.

- Groundwater inputs are very small compared to storm water inputs to Lake Richmond and therefore the lake should not be sensitive to small changes in groundwater quality in terms of annual nutrient loadings.

- In order for nutrient levels in Lake Richmond to be maintained or reduced, further stormwater inputs should be treated prior to discharge and the quantity of additional stormwater should be maintained at current levels or reduced.

(ii) Effect of Stormwater Disposal from the Project Area

The background to the hydrology of Lake Richmond and current nutrient status provided in the previous section indicates that the disposal of stormwater within the project area could only be a very small factor in the overall water and nutrient balance of the Lake.

As noted in Section 4.2, the drainage system for the proposed subdivision will be designed so as to prevent any discharge of stormwater for storm events with a recurrence interval of 1 in 10 years. This will be achieved by constructing the retention basins so that recharge losses to the shallow aquifer can occur.

This design approach may be expressed alternatively, as follows: the probability of an overflow event from the proposed detention infiltration structures to the existing drainage network is once every ten years or more.

The water quality of stormwater discharges which occur as a result of an event of intensity greater than 1 in 10 years is difficult to accurately predict. However in terms of water management principles, some general conclusions may be drawn:

- first flush events, which are generally considered to be large sources of contaminant export , will be fully contained on-site (except when the seasons first rainfall event exceeds a 1 in 10 year recurrence interval),

- any overflow from the system will have passed through the detention basins prior to entry to the main drains to Lake Richmond, and will have been improved in quality by processes including sedimentation, biological nutrient uptake, oxidation, and disinfection by detention (natural die-off) and exposure to sunlight,

- the onsite containment of "first flushes" and detention in accordance with WRC specifications will minimise the amount of additional nutrients which are incorporated into drainage inputs to Lake Richmond,

- stormwater from very intense storms would comprise mainly rainwater (in contrast to other local drainages which would also carry groundwater), and may be expected to have low salinity.

In summary, by reference to the following factors:

- the present subdivision application area and full eventual development area represent 2.7% and 7.7% respectively of the total potential stormwater catchment of Lake Richmond,

- overflow from the project area to the existing stormwater system may occur on average once every ten years,

- for stormwater flows from rainfall events of less than 1 in 10 year recurrence interval the quantity of drainage discharge to Lake Richmond should reduce 6% as a result of proposed improvements to the Peter Street drain,

- all overflow will have been detained under conditions which meet WRC requirements, prior to incorporation in the existing branch drains, and should mainly comprise low salinity rainfall runoff,

it is reasonable to conclude that normal functions of the proposed stormwater system for the site could have only a very small or negligible effect on the current hydrology and water quality of Lake Richmond and the EPA objective for the water quality of surface water inputs to be maintained or reduced will be met.

5.2.2.2 Water Quality Requirements of the Thrombolites

Very little is known in regard to the water quality requirements of the Lake Richmond thrombolites or in fact the biological status of the thrombolite community at the present time. Based on the presumption that the thrombolites remain biologically active, some assumptions may be made from basic biological principles:

- the cyanobacteria which are responsible for the deposition of the structures are photosynthetic and therefore clear water in Lake Richmond is important to allow light to penetrate to the surface of the structures,

- a supply of calcium and bicarbonate ions in the water column or in groundwater entering the lake as bottom seepage must be maintained in order for growth (deposition of calcium carbonate in clotted structures) to proceed,

- the pH of the lake water and the incoming groundwater seepage should be less than approximately 10.5 if most of the carbonate dissolved from the soil profile during recharge in the groundwater catchment is to remain in solution as bi-carbonate,

- if it can be assumed, that the thrombolites can be considered to be biologically intact at the present time, the salinity tolerance of the growth process must vary between approximately 2500 mg/L TDS which was the summer salinity reported by Passmore (1967) prior to the construction of the outlet drain from the lake, to 300-400 mg/L TDS which is the approximate salinity range at the present time : it should be noted that whilst cyanobacterial activity has been confirmed by recent examination of samples recovered from the lake, it is not presently known whether the microorganisms detected are the same as those responsible for creation of the existing structures, (Moore pers. comm),

- small increases in lake water nutrient levels might accelerate thrombolite "growth" by stimulating the biological activity of the cyanobacteria which deposit the structures,

- excessive nutrient levels could impact the thrombolites by promoting epiphytic algal growth which could limit the penetration of light to the structure's surface, by favouring macroalgal growth which could compete for space or by reducing the clarity of the water column if phytoplankton blooms were to occur.

The available data base for water quality in Lake Richmond has been examined to determine whether any conclusions can be made in regard to the modification to the lake's hydrology and water balance and any consequences this may have on the ability for thrombolite growth to be maintained.

Some points which derive from examination of the available data are as follows:

- The salinity of lake water appears to have stabilised in the range 300 to 400mg/L following the rapid fall from 2,500 to 1,100mg/L TDS recorded for 1965 to 1968, and from 1,100 to 300mg/L TDS recorded to 1986.

- Water and Rivers Commission data examining suspended solid concentrations (which indirectly reflect water clarity) report very low levels for the majority of the analyses (range <1 - 34mg/L suspended solids, average 6mg/L from 27 records), indicating that lake water remains very clear for the majority of the time.

- During the mid 1960's, bicarbonate levels in lake water were similar to those in adjacent groundwater Passmore (1967). Calcium levels in lake water at this time varied between 10 and 22 mg/L and were highest at the beginning of summer and lowest at the end of summer.

- Current bicarbonate levels in inflowing groundwater are likely to be high, based on data from bore T280 which recorded 381 and 390mg/L bicarbonate on 6/4/87 and 8/7/80 and 320mg/L of calcium carbonate on 16/9/75 : corresponding calcium levels for these samples were 52, 50 and 54 mg/L.

- The lake water pH has remained in the range 7.9 to 9.5 within which dissolved carbonate is present predominantly in the bi-carbonate form. Figure 14 shows the effect of pH on partitioning between bicarbonate and carbonate, and indicates that most of the carbonate is present in the bicarbonate form in the pH range exhibited by Lake Richmond water.

- There is no recent data describing bicarbonate or carbonate levels in lake water. However the continuing inflow of groundwater, and the entrainment of shallow groundwater in drainage inputs indicates a continuing supply of bicarbonate to the lake's water column is maintained.

- The open drain system is formed from excavation into the same high calcium carbonate sands which are the source of high carbonate/bicarbonate in groundwater. Stormwater may reach equilibrium with respect to dissolved calcium carbonate during flow through the drains into the lake.

- Review of descriptive data for Lake Richmond (EPA, 1990, Keneally *et al.*, 1987, Goodale 1996) indicates that the lake is not known to have exhibited any persistent significant blooms of either macroalgae or phytoplankton. The Water and Rivers Commission data base for suspended solids levels in lake water is supportive of this view.

- Whilst nutrient levels in the lake appear to be elevated, they are lower than other lakes in the Metropolitan area which are effected by urban drainage. Table 3 compares Lake Richmond water quality to selected Metropolitan lakes.

Table 3

A Baseline Biological Monitoring Programme for the Urban Wetlands of the Swan Coastal Plain, Western Australia

Lake Name	mg/L TP	mg/L TN
Jandabup	0.01 - 0.067	0.014 - 9.7
Joondalup	0-013 - 0.195	1.23 - 11.4
Monger	0.036 - 0.964	1.56 - 14.9
North	0.123 - 0.28	0.712 - 6
Thompsons	0.02 - 0.46	1.16 - 17.2
Lake Richmond[1]	<0.01 - 1.3[2]	<0.05 - 4.4

Source: Davies and Rolls 1987

1. Source Water Authority
2. It is possible that the maximum recorded level of phosphorus of 1.3mg/L is a data entry error and that the maximum recorded level for phosphorus is 0.9mg/L

In the absence of any new information which indicates the thrombolites are not in "normal" biological condition, it can only be assumed that the available water quality data base for Lake Richmond describes the water quality tolerance range for the thrombolite community. As long as water quality remains within historical limits, there is currently no logical implication for impact to the thrombolites.

In summary, recognising that:

- the proposed stormwater system will contain all stormwater on site, except for events which exceed 1 in 10 year recurrence interval, for which a treated overflow from the system will occur,

- for storms of less than 1 in 10 year occurrence interval magnitude, stormwater flow to Lake Richmond should diminish by around 6% due to the construction of an infiltration wetland on the existing Peter Street drain,

there is no reason to expect that the project poses any significant risk to the thrombolite community in regard to changes in the quantity and quality of surface water drainage inputs to Lake Richmond. Accordingly the available data does not present any reasons to expect that the EPA objective for thrombolite survival and growth to be ensured in regard to water quality and quantity cannot be met as a result of project implementation.

(ii) Groundwater

Recognising that groundwater inflow to the lake may be inferred as an important source of bicarbonate and calcium ions which are the basis of thrombolite structure, and that the site forms a portion of the groundwater capture zone for the lake, it is appropriate to also comment on the anticipated effects of the proposal on the quantity and quality of recharge to the superficial aquifer and consequently on the quality of groundwater which enters the lake as seepage.

Conversion of vegetated land to urban uses is normally associated with an increase in the proportion of annual rainfall which enters the superficial aquifer as recharge. Estimates of 15% to 25% recharge within vegetated land by Sharma and Craig (1988) Farrington and Bartle (1988) and Thorpe (1988), and an estimate of 20% recharge for this area by Davidson (1978) compare to estimates of around 35% recharge for new urban areas (Appleyard, 1995).

Recognising that the dissolution of calcium carbonate by rainfall is a chemical (acid-base) reaction which should occur quickly and that reactions in carbonate systems require only a few minutes to reach equilibrium (Rich, 1973) it is reasonable to expect that this additional recharge will quickly attain bicarbonate levels comparable with existing groundwater. The transport of calcium and bicarbonate ions into Lake Richmond via groundwater inflow, therefore should not be diminished by an increase in groundwater recharge beneath the site.

Passmore's 1967 work found no seasonal pattern in calcium carbonate in solution in shallow groundwater leading to the conclusion that the superficial aquifer is saturated and probably oversaturated, and saturation is attained very soon after percolation of rainfall from the land surface.

In regard to the effects of stormwater disposal by infiltration on groundwater quality, research findings from Appleyard (1993) regarding groundwater quality beneath stormwater recharge basins set within residential land uses in Ardross found nutrient levels to be as follows:

- total nitrogen generally less than 1mg/L,
- phosphorus levels generally less than 0.01mg/L.

Data describing shallow groundwater quality beneath the urban land uses established on Safety Bay Sand soil profiles is sparse. Monitor bore T280 is located in a general area which has been urbanised for some time, and has equivalent soil/groundwater regime to the site.

Phosphorus concentrations of 0.05mg/L, and 0.07mg/L were reported for samples from T280 on 8/7/1980 and 6/4/87, whilst nitrogen was reported as 0.2mg/L and 0.22mg/L for the same samples.

These values, whilst of a limited nature in terms of sample numbers, are consistent with the data presented by Appleyard (1993), and compare closely with existing lake water quality.

Davidson (1995) presented contour maps showing the concentration of phosphate at the surface of the superficial aquifer for the Rockingham area, including areas which have been under urban uses for some time. Phosphorus concentrations of <0.03mg/L are presented by the data.

Appleyard and Bawden (1987) examined the effects of urbanisation on nutrient levels in the unconfined aquifer underlying Perth and commented "*Concentrations of total phosphorus greater than 0.1mg/L P occur sporadically throughout the Metropolitan area and show no obvious relationship with residential areas with large gardens*".

The combination of relatively low nutrient values expected for groundwater recharge from the stormwater system and the small volume of groundwater seepage in comparison to drainage inputs, indicates that stormwater recharge within the project area should not have a significant influence on water quality in Lake Richmond.

Whilst it is realistic to expect some increases to nutrient levels in groundwater recharge following the establishment of residential gardens, the minor role of groundwater inputs compared to surface water indicates very small if not negligible changes to overall nutrient loadings to the lake would result.

5.2.2.3 Physical Protection of the Thrombolites

The thrombolite community is considered to be at risk of damage from physical trampling by casual observers and users of the reserve.

Increased usage of the Lake Richmond Reserve as discussed in Section 5.1 is expected to occur as a result of the increase to the local residential population and visitors to the proposed Rockingham Lakes Regional Park which will occur as the Estate is developed.

The need to control pedestrian access to the thrombolite community increases with increasing usage of the areas and effective management measures need to be put into place in the Reserve, as a special component of the overall Management plan.

5.2.3 Environmental Management

5.2.3.1 Drainage System

The assessment of potential impacts indicates that the proposed development can be expected to have a small and probably insignificant effect on water quality in Lake Richmond and on the ability of the thrombolite community to persist.

It is noted that little is known of the water quality requirements of thrombolites and it can only be assumed that present water quality in Lake Richmond is adequate. By ensuring the project will cause negligible changes to the lake water quality, it is reasonable to presume that the project will not have any significant determinable impact on the thrombolites.

Analysis of water balance and water quality data for Lake Richmond, the drainage systems and shallow groundwater indicates that the design objective of retaining all stormwater on site within the proposed development area, and recharging this stormwater to the superficial aquifer is appropriate in regard to environmental management objectives.

The stormwater management design strategy for the project conforms to Best Management Practice BMP# I 10 - Infiltration Retention Basin, listed in the document entitled Planning and Management Guidelines for Water Sensitive Urban (Residential) Design, which was prepared by consultants for the Department of Planning and Urban development, the Water Authority of Western Australia, and the Environmental Protection Authority (1994). Appendix H reproduces the descriptions of design and performance features for BMP# I 10 provided in this document.

5.2.3.2 Sewage Pumping Station

As a result of the shallow groundwater table and the proximity of proposed sewage pumping station to the Rockingham Central Branch Drain a 6 hr storage capacity and emergency power generator will be incorporated in the facility. These contingency measures will meet DEP draft guidelines for sewage pumping stations in the proximity of important wetlands.

5.2.4 Conclusions

The analysis of surface water and groundwater aspects of the development proposal lead to the conclusion that the stormwater management design concept for infiltration/detention is appropriate.

The implementation of the stormwater management system , reticulated sewer system and pump station to the specifications discussed here indicate that the project does not create any significant risk that the EPA's objectives for Lake Richmond and the thrombolite community may not be met.

6.0 ENVIRONMENTAL MANAGEMENT COMMITTMENTS

Analysis of environmental factors identified by the EPA in the guidelines has shown that implementation of the project as specified in this document will not diminish the ability for EPA objectives to be met in regard to maintenance of the existing and proposed conservation estate, protection of water quality in Lake Richmond, and protection of the Thrombolite community which is established in the shallow lake margins.

This conclusion is based on the finding that Lake Richmond's hydrology is dominated by surface water inflows from the existing drainage system, to which the project area drainage system will contribute overflow on average once every 10 years. For storms of ten year recurrence interval, or less, all stormwater will be retained on site and discharged to the shallow aquifer through infiltration basins. Any stormwater overflow from the project area will have been detained within the site and water quality would have been improved. In addition, the new stormwater infiltration lake proposed for the present Peter Street drain will reduce current drainage flows to Lake Richmond by around 6% for storms with a return interval of less than one in ten years.

This approach to stormwater management meets the specifications of Best Management Practice BMP# I 10 (EPA, Water Authority, Department of Planning and Urban Development 1994).

The assessment also concluded that whilst the development proposal does not affect any land within the existing or proposed conservation estate, the increase in local population would increase user pressures on the Lake Richmond Parks and Recreation Reserve, which would need to be managed by appropriate planning at the development interface with the reserve, and by increasing management activity within the reserve.

In response to these findings, and recognising generic policies regarding environmental management of land development sites, the proponent makes the following Environmental Management commitments.

Commitment 1

Following the receipt of necessary government approvals, implementation of residential and related land uses within the project area will be carried out by Allied Land Company Pty Ltd in accordance with the development plan presented in this document in consultation with the Ministry for Planning, the City of Rockingham and the Department of Environmental Protection.

Commitment 2

Detailed design and construction of the drainage system during project implementation will be carried out by Allied Land Company Pty Ltd to the general specifications described in this document to the satisfaction of the Water and Rivers Commission, the City of Rockingham and the Department of Environmental Protection.

Commitment 3

Detailed design and construction of the reticulated sewer system during project implementation will be carried out by Allied Land Company Pty Ltd in consultation with the Water and Rivers Commission and City of Rockingham.

Commitment 4.

Allied Land Company Pty Ltd will liaise with the Water and Rivers Commission regarding detailed design and construction of sewer pumping stations during project implementation to ensure the requirements of the Department of Environmental Protection are met in regard to storage capacity and emergency power system.

Commitment 5

Subject to acceptance by the WAPC, following approval from the Minister for the Environment, Allied Land Company Pty Ltd will implement subdivision design for the interface between the residential area and the Lake Richmond Parks and Recreation Reserve in accordance with the development plan presented in this document and will finalise the plan of subdivision in consultation with the Ministry for Planning, the City of Rockingham the Department of Environmental Protection and the Department of Conservation and Land Management.

Commitment 6

Subject to approval by the WAPC, at the appropriate subdivision stage Allied Land Company Pty Ltd will provide pedestrian access points between the development area and the Lake Richmond Parks and Recreation Reserve in accordance with the development plan presented in this document including the provision of gates or other structures which will prevent unauthorised vehicle access to the reserve, in consultation with the Ministry for Planning and the City of Rockingham.

Commitment 7

Prior to the commencement of construction Allied Land Pty Ltd will develop a Construction Management Plan which will incorporate procedures to prevent access of construction vehicles to the Lake Richmond Parks and Recreation Reserve, and the control of noise, dust, fire and fuel

storage within the development area, to the satisfaction of the City of Rockingham and in consultation with the Department of Environmental Protection and the Department of Conservation and Land Management.

Commitment 8

Prior to commencement of construction Allied Land Company Pty Ltd will inform the project construction workforce of the requirement to refer uncovered Aboriginal archaeological materials to the WA Museum, in accordance with the provisions of the Aboriginal Heritage Act 1972.

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7.0 REFERENCES

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FIGURES

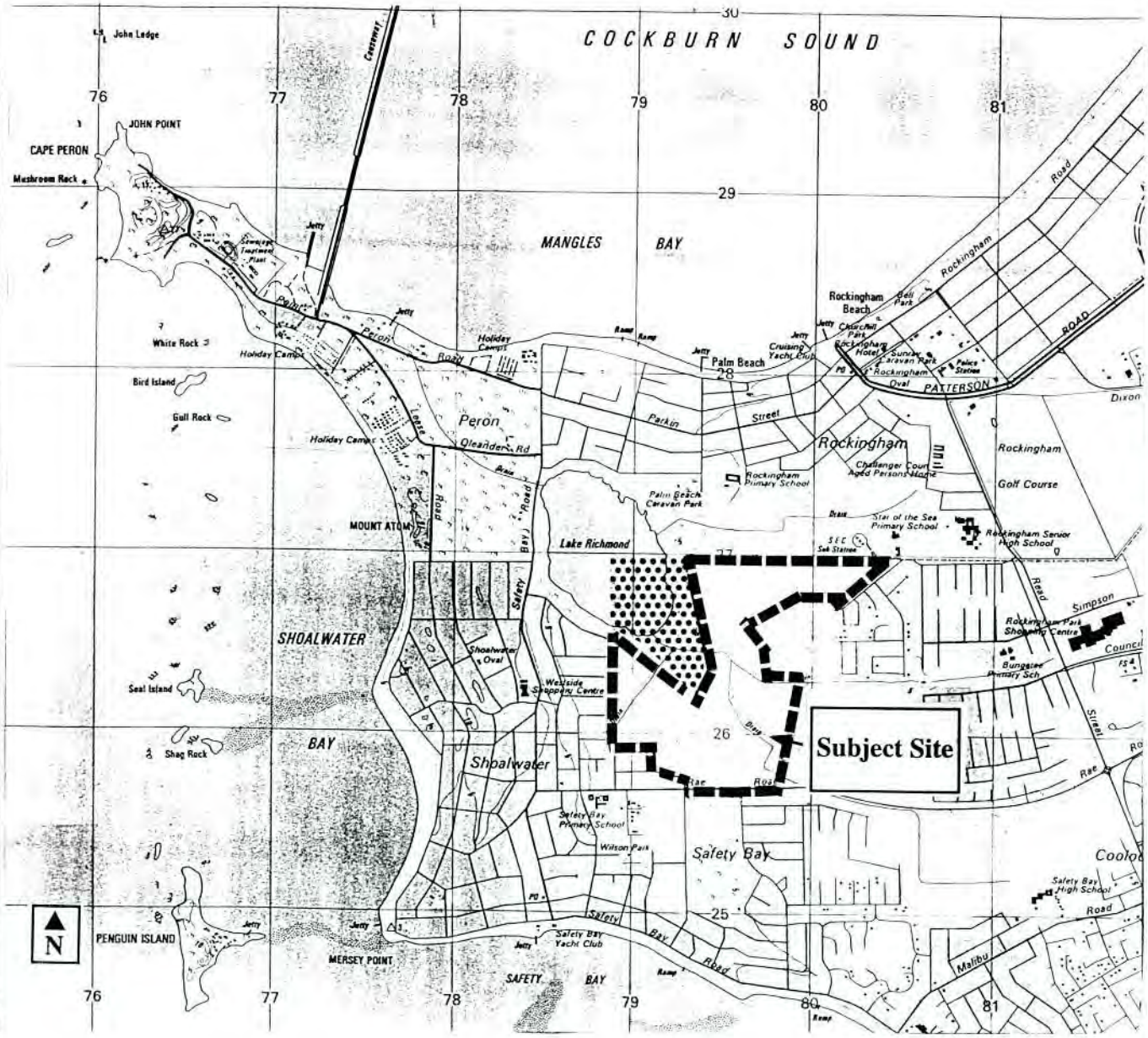

Figure 1

Site Location

Key

Boundary of land proposed for subdivision

Land owned by Allied Land Company Pty Ltd not proposed for development

Scale 1:35,000

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Figure 2

Aerial Photograph of the Subject Site and Lake Richmond

Scale 1:1500

Source: Department of Land and Administration

South Channel
Causeway
John Point
Cape Peron
Point Peron
SU
POINT PERON ROAD
White Rocks
BIRD ISLAND
Gull Rock
Mangles Bay
Rockingham Beach
Palm Beach
ROCKINGHAM ROAD
PATTERSON ROAD
CHALLENGER
ENNIS AVENUE
DIXON ROAD
ROCKINGHAM
PERON ROAD
GARDEN POINT
PARKIN STREET
FISHER STREET
READ STREET
HS
Subject Site
Shoalwater Bay
Shoalwater Bay
MT. ATOM
LAKE
RICHMOND
Beach
SIMPSON AVENUE
COUNCIL AVENUE
HILLMAN
GARDEN ISLAND DRIVE
H
ELANORA DRIVE
SEAL ISLAND
Shag Rock
SHOALWATER
SAFETY BAY ROAD
ISLAND ROAD
CYGNUS STREET
HIGHWAY
ROCKINGHAM GOLF COURSE
COOLOONGUP
ARCADIA DRIVE
RAE STREET
HAWKER ROAD
HS
READ ROAD
GOONGARRI DRIVE
WILLMOTT DRIVE
PENGUIN ISLAND
Mercey Point
MALIBU CHARTHOUSE BAY ROAD
Safety Bay
First Rock
Second Rock
Warnbro Beach
GNANGARA ROAD
WAIKIKI
Warnbro Sound
N

RESERVED LANDS

- PARKS AND RECREATION
- R — RESTRICTED PUBLIC ACCESS
- RAILWAYS
- PORT INSTALLATIONS
- WATERWAYS
- ROADS
  - CONTROLLED ACCESS HIGHWA
  - OTHER MAJOR HIGHWAYS
  - IMPORTANT REGIONAL ROADS
- PUBLIC PURPOSES - DENOTED AS FOLLOWS:
  - H — HOSPITAL
  - HS — HIGH SCHOOL
  - SU — SPECIAL USES

ZONES

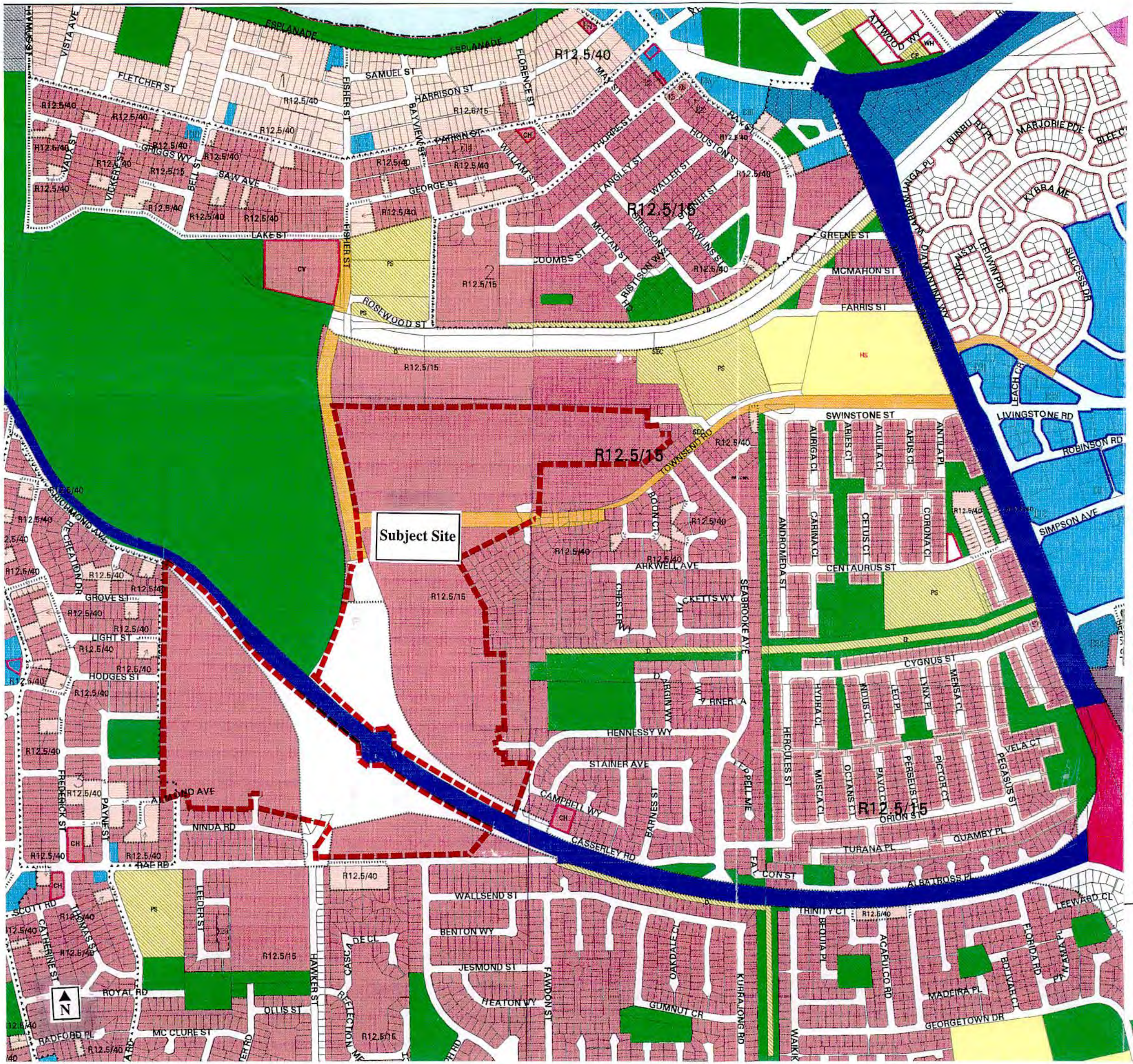
- URBAN
- URBAN DEFERRED
- CENTRAL CITY AREA
- INDUSTRIAL

Figure 3

Metropolitan Region Scheme

Scale 1:25 000

Source: Ministry for Planning



LEGEND

METROPOLITAN REGION SCHEME RESERVES

- PARKS AND RECREATION
  - R — RESTRICTED PUBLIC ACCESS
- RAILWAYS
- PORT INSTALLATIONS
- STATE FORESTS
- WATER CATCHMENTS
- CIVIC AND CULTURAL
- WATERWAYS
- CONTROLLED ACCESS HIGHWAYS
- OTHER MAJOR HIGHWAYS
- IMPORTANT REGIONAL ROADS
- PUBLIC PURPOSES - DENOTED AS FOLLOWS:
  - H — HOSPITAL
  - HS — HIGH SCHOOL
  - TS — TECHNICAL SCHOOL
  - CP — CAR PARK
  - U — UNIVERSITY
  - CG — COMMONWEALTH GOVERNMENT
  - SEC — STATE ENERGY COMMISSION
  - SU — SPECIAL USES
  - WSD — WATER AUTHORITY OF WA
  - P — PRISON

LOCAL SCHEME RESERVES

- LOCAL MAJOR ROADS
- LOCAL RAILWAYS
- LOCAL ROADS
- PUBLIC OPEN SPACE
- PUBLIC PURPOSES
- PUBLIC PURPOSES DENOTED AS FOLLOWS:
  - CH — CHURCH
  - CP — CAR PARK
  - D — DRAIN
  - P — PARKING
  - PS — PRIMARY SCHOOL
- PUBLIC PURPOSES DENOTED AS FOLLOWS:
  - S — SCHOOL SITE
  - SEC — STATE ENERGY COMMISSION
  - WSD — WATER AUTHORITY OF WESTERN AUSTRALIA
- SPECIAL USES
- SPECIAL USES DENOTED AS FOLLOWS:
  - CB — COMMUNITY BUILDINGS
  - CO — COUNCIL OFFICE
  - F — FIRE STATION
  - IHC — INFANT HEALTH CLINIC
  - KG — KINDERGARTEN
  - L — LIBRARY
  - WH — PLACE OF WORSHIP OR HALL

ZONES

- DEVELOPMENT ZONE
- RESIDENTIAL DEFERRED
- RESIDENTIAL SPECIAL
- RESIDENTIAL SPECIAL DENOTED AS FOLLOWS:
  - CH — CHURCH
  - CP — CAR PARK
  - CV — CARAVAN PARK PURPOSES
  - M — MOTEL
- RESIDENTIAL-GR4
- RESIDENTIAL-GR4 RESTRICTED
- RESIDENTIAL-GR5
- RESIDENTIAL-SR3
- RESIDENTIAL SR3 (SPECIAL)
- SPECIAL RESIDENTIAL
- BUSINESS LOCAL
- BUSINESS SPECIAL
- CITY CENTRE
- HOTEL
- MOTEL
- SERVICE COMMERCIAL
- SERVICE STATION
- INDUSTRIAL-SHIPPING INDUSTRY
- INDUSTRY GENERAL
- INDUSTRY LIGHT
- INDUSTRY SERVICE
- RURAL
- SPECIAL RURAL

OTHER

- R CODES (R20)
- ADDITIONAL/RESTRICTED USES (AI/R3)
- SCHEME BOUNDARY
- LGA BOUNDARY
- TWO STOREY HEIGHT LIMIT (SEE SCHEME TEXT) (4)
- SPECIAL RESIDENTIAL AREAS (SEE SCHEME TEXT) (2)
- NO ZONE

VERSION No 1

SCALE 1:10000

Figure 4

City of Rockingham Town Planning Scheme No.1

Scale 1: 10 000

Source: Ministry for Planning

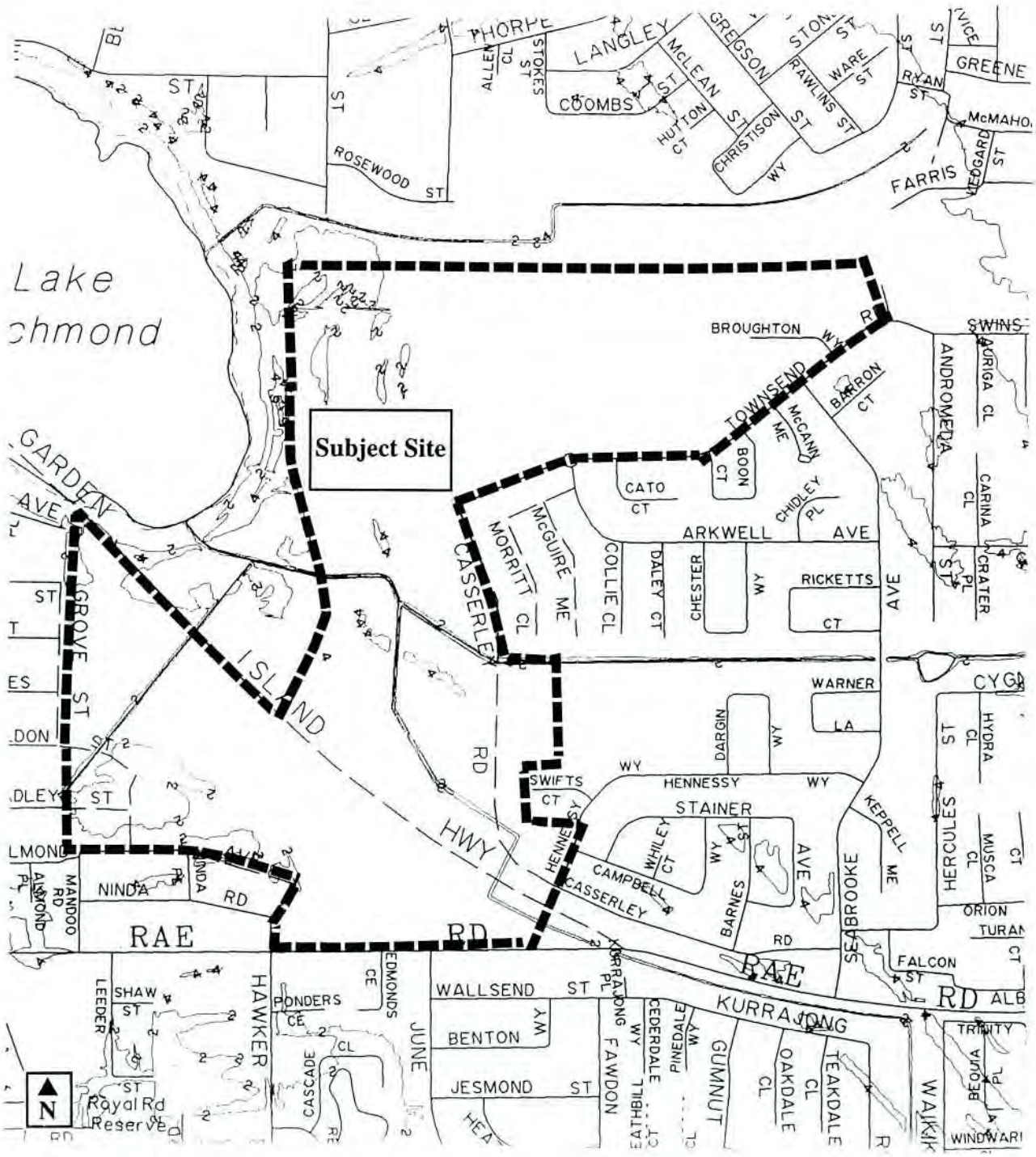


Figure 5

Topography (AHD) of the Site and Surrounding Areas

Scale 1:11 000

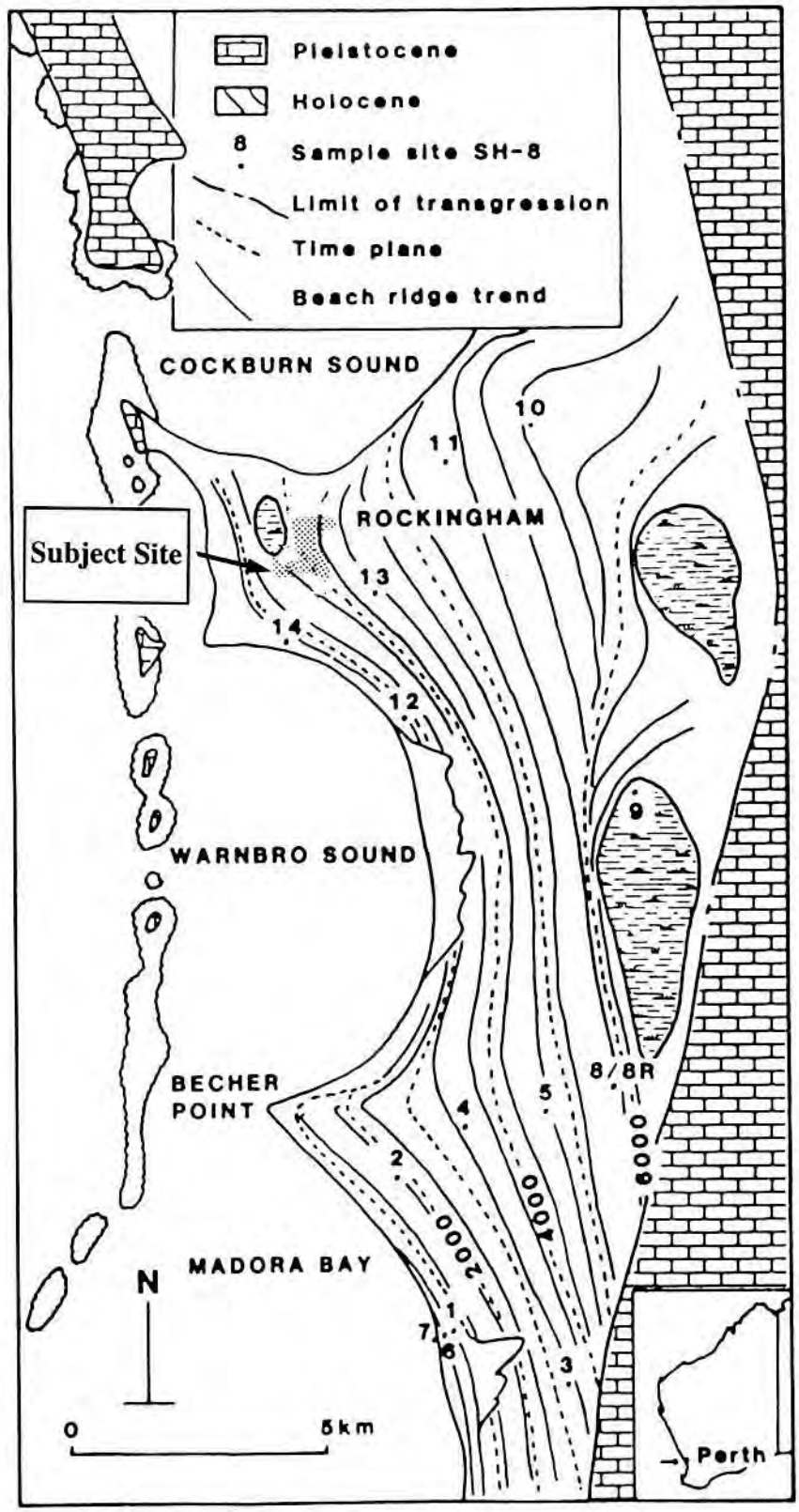
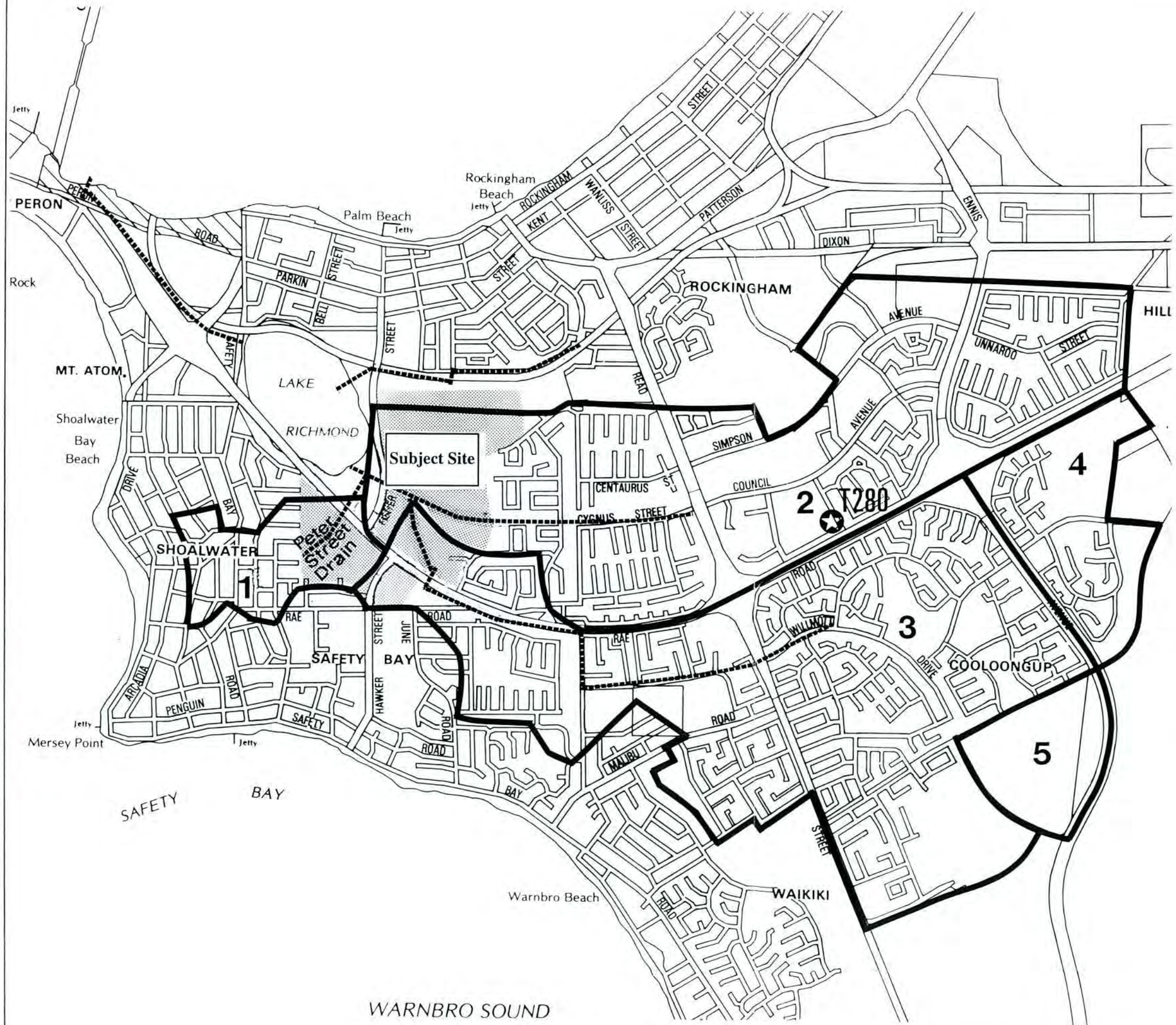


Figure 6

The Becher/Rockingham Beach Ridge Plain Showing Beach Ridge Trends and 1000-year Time Planes.

Scale 1:125 000

Source: Woods and Searle 1983



Catchment	Area
1	78ha
2	465ha
3	559ha
4	111ha
5	50ha

Figure 7

Catchment Boundaries of Water Corporation Drains

Scale 1:35000

Key

Catchment Boundary

Water Corporation Drain

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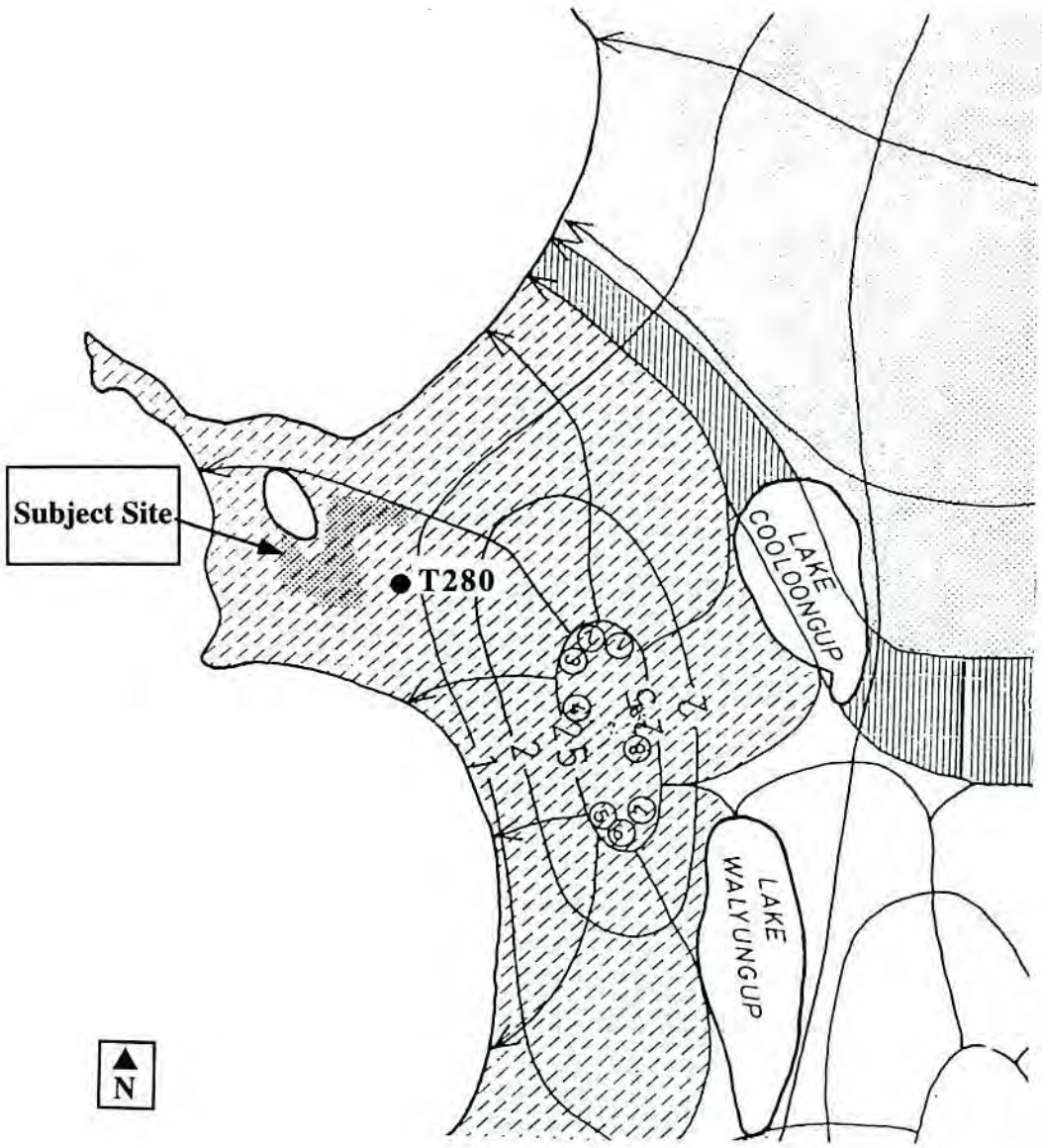


Figure 8

Minimum Groundwater Levels and Direction of Flow for the Safety Bay Mound

Scale 1:70 000

Key:

Average minimum watertable contour ~1~

Modelled flow lines →

Source: Hydrogeology Report. Davidson 1978

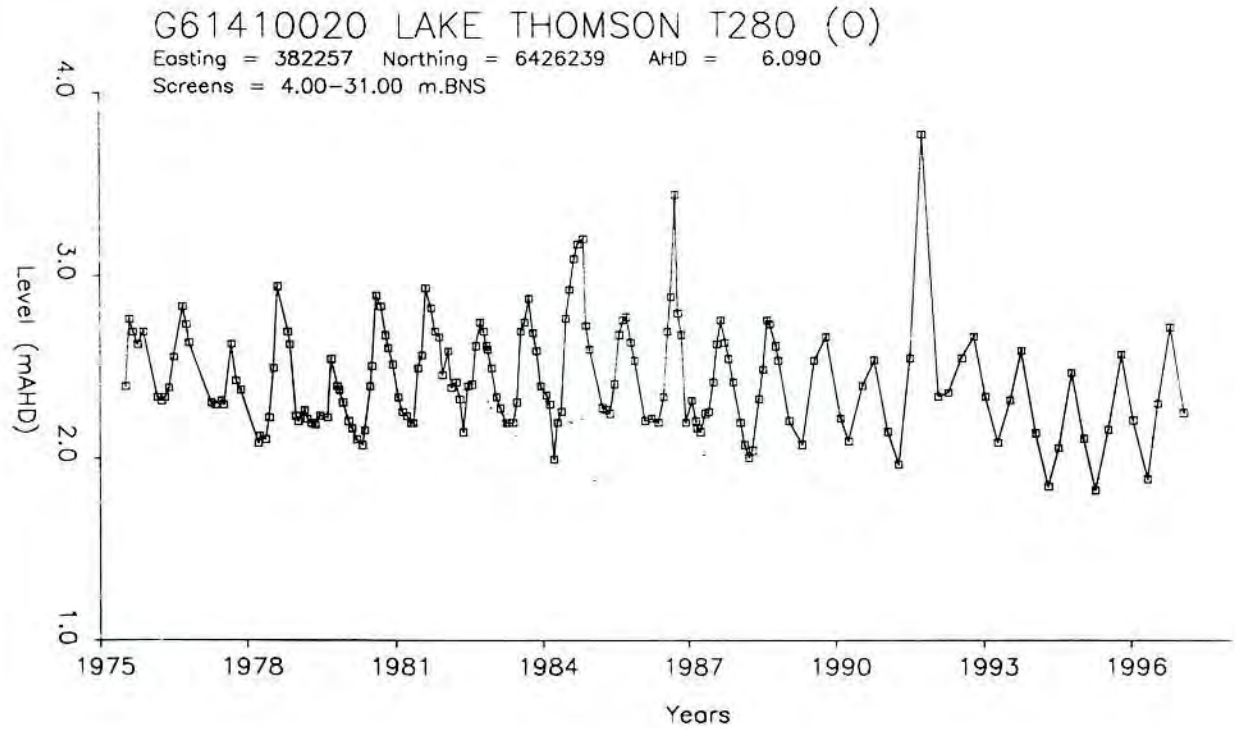


Figure 9

Hydrograph for Monitor Bore T280

Source: Water and Rivers Commission

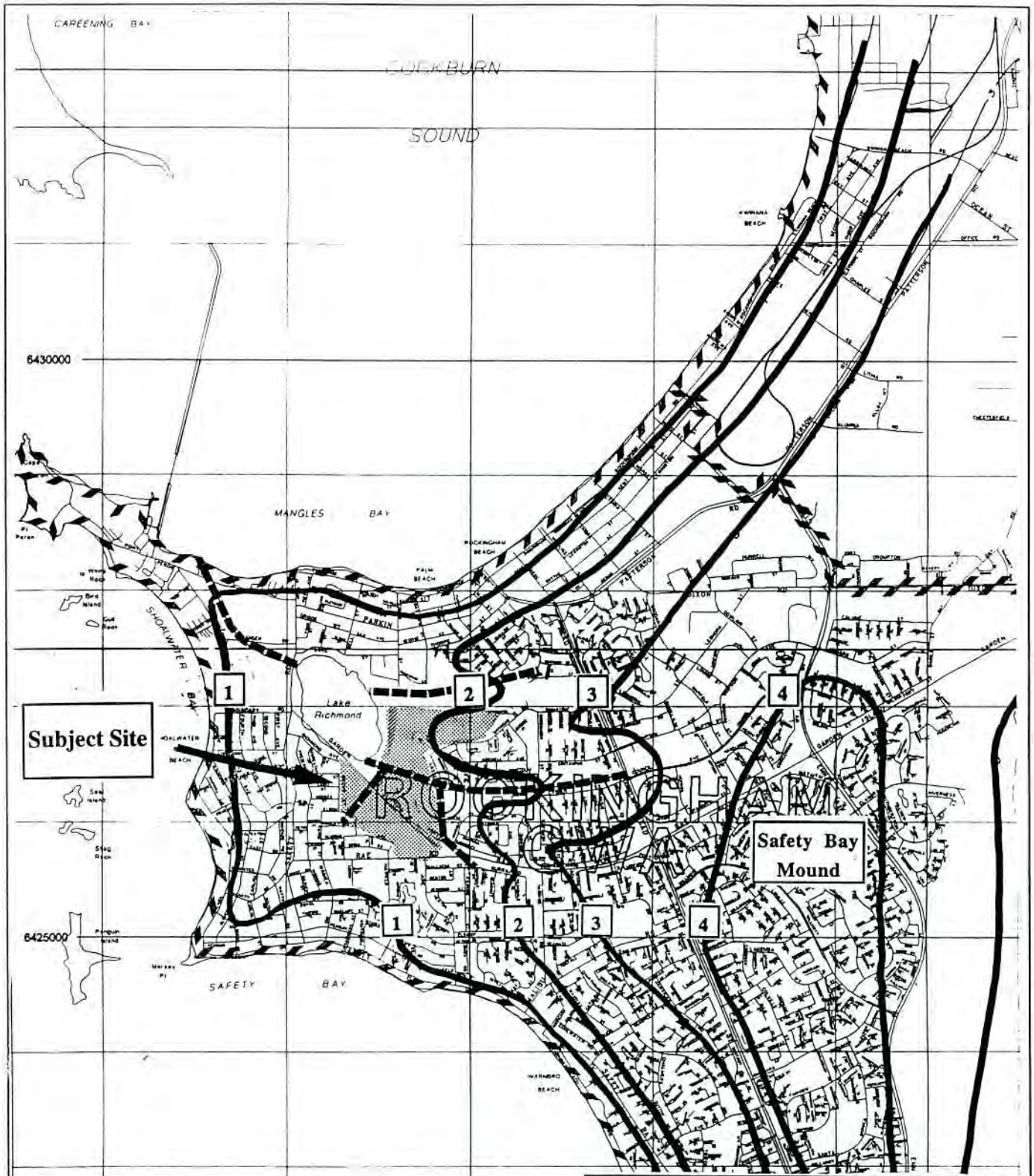


Figure 10

Maximum Water Table Contours for the Safety Bay Mound.

Scale: 1:45 000

Key:

Watertable Contour (m)

Surface Drains

Source: Water and Rivers Commission 1996

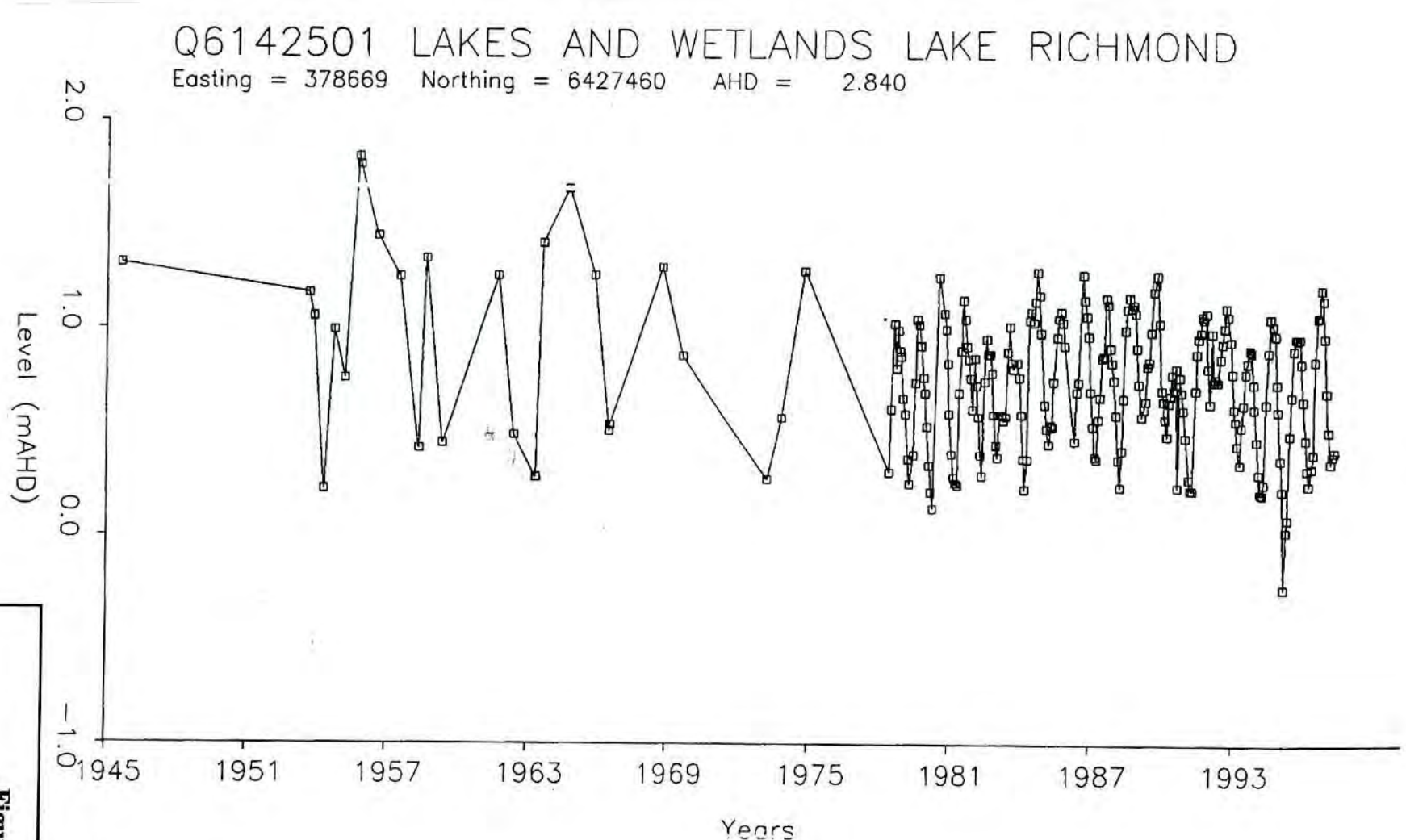


Figure 11

Water Levels in Lake Richmond 1945 to Present

Source: Water and Rivers Commission Database

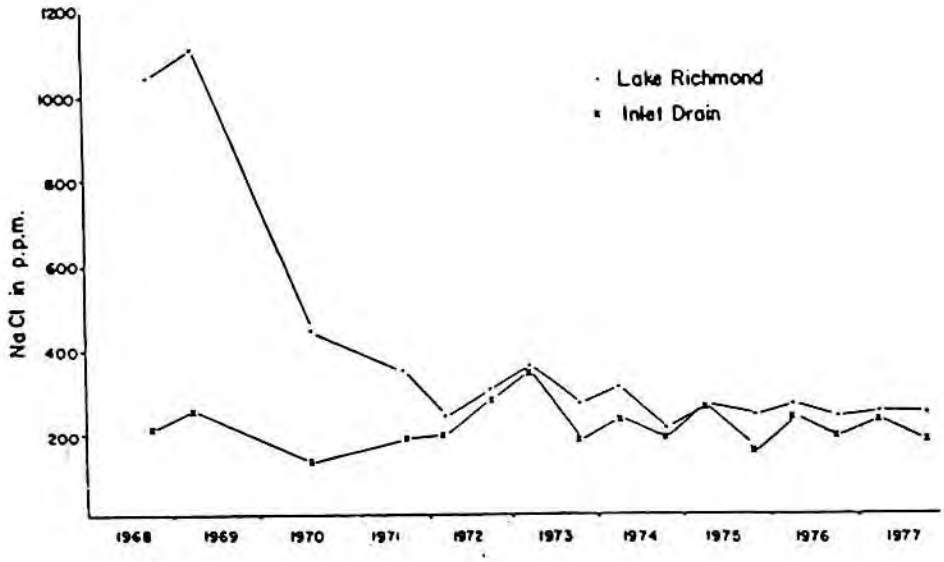
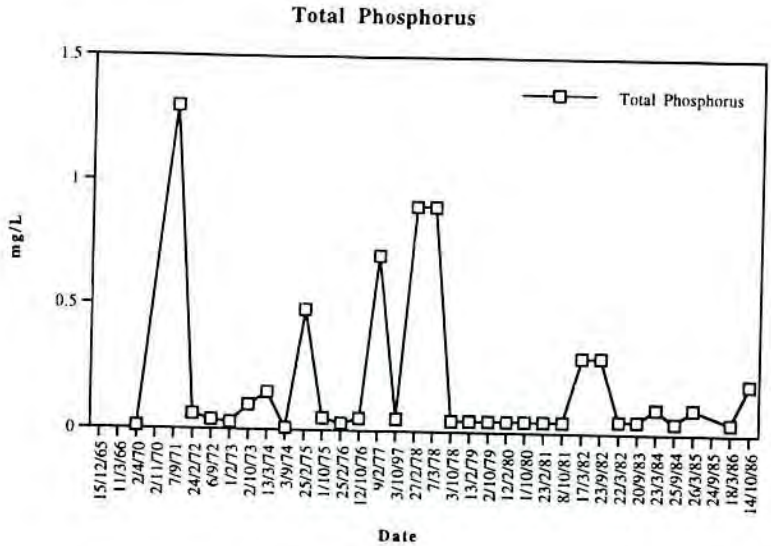


Figure 12

Lake Richmond Salinity Levels

Source: Naturalist News 1987



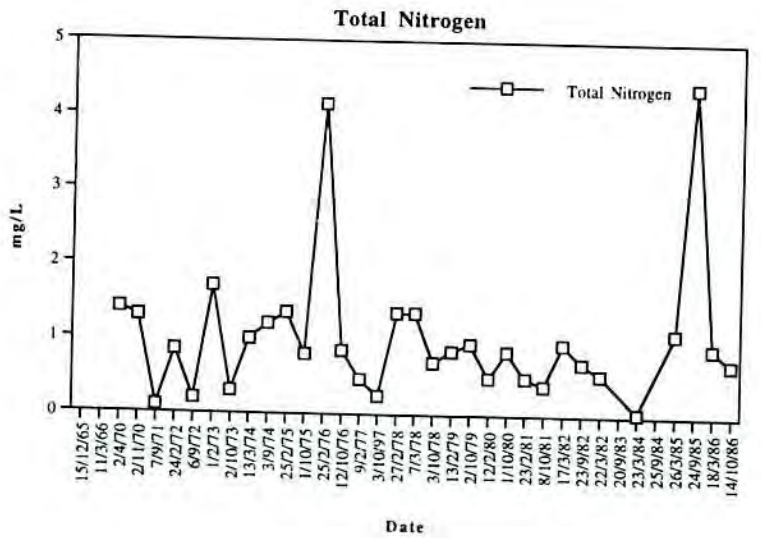


Figure 13

Nutrient Trends in Lake Richmond 1970-1986

Source: Water and Rivers Commission

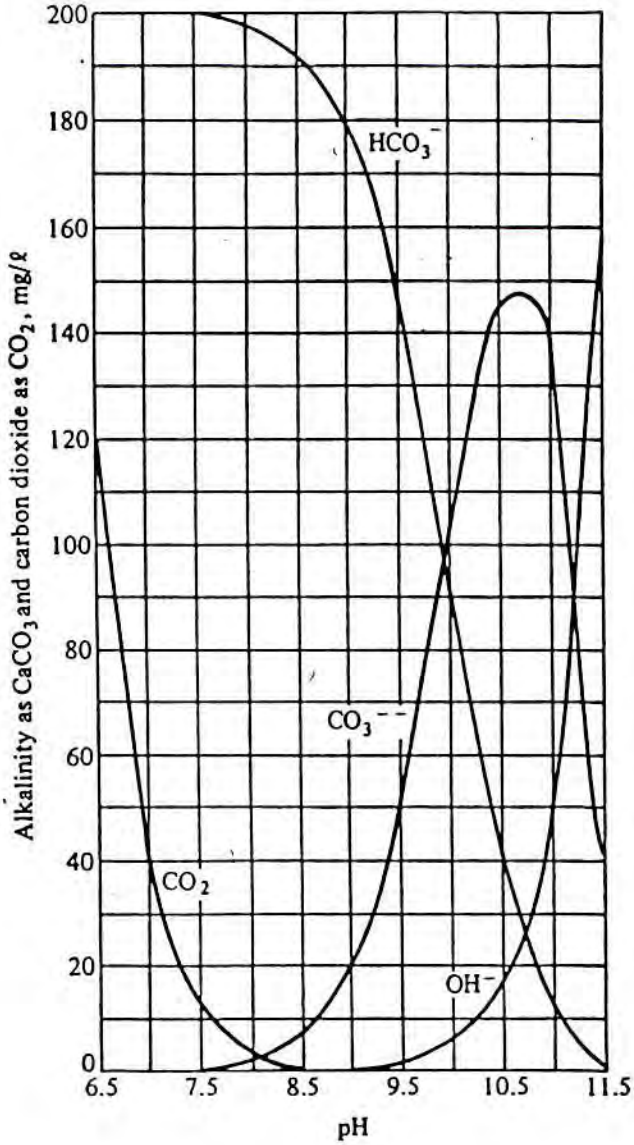
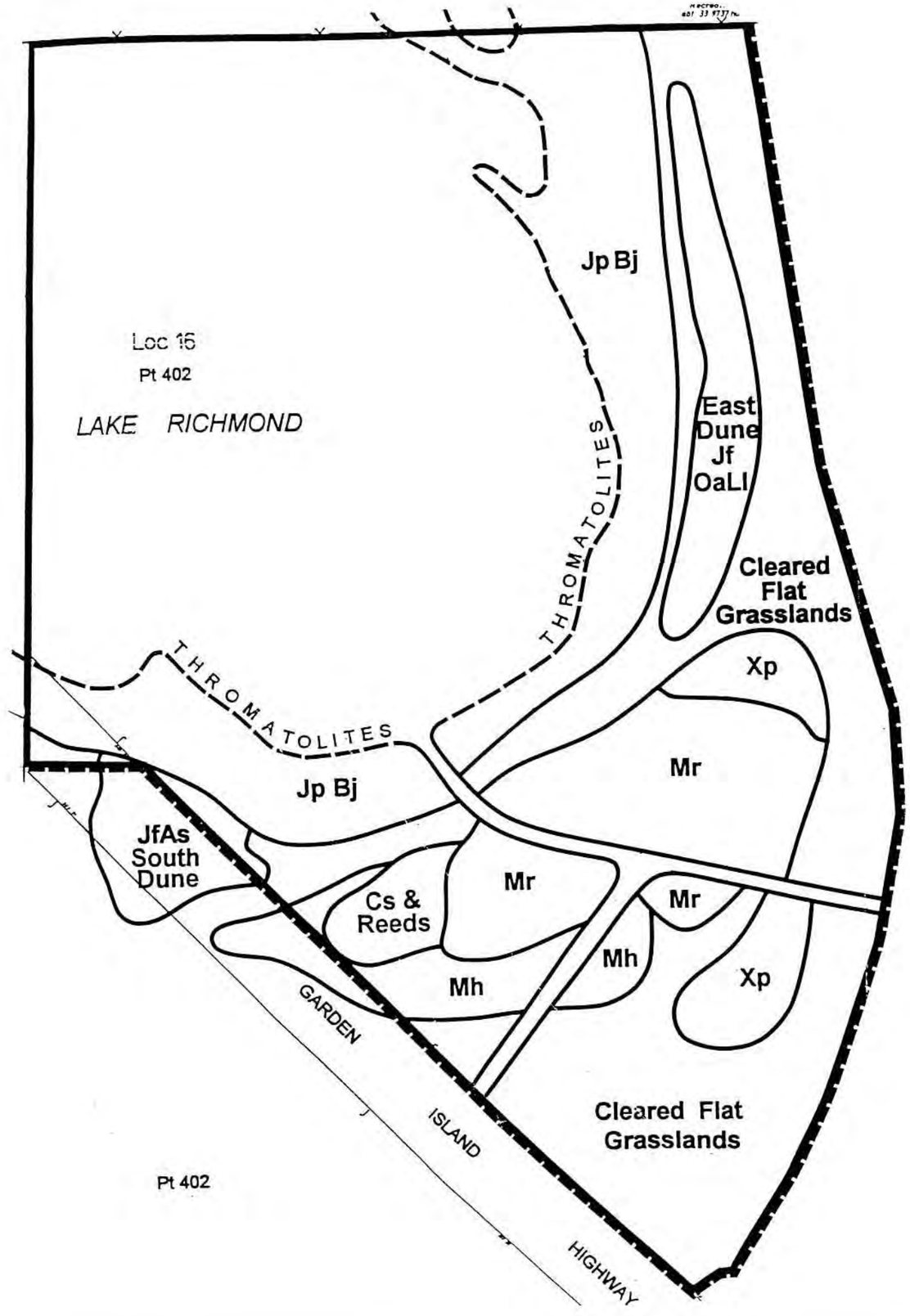


Figure 14

Alkalinity Species and Carbon Dioxide at Various pH Values

Source: Rich 1974



LEGEND

———	Subject Land
- - - -	Foreshore Reserve Boundary
Mr	*Melaleuca rhaphiophylla*
Mh	*Melaleuca huegelii*
Jp Bj	*Juncus pallidus* and *Baumea juncea* Rush/Sedgeland Sedge Land
Jf As	*Jacksonia furcellata* and *Acacia saligna* Southern Dune
Cs	Pampas Grass *Cortaderia selloana* Damp Low Lying Area
Xp	*Xanthorrhoea preissii* Open Area
JFOaLl	*Jacksonia furcellata, Olearia axillaris* and *Leptospermum laevigatum* Eastern Dune

N

metres

0 100

SCALE 1:3,000

Loc 16
Pt 402

Figure 15

Vegetation Surrounding Lake Richmond

Scale 1:3000

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PROPOSED ALTERNATIVE
DEVELOPMENT PLAN
CAPE PERON ESTATE
ROCKINGHAM

0 100 Metres

SCALE 1:5000

N

3 Metre P.A.W.

Drainage Facility

2799

4536

2.6291 ha

1.7912 ha

4319

5290

GARDEN ISLAND HIGHWAY

ROCKINGHAM RD

ROCKINGHAM REGIMENT RD

Figure 16

Proposed Development Plan

Scale 1:5000

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

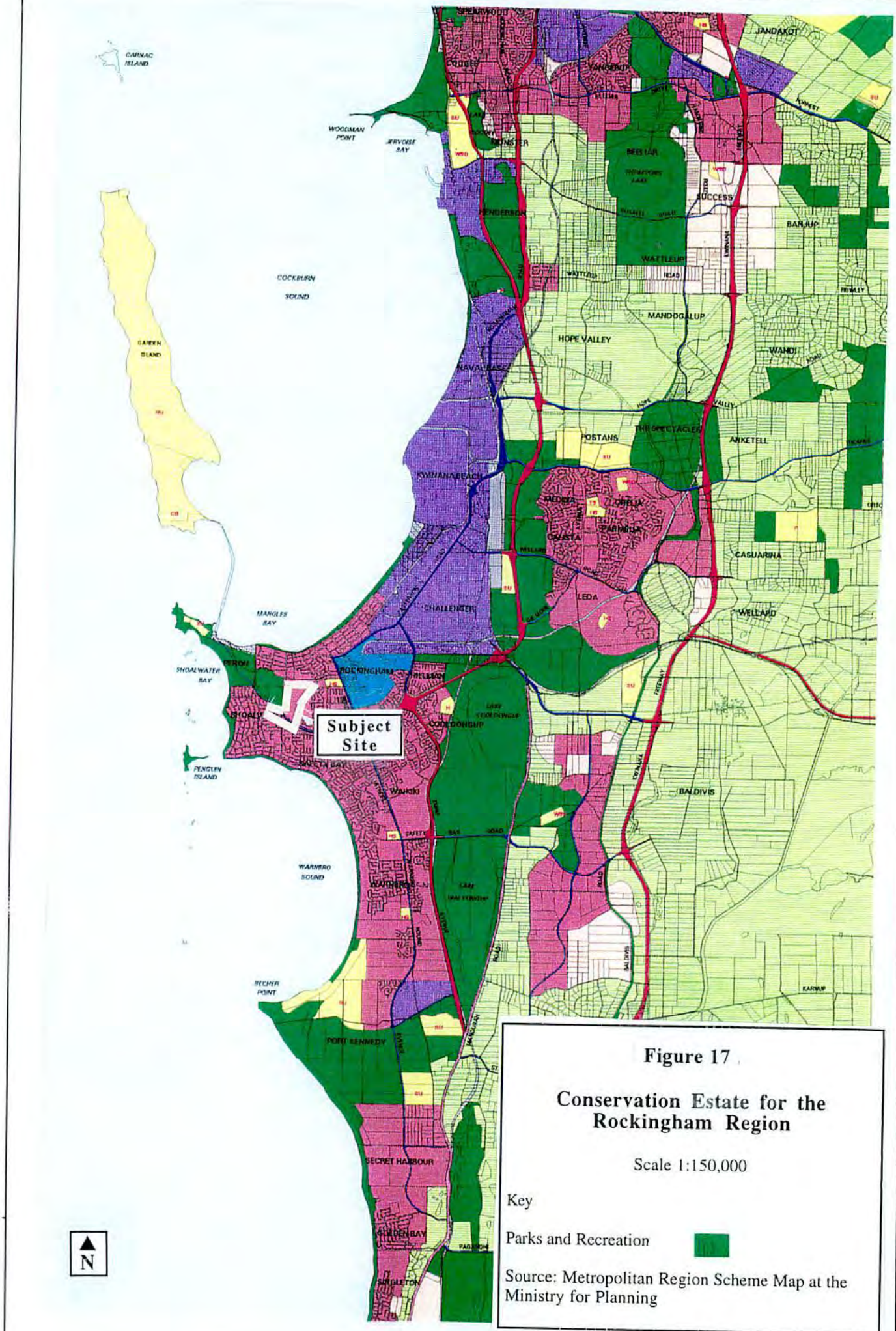
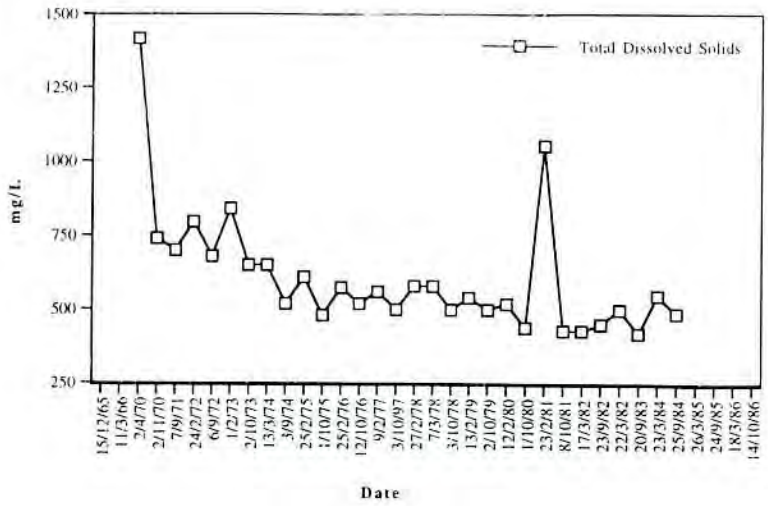


Figure 17

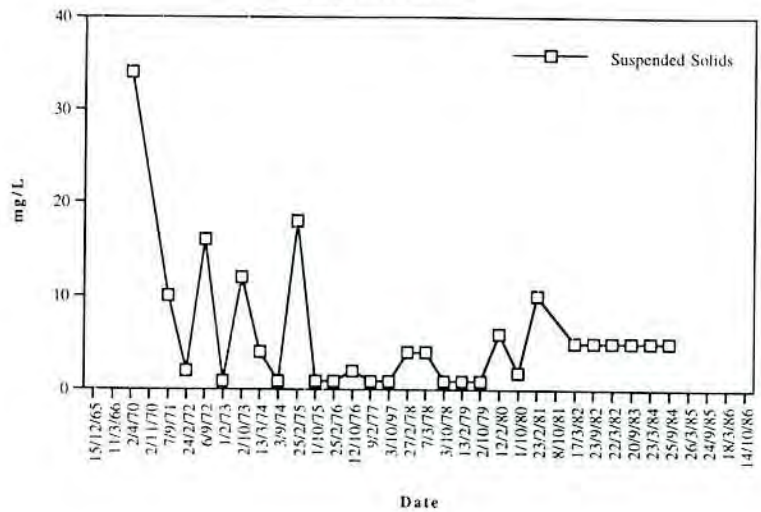
Conservation Estate for the Rockingham Region

Scale 1:150,000

Total Dissolved Solids



Suspended Solids



pH

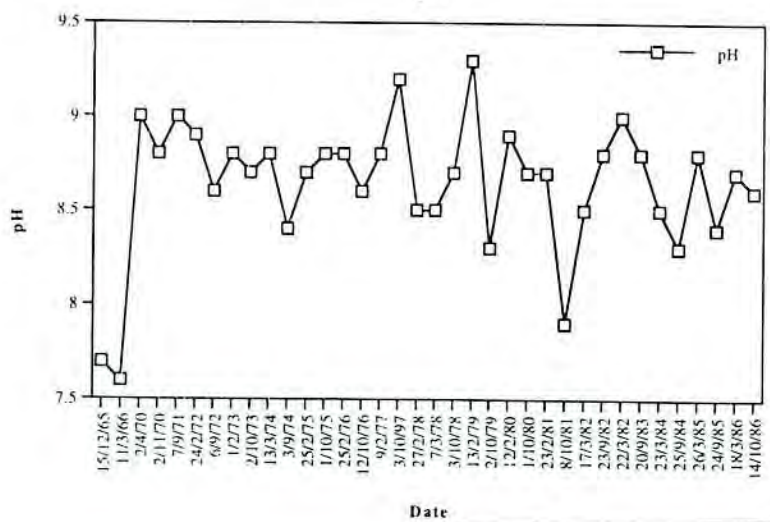


Figure 18

Water Quality Trends in Lake Richmond 1970-1986

Source: Water and Rivers Commission

APPENDIX A

CER Guidelines

Environmental Protection Authority

RESIDENTIAL/COMMERCIAL SUBDIVISION, PT LOT 402 RAE ROAD, COCKBURN SOUND LOCATION 16, ROCKINGHAM (Assess No. 1077).

CONSULTATIVE ENVIRONMENTAL REVIEW GUIDELINES

1.0 Overview

Allied Land Company Pty Ltd proposes to subdivide the above land into 1035 residential lots at R15, 86 group dwelling lots at R40 and three commercial lots identified as service station, retail and other commercial, with a total area of 2.14 ha. Pt Lot 402 includes the south east corner of Lake Richmond, which is zoned Parks and Recreation with the balance either Urban or Important Regional Road (Garden Island Expressway). Lake Richmond has been placed on the Register of the National Estate Database. The lake and surrounding area, Reserves C9458 and C33659, have legal and administrative status of a Registered Heritage site with the Australian Heritage Commission. The Lake is a flora and fauna reserve and was also identified in the System Six Report (Area M102) and has been included in the System Six Update. Lake Richmond also supports a well developed microbialite (thrombolite) community which has recently been identified by CALM as a Threatened Ecological Community. The Environmental Protection Authority (EPA) has required a Consultative Environmental Review (CER) be prepared to identify and manage the potential environmental impacts from the proposal.

All environmental reviews have the objective of protecting the environment, and environmental impact assessment is deliberately a public process in order to obtain broad ranging advice. The review requires the proponent to describe the proposal, receiving environment, potential environmental impacts and the management of the issues arising from the environmental impacts, so that the environment is protected to an acceptable level.

Throughout the assessment process the EPA aims to help the proponent to improve the proposal so the environment is protected. The DEP, on behalf of the EPA, coordinates advice from relevant government agencies and the public about environmental matters during the assessment of the proposal.

The primary purpose of the CER is to provide information on the proposal to the EPA within the regional framework. The aim of this document is to emphasise those relevant environmental factors which have the potential to impact on the physical and biological environment.

2.0 Objectives of the CER

The objectives of the CER are to:

- adequately describe all components of the proposal, so that the Minister for the Environment can consider approval of a well-defined project;
- provide the basis of the proponent's environmental management program, which shows that the environmental issues resulting from the proposal can be managed; and
- communicate clearly with the public (including government agencies), so that the EPA can have informed public comment to help in providing advice to government.

3.0 Contents of the CER

The fundamental contents of the CER should include:

- a brief introduction of the proponent, the project and location. A map/plan, which both clearly indicates the nature and extent of the initial project and the works proposed, and a regional map should also be included which identifies the proposal within a social and regional setting;
- a summary table which clearly presents the characteristics of the proposal;
- details of decision making authorities and involved agencies;
- reference to the description of the receiving environment which may be impacted, including the marine environment;
- discussion of the relevant environmental factors;
- discussion of the management of the factors raised including commitments to appropriate action;
- a description and summary of an environmental management program, including the key commitments, monitoring work and the auditing of the program which will provide the basis for ensuring the operation of the site in an acceptable manner.

The language used in the body of the CER should be kept simple and concise, considering the audience includes non-technical people, and any extensive, technical detail should either be referenced or appended to the CER. The CER will form the legal basis of the Minister for the Environment's approval of the proposal and, hence, should include a description of all the main and ancillary components of the proposal, including options if necessary.

The CER should be well referenced and contain a bibliography. Statements of fact and conclusions should be supported by references or evidence contained within the CER. A glossary should be provided in which all technical terms, and unfamiliar abbreviations and units of measurement are explained in simple language. Where detailed technical or supporting documentation is required, this should be placed in appendices.

4.0 Environmental Management

The EPA considers that the proponent should approach environmental management of the proposal in terms of best practise. Best practice environmental management includes:

- an overall objective to reduce as far as practicable potential impacts on the environment;
- development of an environmental policy;
- agreed environmental objectives;
- management of environmental objectives;
- involving the public as appropriate;
- audit performance against agreed indicators;
- regular reporting to the EPA (or nominated agency); and
- commitment to a quality assured management system and continuous improvement.

Factors can be determined from a consideration, called scoping, of the potential impacts from the various components of the proposal on the receiving environment, including people. Relevant

environmental factors are those which have the potential to have significant environmental impacts and accordingly may require the EPA to report on to the Minister for the Environment. The CER should focus on these relevant factors for the proposal, as have been identified in consultation with the EPA and relevant public and government agencies.

A description of the project component and the receiving environment should be referenced to the discussion of the factor. The technical basis for measuring the impact and any objectives or standards for assessing and managing each factor should be provided.

The EPA considers that the proponent should provide, within the body of the document, a table which describes the potential environmental impacts, with regards to the relevant environmental factors (those upon which the EPA is likely to report on to the Minister for the Environment). The following elements should be addressed in the table:

(a) identification of the characteristics of the proposal;

(b) nominated environmental management objectives(s) for those aspects which require management;

(c) description of the existing environment;

(d) potential impacts of the proposal on the environment;

(e) environmental management response or commitment to manage impacts to meet the above objective(s); and

(f) likely impact of application of this response.

The factors from which the key environmental factors are derived (and their corresponding objectives) at this stage should be set out under the following categories :

- biophysical;
- pollution; and
- social surroundings.

A range of factors identified and the EPA's management objective for these factors have been listed in Attachment 1. The following list are the key preliminary environmental factors that the EPA have identified in this assessment:

Further key environmental factors may be identified during the preparation of the CER, and on-going consultation with the EPA and relevant agencies is recommended. Minor issues which can be readily managed as part of normal operations for similar projects may be briefly described. Information used to reach conclusions should be properly referenced, including personal communications. Assessments of the significance of an impact should be soundly based and the assessment should lead to a discussion of the management of the issue.

5.0 Specific Issues

In discussing the environmental factors, the CER should cover, but not be limited to the specific issues listed below:

1. The appropriateness of the Parks and Recreation reservation as a satisfactory ecological buffer for Lake Richmond.

2. Local geology and hydrogeology

3. Thrombolites
   - biological status;
   - physical fragility;
   - light requirements

- water quality tolerance; and
- carbonate and bicarbonate requirements.

4. Lake Richmond
   - nutrient status and loads;
   - physical characteristics - depth, salinity, stratification (temperature, oxygen, pH and salinity), light penetration and turbidity;
   - salinity status (current and historic);
   - carbonate and bicarbonate status; and
   - carbonate and bicarbonate flows (surface water, sediments and ground water).

   Synthesise information and relate to the ecology of the thrombolites, flora and fauna, and the implications and impacts associated with the proposal.

5. Water quantity (salinity impacts on Lake Richmond)

   The relationship between increased water flow to Richmond Lake via the proposal and the associated impact this may have on overall Lake salinity and hence ecology of thrombolites, in particular and flora and fauna.

6. Ground water flows of carbonate and bicarbonate

   Assess the importance of ground water flows in carrying carbonate and bicarbonate ions to the Lake sediments and water column and hence supporting the Thrombolites.

7. Drainage management

   Address and detail how the local drainage system and urban design is consistent with 'best planning practices' associated with Water Sensitive Urban Design ("Planning & Management Guidelines for Water Sensitive Urban (Residential) Design", DPUD, WAWA, and EPA, June 1994).

8. Waste water

   Address the impact of emergency waste water overflows from any proposed pump station for the proposal into the main drain and consequently Lake Richmond. Pump stations should meet DEP draft guidelines, Contact Harvey Johnstone 222 7161.

9. Undertake an Aboriginal site survey

6.0 Public Consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the CER. It should describe the activities undertaken, the dates, the groups/individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management of the issues which should clearly indicate how community concerns have been addressed. Those concerns which are dealt with outside the EPA process can be noted and referenced.

7.0 Environmental Management Commitments

The method of implementation of the proposal and all commitments made by the proponent in the CER will become *legally enforceable* under the environmental conditions of the Minister for the Environment's approval. Specific commitments to protect the environment, typically related to the key issues, should be separately listed, numbered and take the form of:

- who would do the work;
- what the work is;
- when and where the work would be carried out; and

- what agencies would be involved.

These key commitments show that the proponent is committed to actionable and auditable management of the environmental issues.

Other commitments show that the proponent is dedicated to good environmental management of the project, and the EPA expects that the proponent will audit these commitments by internal processes under an Environmental Management System. The commitments define the goals/objectives for the environmental management program and procedures (the details of how the commitment will be met), which should be described in as much detail as possible. The EPA acknowledges that, with the implementation of best practice and continuous improvement for the project, the procedures may need to be modified, or added to, in regular updates to the environmental management program.

An example of a typical commitment is:

Issue	Objective	Commitment	Timing (Phase)	Whose requirements	Specification (Performance Indicator)
EMP	Implement effective EMP	Develop and implement an effective EMP	Pre-construction and on-going	EPA	EMP developed and implemented to requirements of EPA.

Attachment 1

RESIDENTIAL/COMMERCIAL SUBDIVISION, PT LOT 402 RAE ROAD, COCKBURN SOUND LOCATION 16, ROCKINGHAM, ASSESS NO. 1077

CONSULTATIVE ENVIRONMENTAL REVIEW GUIDELINES

Preliminary Environmental Factors	EPA Objectives	EPA Evaluation Framework/Policy
BIOPHYSICAL IMPACTS		
Vegetation in existing conservation estate	Vegetation in the existing and proposed conservation estate is not adversely impacted.	The EPA considers there should be representative land systems set aside for the conservation of flora and fauna.
Fauna and habitat in existing conservation estate	Fauna and habitat in the existing and proposed conservation estate is not adversely impacted.	Where the proposal could impact on the habitat or behaviour of regionally significant fauna, those impacts should be reduced as far as practicable.
Declared rare fauna	Protect Threatened Fauna and Priority fauna species, and their habitats consistent with the provisions of the Wildlife Conservation Act 1950.	To meet the requirements of the Wildlife Conservation Act 1950.
Wetlands	Wetlands are protected and key ecological functions are maintained. Maintain or improve ground water and surface water quality flowing into the lake.	Wetlands identified in Bulletin 685 should be protected and have their ecological function maintained. Where there is a loss of a wetland then the functions lost should be replaced elsewhere.
Thrombolites	Ensure Thrombolite survival and growth is not adversely impacted by: • maintaining or improving the existing quantity and quality of ground water and surface water flows into the lake; and • preventing physical impacts (eg. crushing).	
SOCIAL SURROUNDINGS		
Heritage (Indigenous and non-indigenous cultures)	Comply with statutory requirements in relation to areas of cultural or historical significance.	To comply with the appropriate acts.

APPENDIX B

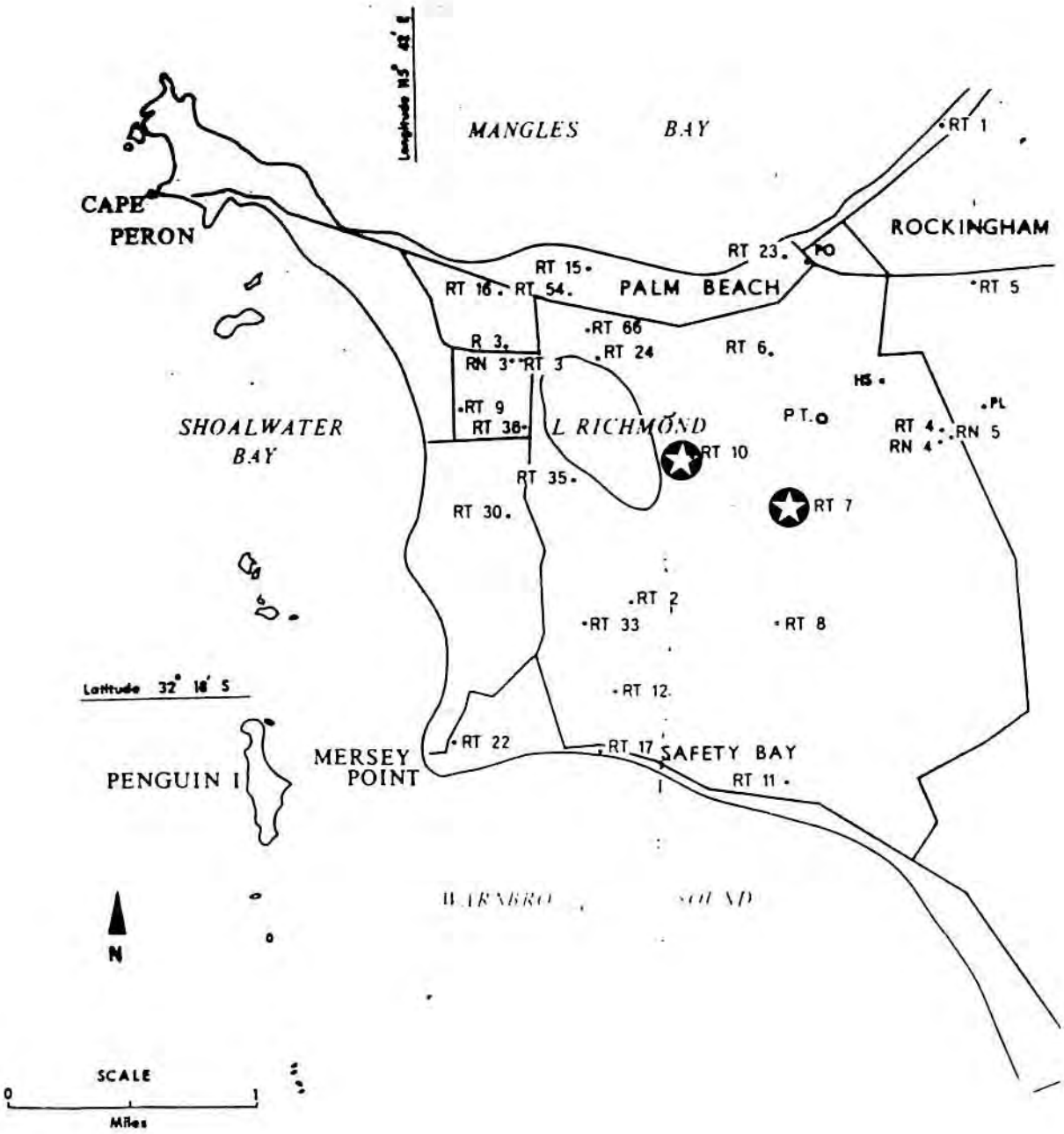
Groundwater Quality Records

Groundwater Data for Bores RT7 and RT10.
Source: Passmore 1967
See Accompanying Map for Bore Locations

Parameter	Date	Bore RT7	Bore RT10
pH	8.7.65	7.6	8.05
Salinity ppm.	8.7.65	760	300
Ca^{2+}	8.7.65	96	68
HCO_{3-}	8.7.65	329	219
pH	21.9.65	7.55	7.8
Salinity ppm.	21.9.65	710	340
Ca^{2+}	21.9.65	96	92
HCO_{3-}	21.9.65	366	213
pH	11.3.66	7.56	7.75
Salinity ppm.	11.3.66	810	480
Ca^{2+}	11.3.66	96	72
HCO_{3-}	11.3.66	372	237

Bore T280 Water Quality (1975)
Source: Water and Rivers Commission
See Figure 7 for Bore Location

Date	pH	TDS mg/L	CL mg/L	$CaCO_3$ mg/L	$C0_3$ mg/L	HCO_3 mg/L	N	Total P mg/L	Na mg/L	Ca mg/L	S mg/L	TSS mg/L
26/06/75	8.0	380	110	-	-	-	-	-	-	-	-	-
01/08/97	7.6	540	130	-	-	-	-	-	-	-	-	-
07/08/75	7.6	540	130	-	-	-	-	-	-	-	-	-
16/09/75	7.6	540	120	321	-	-	-	-	-	54	-	-
08/07/80	6.8	500	101	319	0	390	0.2	0.07	66	50	26	<695
06/04/87	7.9	-	82	312	<2	381	0.22	0.05	56	52	33	<671



Location of Bores RT7 and RT10

Source: Passmore 1967

APPENDIX C

CALM DRF Search Record

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

HEAD OFFICE
HACKETT DRIVE CRAWLEY
WESTERN AUSTRALIA
Phone (09) 442 0300
Facsimile (09) 386 1578

STATE OPERATIONS HEADQUARTERS
50 HAYMAN ROAD COMO
WESTERN AUSTRALIA
Phone (09) 334 0333
Facsimile (09) 334 0466
Teletype (09) 344 0546

Please address all correspondence to Executive Director, P.O. Box 104, COMO W.A. 6152

Your Ref: 036719F0801
Our Ref: Peter Mawson
Enquiries: 09 3340421
Phone:

Mr H. Rolls
Bowman Bishaw Gorham
Po Box 946
WEST PERTH WA 6872

Dear Mr Rolls

REQUEST FOR THREATENED FAUNA INFORMATION

I refer to your request of 20 December for information on threatened fauna in the Rockingham area.

A search was undertaken for this area of the Department's Threatened Fauna database, which includes species which are declared as '*Rare or likely to become extinct* (Schedule 1)', '*Birds protected under an international agreement* (Schedule 3)', and '*Other specially protected fauna* (Schedule 4)'. Attached are print outs from these databases where records were found.

Attached also are the conditions under which this information has been supplied. Your attention is specifically drawn to the sixth point which refers to the requirement to undertake field investigations for the accurate determination of threatened fauna occurrence at a site. The information supplied should be regarded as an indication only of the threatened fauna that may be present.

An invoice for $50.00, being the set charge for the supply of this information, will be forwarded.

It would be appreciated if any populations of threatened fauna encountered by you in the area could be reported to this Department to ensure their ongoing management.

If you require any further details, or wish to discuss threatened fauna management, please contact my Senior Zoologist, Mr Peter Mawson on 09 3340421.

Yours faithfully

for Syd Shea
EXECUTIVE DIRECTOR

17 January, 1996

Attachment

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

THREATENED FAUNA INFORMATION

Conditions In Respect Of Supply Of Information

* All requests for data to be made in writing to the Executive Director, Department of Conservation and Land Management, Attention: Senior Zoologist, Wildlife Branch.

* The data supplied may not be supplied to other organisations, nor be used for any purpose other than for the project for which they have been provided without the prior consent of the Executive Director, Department of Conservation and Land Management.

* Specific locality information for Threatened Fauna is regarded as confidential, and should be treated as such by receiving organisations. Specific locality information for Threatened Fauna may not be used in reports without the written permission of the Executive Director, Department of Conservation and Land Management. Reports may only show generalised locations or, where necessary, show specific locations without identifying species. The Senior Zoologist is to be contacted for guidance on the presentation of Threatened Fauna information.

* Receiving organisations should note that while every effort has been made to prevent errors and omissions in the data, they may be present. The Department of Conservation and land Management accepts no responsibility for this.

* Receiving organisations must also recognise that the database is subject to continual updating and amendment, and such considerations should be taken into account by the user.

* It should be noted that the supplied data do not necessarily represent a comprehensive listing of the Threatened Fauna of the area in question. Its comprehensiveness is dependent of the amount of survey carried out within a specified area. The receiving organisation should employ a biologist/zoologist, if required, to undertake a survey of the area under consideration.

* Acknowledgment of the Department of Conservation and Land Management as the source of data is to be made in any published material. Copies of all such publications are to be forwarded to the Department of Conservation and Land Management, Attention; Senior Zoologist, Wildlife Branch.

The search of the database indicated that no threatened fauna have been recorded the area you have indicated. However, given the habitat in the area it is possible that the following species of 'Specially Protected' fauna may be infrequent visitors to the area in question.

Schedule 4 Taxa (Specially Protected Fauna)

Carnaby's cockatoo (*Calyptorhynchus latirostris*) is a visitor to the coastal areas in the summer and autumn months, where it feeds on remnant vegetation. It does not nest in the area.

Perergrine Falcon (*Falco peregrinus*) is an uncommon visitor to the west coast, but may be attracted to the area by the presenceof feral pigeons and the two species of introduced doves (*Streptopelia* sp.) which are associated with urban ares and the Kwinana grain terminal.

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

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Teletype (09) 344 0546

Please address all correspondence to Executive Director, P.O. Box 104, COMO W.A. 6152

Your Ref:
Our Ref: 037751F0216
Enquiries: Dr Atkins
Phone: 09 3340425

Mr Steve Rolls
Bowman Bishaw Gorham
PO Box 946
WEST PERTH WA 6872

Dear Mr Rolls

REQUEST FOR RARE FLORA INFORMATION

I refer to your request of 20 December 1995 for information on rare flora in the Rockingham area.

A search was undertaken for this area of the Department's Declared Rare Flora database, the Priority Species List (species that are declared rare [R, or X for those presumed to be extinct], poorly known [1 - 3], or require monitoring [4]), and the WA Herbarium specimen database for priority species collected in that area. Attached are printouts from these databases where records were found.

Attached also are the conditions under which this information has been supplied. Your attention is specifically drawn to the sixth point which refers to the requirement to undertake field investigations for the accurate determination of rare flora occurrence at a site. The information supplied should be regarded as an indication only of the rare flora that may be present.

An invoice for $90, being the set charge for the supply of this information, will be forwarded.

It would be appreciated if any populations of rare flora encountered by you in the area could be reported to this Department to ensure their ongoing management.

If you require any further details, or wish to discuss rare flora management, please contact my Senior Botanist, Dr Ken Atkins on 09 3340425.

Yours faithfully

Brenda Moran

.....
for Syd Shea
EXECUTIVE DIRECTOR

21 December, 1995

WAHERB SPECIMEN DATABASE
GENERAL ENQUIRY

Platysace filiformis (Bunge) Norman (Apiaceae)
CONSERVATION STATUS: P2
Coll.: R.J. Cranfield 1180/80 Date: 16 01 1980 (PERTH 03542688)
Locality: Hope Valley
Lat.: 32^ 12' S Long.: 115^ 46' E
Spindly spreading shrub, 30 cm high. Flowers white. Grey sand.
Previous det.: Platysace compressa (Labill.) Norman

Rhodanthe pyrethrum (Steetz) Paul G. Wilson (Asteraceae)
CONSERVATION STATUS: P3
Coll.: G.J. Keighery 13343 Date: 03 11 1994 (PERTH 04103904)
Locality: Wellard Road Nature Reserve, NW of Harvey
Lat.: 32^ 16' S Long.: 115^ 49' E
Annual herb to 15 cm. Flowers white, centre yellow. In full flower.
Winter wet brown clay. Melaleuca polygaloides / M. uncinata shrubland.
Abundance: abundant

Lepidium puberulum Bunge (Brassicaceae)
CONSERVATION STATUS: P4
Coll.: B. McArthur s.n. Date: 17 09 1991 (PERTH 02159341)
Locality: Garden Island
Lat.: 32^ 12' S Long.: 115^ 40' E
Burnt area, regenerating. Melaleuca/Acacia communities.
Previous det.: Lepidium sp.

Bossiaea divaricata Turcz. (Papilionaceae)
CONSERVATION STATUS: P3
Coll.: Anonymous s.n. Date: (PERTH 1059157)
Locality: Gardner River
Lat.: 32^ 12' S Long.: 115^ 40' E
Shrub, 2 ft. On bluffs.

Dodonaea hackettiana W. Fitzg. (Sapindaceae)
CONSERVATION STATUS: P4
Coll.: A.H. Burbidge 3980 Date: 22 04 1986 (PERTH 01157647)
Locality: The Spectacles, near Medina
Lat.: 32^ 14' S Long.: 115^ 48' E
Erect shrub, ca 1.5 m high. Level, but disturbed sand. Abundance: rare.

Attachment

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

RARE FLORA INFORMATION

CONDITIONS IN RESPECT OF SUPPLY OF INFORMATION

- All requests for data to be made in writing to the Executive Director, Department of Conservation and Land Management, Attention : Administrative Officer Flora, Wildlife Branch.

- The data supplied may not be supplied to other organisations, nor be used for any purpose other than for the project for which they have been provided, without the prior written consent of the Executive Director, Department of Conservation and Land Management.

- Specific locality information for Declared Rare Flora is regarded as confidential, and should be treated as such by receiving organisations. Specific locality information for DRF may not be used in reports without the written permission of the Executive Director, Department of Conservation and Land Management. Reports may only show generalized locations or, where necessary, show specific locations without identifying species. The Administrative Officer Flora is to be contacted for guidance on the presentation of rare flora information.

- Note that the Department of Conservation and Land Management respects the privacy of private landowners who may have rare flora on their property. Rare flora locations identified in the data as being on private property should be treated in confidence, and contact with property owners made through the Department of Conservation and Land Management.

- Receiving organisations should note that while every effort has been made to prevent errors and omissions in the data provided, they may be present. The Department of Conservation and Land Management accepts no responsibility for this.

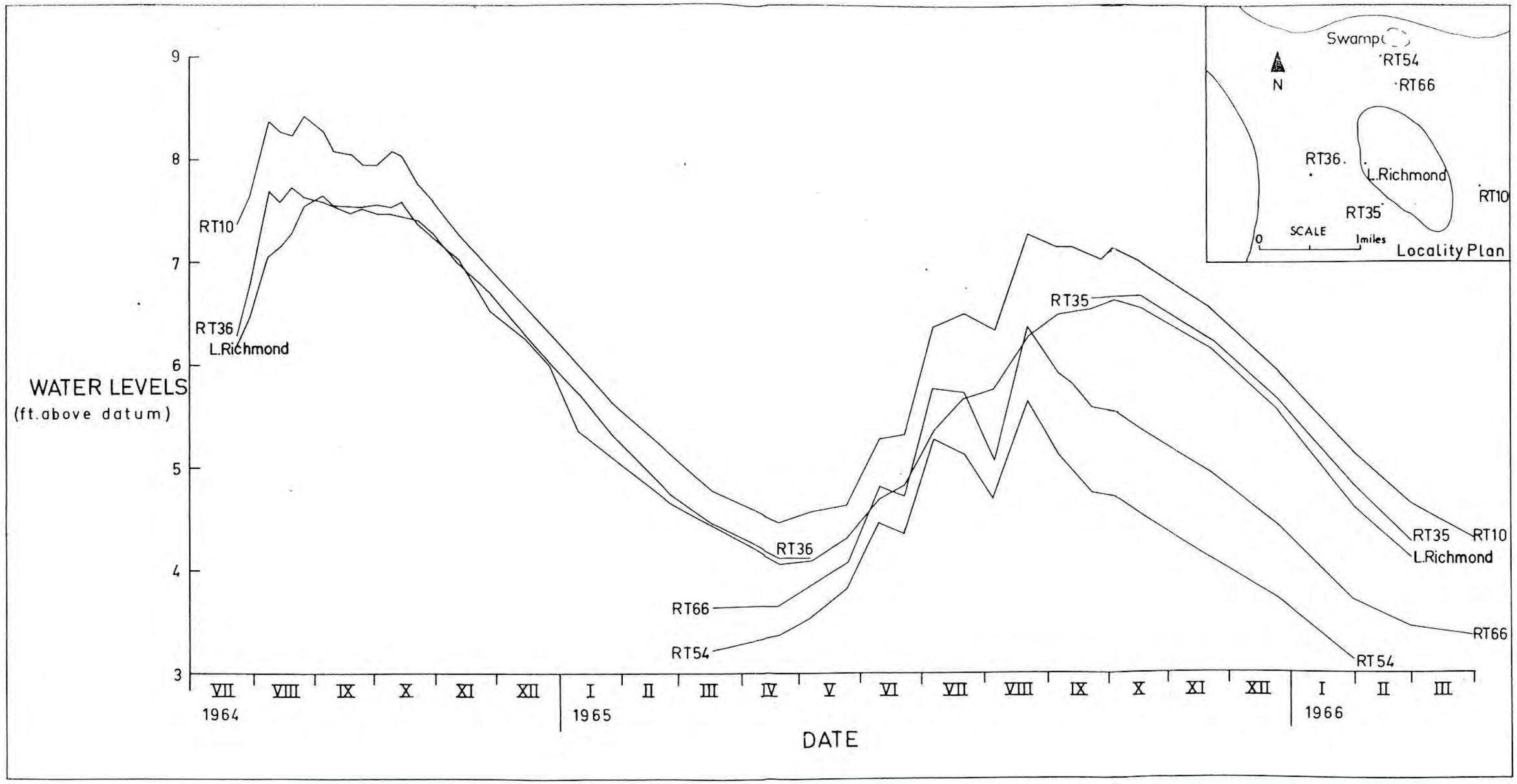
- Receiving organisations must also recognise that the database is subject to continual updating and amendment, and such considerations should be taken into account by the user.

- It should be noted that the supplied data do not necessarily represent a comprehensive listing of the rare flora of the area in question. Its comprehensiveness is dependant on the amount of survey carried out within the specified area. The receiving organisation should employ a botanist, if required, to undertake a survey of the area under consideration.

- Acknowledgement of the Department of Conservation and Land Management as source of the data is to be made in any published material. Copies of all such publications are to be forwarded to the Department of Conservation and Land Management, Attention : Senior Botanist, Wildlife Branch.

APPENDIX D

Relationship between Lake Richmond Water Levels and Surrounding Groundwater Levels



Levels Of Lake Richmond and nearby Water Table from July 1964 to March 1966

Source: Passmore 1967

BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

APPENDIX E

Water Quality Records for Lake Richmond

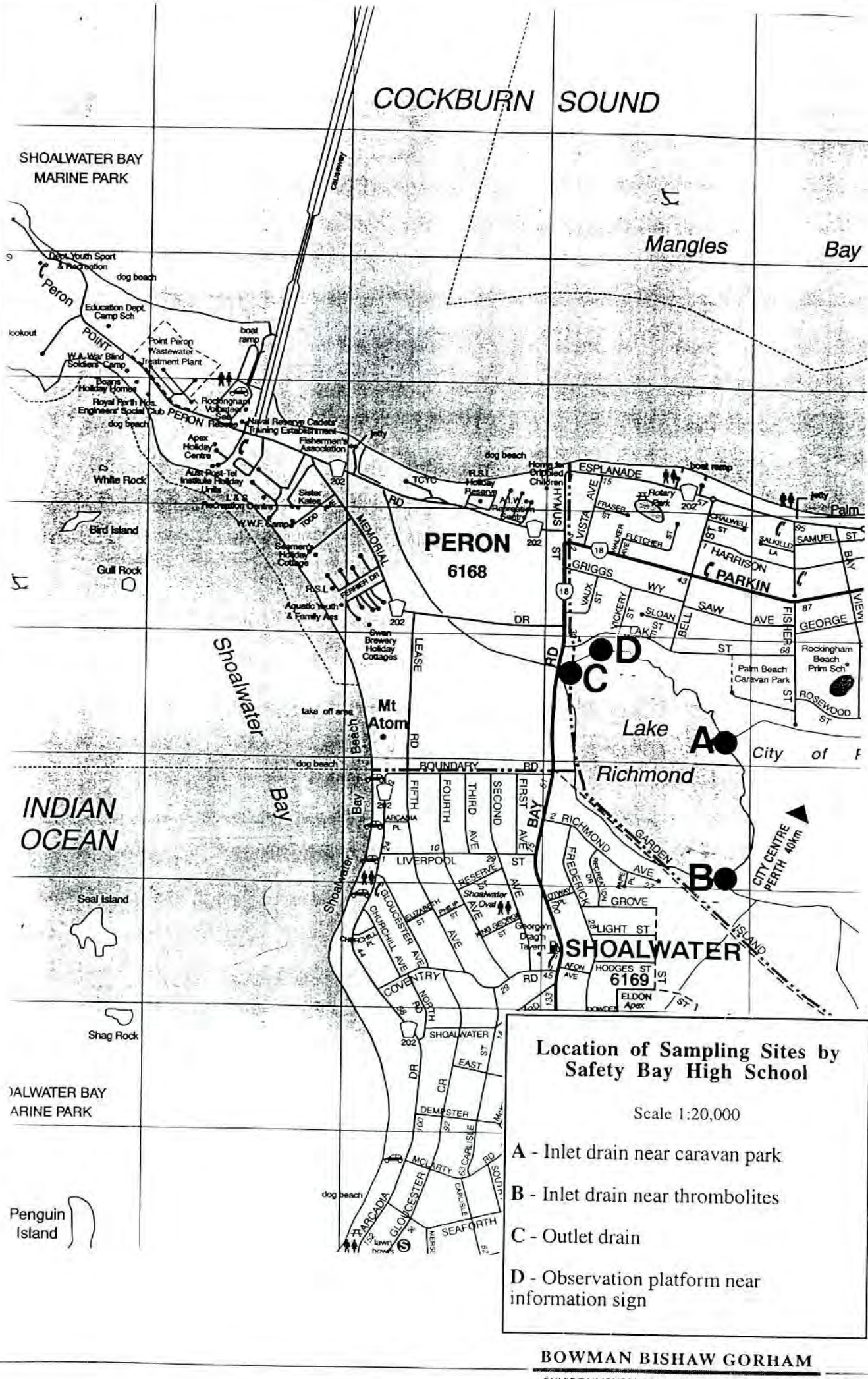
Lake Richmond Water Quality Data (1970-1986)
Source: Water & Rivers Commission

Date	pH	Suspended Solids mg/L	Total Nitrogen mg/L	Total Phosphorus mg/L	TDS mg/L
02/04/70	9.0	34	1.4	0.01	1416
02/11/70	8.8	-	1.3	-	740
07/09/71	9.0	10	0.1	1.3	700
24/02/72	8.9	2	0.850	0.06	796
06/09/72	8.6	16	0.2	0.04	680
01/02/73	8.8	<1	1.7	0.03	840
02/10/73	8.7	12	0.3	0.1	650
13/03/74	8.8	4	1	0.15	650
03/09/74	8.4	<1	1.2	<0.01	520
25/02/75	8.7	18	1.350	0.48	610
01/10/75	8.8	<1	0.800	0.05	480
25/02/76	8.8	<1	4.15	0.03	574
12/10/76	8.6	2	0.850	0.05	520
09/02/77	8.8	<1	0.470	0.7	560
03/10/77	9.2	<1	0.250	0.05	500
27/02/78	8.5	4	1.35	0.9	580
07/03/78	8.5	4	1.35	0.9	580
03/10/78	8.7	<1	0.7	<0.05	500
13/02/79	9.3	<1	0.85	<0.05	540
02/10/79	8.3	<1	0.95	<0.05	500
12/02/80	8.9	6	0.5	<0.05	520
01/10/80	8.7	<2	0.85	<0.05	440
23/02/81	8.7	10	0.5	<0.05	1050
08/10/81	7.9	-	0.4	<0.05	430
17/03/82	8.5	5	0.95	0.3	430
23/09/82	8.8	5	0.7	0.3	450
22/3/82	9.0	5	0.55	0.05	500
20/9/83	8.8	5	-	0.05	420
23/03/84	8.5	5	<0.05	0.1	550
25/09/84	8.3	<5	-	<0.05	490
26/03/85	8.8	-	1.1	0.1	-
24/09/85	8.4	-	4.4	-	-
18/03/86	8.7	-	0.9	<0.05	-
14/10/86	8.6	-	0.7	0.2	-

Rockingham Senior Highschool Water Quality Monitoring

See Accompanying Map For Sampling Locations

Date	Location	PO_4	N	NO_3
29/08/97	Inlet (Caravan Park)	0.11	1.28	0.29
	Inlet (Thrombolite)	0.12	0.39	0.088
	Outlet	0.03	0.39	0.089
	Observation Platform	0.16	0.004	0.001
05/04/95	Inlet (Caravan Park)	0.38	-	0.04
	Inlet (Thrombolite)	0.07	-	0.03
	Outlet	0.03	-	0.00
	Observation Platform	0.03	-	0.00
22/08/95	Inlet (Caravan Park)	0.16	-	0.032
	Observation Platform	0.12	-	0.08
19/03/97	Inlet (Caravan Park)	0.03	-	0
	Observation Platform	0.08	-	0
20/08/96	Inlet (Caravan Park)	0.08	-	0.24
	Jetty	0.91	-	0.018


COCKBURN SOUND
SHOALWATER BAY MARINE PARK
Mangles Bay
Peron Point
Education Dept. Camp Sch
Point Peron Wastewater Treatment Plant
boat ramp
W.A. War Blind Soldiers' Camp
Beard Holiday Homes
Royal Perth Yacht Club
Engineers' Social Club
Rockingham Volleyball Club
Naval Reserve Cadets' Training Establishment
Fishermen's Association
Jetty
Apex Holiday Centre
Aust. Post-Tel Institute Holiday Units
L & S Recreation Centre
W.W.F. Camp
Sister Kates
White Rock
Bird Island
Gull Rock
Seamen's Holiday Cottage
R.S.L.
Aquatic Youth & Family Assn
Swan Brewery Holiday Cottages
PERON
6168
MEMORIAL DR
PERMIER DR
LEASE
Shoalwater Bay
Mt Atom
take off area
dog beach
TCYC
R.S.L. Holiday Resort
M.V. Recreation Centre
Home for Crippled Children
ESPLANADE
Rotary Park
boat ramp
Jetty
Palm
HARRISON
PARKIN
GRIGGS
SAMUEL
GEORGE
SLOAN
SAW
BELL
FISHER
VIEW
BAY
LAKE
Rockingham Beach Prim Sch
Palm Beach Caravan Park
ROSEWOOD
Lake Richmond
City of R
A
B
C
D
BOUNDARY RD
INDIAN OCEAN
Seal Island
Shag Rock
Penguin Island
FIFTH
FOURTH
THIRD
SECOND
FIRST
BAY
ARCADIA
LIVERPOOL
RESERVE
Shoalwater Oval
RICHMOND
GARDEN
FREDERICK
GROVE
FLIGHT
SHOALWATER
HODGES
6169
ELDON
Apex
CITY CENTRE PERTH 40km
ISLAND
GLOUCESTER
CHURCHILL
ELIZABETH
PHILIP
KING GEORGE
George'n Drag'n Tavern
COVENTRY
NORTH
EAST
DEMPSTER
MCLARTY
CARLISLE
SEAFORTH
lawn bowls
Location of Sampling Sites by Safety Bay High School
Scale 1:20,000
A - Inlet drain near caravan park
B - Inlet drain near thrombolites
C - Outlet drain
D - Observation platform near information sign
BOWMAN BISHAW GORHAM
ENVIRONMENTAL MANAGEMENT CONSULTANTS

APPENDIX F

Species List Flora - Lake Richmond

Species List for Lake Richmond

species recorded during survey February 3, 1996

This does not represent a complete list of all species

(* signifies introduced species)

	genus	species	common name
	Acacia	*cyclops*	
	Acacia	*rostellifera*	
	Acacia	*saligna*	
	Acanthocarpus	*preissii*	
*	*Avena*	*barbata*	wild oats
	Baumea	*juncea*	
*	*Briza*	*maxima*	
*	*Briza*	*minor*	
	Centella	*cordifolia*	(was Hydrocotyle asiatica)
	Conostylis	*candicans*	
*	*Conyza*	*bonariensis*	
	Cortaderia	*selloana*	pampas grass
	Cynodon	*dactylon*	couch grass
	Cyperus	*sp*	
	Dianella	*divaricata*	
*	*Ditttrichia*	*graveolens*	
	Euphorbia	*peplus*	
	Euphorbia	*terracina*	
	Gahnia	*trifida*	
	Hardenbergia	*comptoniana*	
	Isolepis	*nodosa*	
	Jacksonia	*furcellata*	
	Juncus	*pallidus*	
	Kennedia	*prostrata*	
	Lagurus	*ovatus*	
	Lepidosperma	*angustifolium*	
	Lepidosperma	*gladiatum*	
*	*Lepidosperma*	*sp*	
*	*Leptospermum*	*laevigatum*	tea tree
	Leucopogon	*sp.*	
*	*Lobelia*	*alata*	
	Melaleuca	*huegelii*	
*	*Melaleuca*	*rhaphiophylla*	
	Myoporum	*caprarioides*	
	Olearia	*axillaris*	
	Paspalum	*dilatatum*	
*	*Pelargonium*	*capitatum.*	
*	*Pennisetum*	*clandestinum*	Kikuyu grass
	Phyllanthus	*calycinus*	
	Rhagodia	*baccata*	
*	*Solanum*	*nigrum*	night shade
	Sporobolus	*virginicus*	sand couch
*	*Spyridium*	*globulosum*	
	Trachyandra	*divaricata*	
	Tricoryne	*elatior*	
	Typha	*sp*	bulrush
	Xanthorrhoea	*preissii*	

APPENDIX G

Water Balance Estimates for Lake Richmond

Estimates of Water Balance Elements for Lake Richmond

(i) Volume of Lake Richmond

If the lake area is assumed to be 40ha and is estimated to have an average depth of 12m then the volume of the lake is in the order of $5 \times 10^6 m^3$.

(ii) Drainage Inputs

The surface water catchment of the drainage system which discharges to the lake shown on Figure 7 is 1,102ha.

Assuming 20% of this area is paved from which runoff is approximately 75% of rainfall and the annual rainfall is 850mm then the volume of drainage flows into the lake is approximately $1.4 \times 10^6 m^3$/annum.

The drainage system also carries groundwater during winter when water tables rise. Available data does not provide the opportunity to reasonably estimate this volume. The drainage water inflow estimate should be regarded as an underestimate in this regard.

(iii) Direct Rainfall to the Lake

The lake area is 40ha ($400,000 m^2$), therefore direct rainfall inputs at 850mm/annum will be approximately $340,000 m^3$/annum.

(iv) Groundwater Inflow

Research by Townley *et al.* (1993) showed that groundwater flow around lakes on the Swan Coastal Plain is complex, and requires sophisticated mathematical analysis in order to gain a reasonably accurate estimate of throughflow.

A broad estimate of the likely maximum groundwater inflow into Lake Richmond can be derived by assuming that all flow in the superficial aquifer towards the lake, in a cross sectional area equal to the full length of the lake (1000m) and over the full thickness of the aquifer (25m) flows into the lake. This is a consistent assumption based on the Townley *et al.* (1993) findings regarding the capture zones of through flow lakes and the "rule of thumb" finding that "a water body five or ten times longer than the aquifer thickness draws water from virtually the whole thickness of the aquifer...".

The watertable gradient of the superficial aquifer indicated by available contour maps, upgradient of Lake Richmond is approximately 0.1% (1m fall over 1km distance).

If aquifer permeability is assumed to be 30m/day, groundwater velocity is estimated at 0.03m/day (11m/annum).

If the aquifer thickness is an average of 25m, aquifer throughflow beneath a 1,000m long section is estimated at 275,000m^3/annum.

This is a very crude estimate and could only be reasonably used as an order of magnitude estimate, but it is likely to be reasonable figure in this context. Davidson's (1978) flow net analysis for the Safety Bay Groundwater Manual estimated total through flow to Cape Peron was approximately 840,000m^3/annum suggesting the 275,000 estimate for groundwater inflow to Lake Richmond is a high figure.

(v) Evaporation

The lake's water surface area of 40ha and an evaporation estimate of 14,000mm/annum yield an evaporative loss of 560,000m^3/annum.

APPENDIX H

Best Management Practice # I 10

BMP #I10: INFILTRATION RETENTION BASIN

PURPOSE

- To reduce volumes and peak rates by providing infiltrations of stormwater after concentration.
- To improve water quality by filtration.
- To maintain or increase natural groundwater recharge.

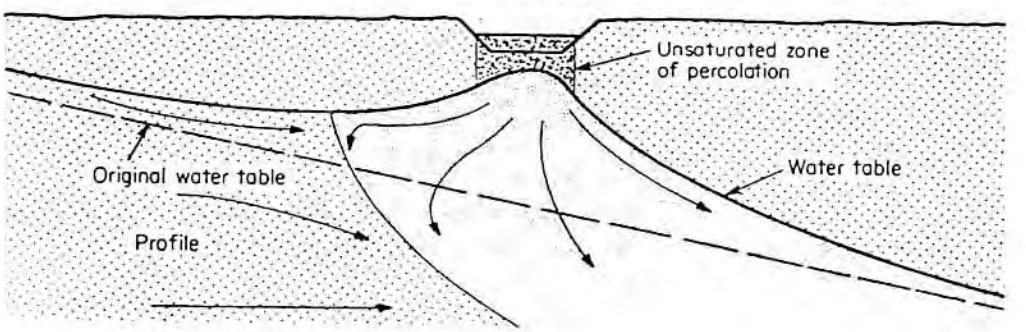
ACHIEVEMENT OF WATER SENSITIVE OBJECTIVES

• **Water Quality**	–	Moderate to high pollutant removal capacity.
• **Water Balance**	–	High volume control, moderate to high streambank erosion control and moderate to high peak discharge control.
• **Water Conservation**	–	High groundwater recharge capability.
• **Other General**	–	Moderate habitat creation, moderate to high recreational and aesthetic values.

DESCRIPTION/DIAGRAM

- Infiltration basins are water impoundments lined with relatively permeable soils, made by excavation or by construction of dams or embankments. Infiltration basins are designed to temporarily store surface runoff water for a selected design storm or runoff volume, and to increase groundwater recharge through infiltration of stored water through the sides and bed of the basin.

IR Basin



(Source : Reed, Middlebrooks & Crite, 1988)

APPLICATION/PHYSICAL SUITABILITY

- Feasible when soils are permeable and the water table and bedrock are situated well below the soil surface.
- More practical and cost effective when serving catchments greater than 2 ha.

ENVIRONMENTAL AND HUMAN INTEGRATION

- The value of infiltration basins in creating local wildlife habitat is not as great as for wet detention basins (BMP #I8). However, the perimeter of the basin can be planted with trees and shrubs.
- While infiltration basins do not provide all the amenities associated with wet basins, they can look attractive when well landscaped, and contoured. In most cases the basin can be utilised for recreational playing fields.
- Due to possible groundwater contamination in high water table conditions, it is not advisable to site near groundwater drinking supplies.
- Depending on design can be used as recreational playing field.
- Infiltration basins do not produce thermal or low dissolved oxygen impacts to downstream waters.

LIMITATIONS

- Due to susceptibility to clogging by high sediment loads in stormwater a gross pollutant trap (BMP #R9) is recommended.

COST EFFECTIVENESS

- Infiltration basins cost marginally more than a dry detention basins and also exhibit economies of scale. In terms of cost per unit volume treated infiltration basins are one of the most cost effective BMPs.

MAINTENANCE

- Infiltration basins need constant maintenance to ensure porosity is not reduced.

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