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LAKE CLIFTON PROPERTIES

REALIGNED ACCESS ROUTE AND LAND EXCHANGE PROPOSAL

ATTACHMENTS

VOLUME 1

Prepared By

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INVESTMENTS PTY LTD

for the

National Parks and Nature Conservation Authority

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CONSERVATION

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A. Access Road and Environmental Development (Gutteridge Haskins & Davey, 1998)

B. Floristic Community types in the proposed White Hill Road to Lake Clifton West Access Route Corridor, City of Mandurah (Weston, 1998)

Potential Rare Flora in the Proposed White Hill Road to Lake Clifton West Access Route Corridor, City of Mandurah (Weston 1998)

C. Overview of Environmental Issues, Lake Clifton West (Gutteridge Haskins & Davey, 1998)

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Cape Bouvard Investments

Lake Clifton West

Report on

Access Road and Environmental Development

June 1998

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Document Status

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1. Introduction

Cape Bouvard Investments Pty Ltd (CBI) is proposing to develop its land west of Lake Clifton, comprising Lots 2240, 2275, 2657 & 3045 with a total area of 790.22 ha. The land extends between Lake Clifton and the Indian Ocean and is approximately 30 km south of Mandurah. The current land holding is bound by the Yalgorup National Park to the north and south, which contains part of the environmentally sensitive foreshore of Lake Clifton.

CBI is currently investigating with the National Parks and Nature Conservation Authority (NPNCA) the possibility of a land exchange whereby the highly sensitive Lake Clifton foreshore and wetlands area owned by CBI is exchanged for National Park land along the coast, to the north and adjacent to CBI's current land holding. It is proposed to develop this coastal land as a approximately 1300 lot environmentally integrated settlement comprising residential clusters. The land exchange would result in the addition of a significant 'buffer' area of Lake Clifton shoreline to Yalgorup National Park. The land exchange would also increase the area of the Park by about 300 ha. with land having significant areas of high conservation vegetation.

This report investigates the alignment and design of the access road that is required to the existing boundary of CBI property and development of the residential clusters. The access road will be designed to conform to Environmental Protection Authority (EPA) development criteria as set out in its published bulletins. The design will also adhere to the principles as outlined in the recently published 'Coastal and Lakelands Planning Staretgy' (WAPC 1997) for developments within the Lake Clifton Catchment.

2. Access Traffic

The proposed approximately 1300 lot development is designed with one major access. Emergency egress is via an alternative route to the south.

2.1 Trip Rates

In order to establish appropriate trip rates, Land Use Traffic Generation guidelines produced by the Director General of Transport South Australia have been referenced, together with the 1986 Travel Survey, Perth Metropolitan Area.

2.2 Traffic Volumes

To establish a realistic estimate of traffic volumes on the access road into the development the following profile has been used:

- approximately 1300 lots
- 50% Holiday Homes (assumed to have a 50% occupancy rate)
- 35% Permanent Residential
- 15% Retirees
- A conservative estimate of 10% of trips being internal to the development

Estimate of Trips per day

	Trips/Dwelling	Trips/day (1300 Lots)
50% Holiday Homes x 50% occupancy x 90% external trips	7 x 0.5 x 0.9	2047
35% Permanent Residential x 90% external trips	8 x 0.9	3276
15% Retirees x 90% external trips	3 x 0.9	526
Total Trips/day		**5849 vpd**

The above figures provide a reasonable assessment of traffic volumes on the access road to the development. The proposed road design will be able to handle the traffic volumes with traffic control improvements being made in several areas.

3. Access Location and Design Considerations

The proposed access road is shown on Figure 1. Other northern route options were discussed in the previous submission to NPNCA, however the Department of Conservation and Land Management (CALM) indicated that most western route was the preferred northern access route. This route avoids the existing road reserve along the foreshore of Lake Clifton which is in a sensitive area with pockets of significant remnant vegetation. Closing the existing foreshore road reserve is nominated as a priority in the Coastal and Lakelands Planning Strategy, and the Yalgorup National Park Management Plan (CALM & NPNCA, 1995).

The northern access to the development will minimise the impact on the existing environment and complement the intent of the development to provide a quality secluded, safe, quiet environment. It will also have minimal impact on the existing landforms and unique characteristics of the site. To achieve this standard, engineering practices will be complemented with environmental consideration such as minimum vegetation clearing for the road, aligning the road in a sensitive manner to avoid significant pockets of vegetation, minimising required earthworks and careful consideration will be given to the methods of disposing of drainage water.

The original preferred route by CALM was selected by Malcolm Trudgeon based on mapping completed at 1:20,000 and 5 m contours. However, on completion of the aerial survey and using more detailed information at 1:2000 and 0.5 m contours, it became evident that the original route could be improved. In some locations it was located on the side of steep dunes which would have resulted in significant earthworks causing the removal of the dune face. This was contrary to the design philosophy of the road in having minimal impact on the surrounding landforms.

Therefore, in conjunction with Dr Arthur Weston the route was modified with significant improvements on reducing the impacts on the existing landform and dunal vegetation. The route has also been located to avoid significant vegetation groups.

After a detailed site survey by Dr Arthur Weston further modifications to the road were made to areas of significant vegetation.

To avoid impacting on the existing landform and vegetation in accordance with the design philosophy for an environmentally sensitive development, the following design criteria is proposed for the access road:

- The road has significant undulations and curves to fit into the existing landform. It is to be designed with a design speed of 40 - 70 km with a 60 km/hr speed limit. There are three locations on the route which have a bend design speed of 40 km/hr.
- The pavement has a proposed minimum width of 7.0 m wide with 1.0 m shoulders giving a total width of 9.0 m.

- Initially the pavement will be a limestone track, which when traffic volumes increase will be upgraded to a sealed pavement. The ultimate pavement will be based on a standard rural two coat seal. In steep areas, scouring will need to be addressed by initially constructing the pavement to a bitumen seal stage.
- To avoid significant cut to fill on the crests of the dunes, the vertical gradient will be to desirable maximum of 12.5 % with an absolute maximum of 15 % in the worst locations. Widening of the pavement for safety purposes may be required in steep locations.

4. Drainage

The road drainage philosophy for the development is to spread the discharge of stormwater as evenly as practical to minimise variation in micro-area water balance.

For most of the road network this will be by direct runoff into a vegetated swale drain with scour protection where required. On steeper sections where the runoff will form a nuisance, kerbing, asphalt, piping and soakwells within the road reserve will be installed.

No steep drainage sumps will be created in the development. Only vegetated and shallow sided basins that are designed to conform with the existing dune landforms will be used to dissipate stormwater.

5. Services to Site

The existing service infrastructure to provide water, sewerage pressure main, power and communications to the development is from the north. The access for services would be via the realigned access road from he North and constructed in conjunction with the road.

It is intended to place the services in a common trench to minimise the width required for installation of the service corridor, thus minimising the impacts on the existing vegetation and landform.

6. Engineering Infrastructure On Site

6.1 Earthworks

No clearing will occur in areas identified as significant mature vegetation. This vegetation consists of mature stands of native trees and sub-canopy native vegetation.

Areas to be cleared are identified as 'undulating land form' and comprise low open coastal heath type vegetation interspersed with sandy swales. The planning allows future flexibility to review and realign the road and lot layout to integrate the development into the existing landforms. This will minimise the impacts on the high relief dune landforms, thus optimising the design so that it will have minimal impact on the unique landscape features of the area.

No development will occur along the narrow coastal strip of the Quindalup Dune Complex (Q3 and Q4 age). This area is subject to wind blow outs and storm erosion and will be protected by a development buffer or reserve. Access through the dunes will be strictly controlled. CBI are committed to implementing a dune stabilisation management plan to protect these sensitive landforms.

The proposed development is based on clusters of lots in a rural road setting, maintaining a rural landscape. The land that is physically impacted upon is approximately 15% of the proposed land holding for the approximately 1300 lot development. A significant 'buffer' of land will exist between the development and Lake Clifton. **Absolutely no development whatsoever will occur on the ecologically sensitive Vasse Landforms abutting the lake, as recommended in the Coastal and Lakelands Strategy (WAPC, 1997).**

The area impacted (15% of the land holding) is significantly less than a rural or semi-rural development where the land would be controlled by private land holdings. This allows for maintaining significant amounts of existing vegetation and landforms for the area as well as effectively reducing the catchment size for nutrient loadings in the Lake Clifton Catchment. This provides a break in the continuity of coastal urban development with areas of regional open space in accordance with urban development requirements in the Coastal and Lakelands Planning Strategy report.

CBI will consider options for encouraging residences to be built which are harmonious with the topography of this area, retain existing vegetation and comply with water sensitive design guidelines to enhance the existing landscape character of the development.

Lots in some of the cluster areas will not be cleared at all, and in some areas steep dune slopes will remain unaltered to retain the landscape character and high visual appeal of the development.

The variability of limestone outcrops within the dune area is unknown. Best information available from groundwater monitoring bores installed during a recent hydrogeological investigation of the site (Ultramafics, 1997) is that in the main

the limestone occurs at about 1 m to 2 m AHD, and beneath the dunes. There is at least one substantial pocket of limestone which extends up to 34 m AHD, but this is located in that portion of the currently CBI-owned land that is proposed for transfer to the Yalgorup National Park in the land exchange..

A revegetation program for the development will also occur in consultation with CALM using species endemic to the area. The revegetation program will serve several purposes:

- be an integral part of the dune stabilisation management plan;
- help maintain the water balance across the site at the pre-development situation; and
- maintain and enhance the aesthetic features and character of the site.

In its Executive Summary, the Coastal and Lakelands Planning Strategy report states that "*...in coastal areas of high environmental sensitivity...given adequate foreshore reserves, correct siting, adequate site assessment, and appropriate design, (these areas) can be satisfactorily developed for relatively dense urban or resort uses*". The Strategy calls for innovative residential design and the application of water-sensitive design principles, compatible with site conditions. This is further elaborated upon in the body of the Strategy document, which allows for development in the coastal zone (between the ocean and the lakes) on the basis of comprehensive environmental assessment and approved management plans (p82, WAPC, 1997).

The proposed CBI development will comply with these Strategy requirements by ensuring that development on sensitive landforms (the Q4 and Q3 age Quindalup Dune system and the Vasse landforms) is avoided, the water balance of the area is not upset by the development, comprehensive environmental assessment is carried out (indeed much of this has already been done), and management plans will be developed to the approval of the appropriate agencies.

6.2 Roads

The roads internal to the development will minimise the impact on the existing environment and support the intent of the development to provide safe and secluded environs. To achieve this, standard engineering practice will be complemented by other treatments. The water balance emphasises the need to reduce road clearing envelopes.

The local distributor roads within the network are to be 7 metres wide with the remaining roads to be 5 metres wide to meet the criteria for seclusion. At the time of detailed design, when all survey levels are available, it will be preferable to consider each nodal access road individually to determine if narrower roads at 3.5 m wide with passing zones 5.0 m wide could be practically designed. The passing zones would be at every intersection and midway between intersections. Additional passing zones would be constructed so a zone occurred at least every 200 m, or where required for safe sight distances between passing zones.

The dune environment has inherent features which can be maintained provided the standard services do not stringently apply. In particular the alignment of the

underground services on the road reserve will result in greater clearing and earthworks than if negotiations are undertaken to rationalise the position of the service trenches. The positioning of as many services as practical under the road pavement is desirable to further minimise the clearing envelope.

To ensure minimum disturbance of landform, the roads will be constructed with a one-way crossfall following the natural slope, thereby reducing earthworks. Also the roads will be kerbed on both sides (flush or raised), resulting in the following benefits:

- reduced construction and clearing width required;
- elimination of ongoing shoulder grading maintenance (required on unkerbed roads) which would damage roadside regrowth vegetation; and
- enabling more options to be considered for stormwater disposal.

6.3 Drainage

The road drainage philosophy for the development is to spread the discharge of stormwater as evenly as practical to minimise variation in micro-area water balance.

For most of the road network this will be by direct runoff, either by use of flush kerbing or by openings in raised kerbing at no more than 20 m intervals into a vegetated swale drain. Where the runoff might form a potential nuisance for a private lot discharge by soak wells within the road reserve at 40 m spacings are recommended. A total of 15% of the road has been identified as requiring control of water via a piped drainage to soakage basins to avoid entering private property. No steep drainage sumps will be created in the development. Only vegetated and shallow sided basins that are designed to conform with the existing dune landforms will be used to dissipate stormwater.

6.4 Water Supply

The proposed water supply for the development is from the Water Corporation's Cadadup Tank located at Dawesville, approximately 16 km to the north (TWL RL 56 m).

In order to ensure the water balance over the area is maintained, it is not proposed to construct any groundwater extraction bores for the purpose of water supply into homes.

This will protect the groundwater resource from uncontrolled extraction, and in so doing ensure control of the existing groundwater regime. This is a crucial element in the protection and maintenance of the environment of Lake Clifton, and the microbialite communities it supports. Details of water balance maintenance measures to be adopted in the catchment are contained in Section 7.

The proposed scheme will consist of a 16 km DN 250 PVC water main to header tanks located at approximately RL 30m - 35m AHD with an interim booster station located midway on the Old Coast Road. From the header tanks the water

supply will be distributed via booster pump into a local distributor feeder network system.

6.5 Waste Water

The proposed development is located in the environmentally sensitive area adjacent to the Yalgorup National Park and Lake Clifton. Therefore, careful consideration has been given to the impacts of waste water treatment and disposal, in particular with respect to any change it may have on the water balance over the site, and the effects of any discharges of nutrients to the environment. The control of nutrient inputs to the lake catchment is noted as being of particular environmental importance in the Coastal and Lakelands Planning Strategy and EPA development criteria for the lake (WAPC, 1997; EPA, 1997).

In consideration of the potential environmental impacts of on-site treatment of sewage and waste water, the entire 1300 lot development will be reticulated with deep sewer.

Sewage and waste water will be collected and conveyed to a series of pump stations which will pump it north, and into the existing sewerage system in the area. Ultimately the sewage will be treated at the planned wastewater treatment plant at Tims Thicket. This will avoid the discharge and build up of nutrients, and increased groundwater recharge, at point sources from septic tanks, amended soil systems or individual aerobic treatment units in the sensitive Lake Clifton catchment, as would normally be the case for a rural or semi rural development.

The nodal nature of the development and steep dune country in which it is located require that 20 pump stations be installed to service the area.

Whilst the difference in cost between pumping the waste water off-site for treatment, and on-site treatment and disposal, is relatively small, the potential for adverse environmental impacts arising from the latter is unacceptable to CBI. Further, on-site waste water treatment and disposal is not in keeping with the design ethos of the proposed development, namely to achieve harmonious integration with the existing environment through low environmental impact.

6.6 Power Supply

Power for the proposed development will involve extending a 22 kVA feeder line from the White Hill Road and Old Coast Road intersection. To be visually compatible with the environment the 22 kVA feeder cable and reticulated power will be laid underground.

6.7 Miscellaneous

6.7.1 *Vermin Fence*

Physical impacts (trampling and loss of fringing vegetation) is one of the EPA's three issues of concern identified in its criteria for development (Coastal and Lakelands Planning Strategy, WAPC, 1997). The creation of a land buffer through the proposed land exchange will place control of fringing vegetation of Lake Clifton with the NPNCA.

A vermin-proof boundary fence will be erected around the entire approximately 1300 lot development. The fence will further enhance the protection of the National Park by controlling the access of vermin, and of people trampling through the sensitive environment. The fence will be 2 m high and will have a limited number of fauna gates. Installation will vary from loose sand through to limestone rock.

Fencing will also occur along the eastern side of the coastal dune strip bordering the ocean, in accordance with the recommendations of the Coastal and Lakelands Planning Strategy. This will be part of the dune stabilisation and management plan for control of access onto these dunes. This will restrict 4WD vehicle access and trampling in these sensitive areas.

6.7.2 *Bike Paths/ Bush Trails*

There are proposed to be 40 km of bike paths/ bush trails throughout the development. These will be used for recreational purposes and will also form a major part of the bushfire management strategy and dune stabilisation management plan.

Control of erosion and access through the fringing coastal dune system is nominated in the Coastal and Lakelands Planing Strategy as a priority for the management of the coastal zone. CBI is committed to implementing a dune stabilisation management plan which includes controlling access through them. The proposed paths will be used to control access both through the dunes and the development in order to limit impacts on the existing land forms and vegetation. Half of the paths will consist of a crushed limestone surface 2 m wide.

7. Hydrological Balance

7.1 Background

An initial hydrogeological investigation of the CBI's Lake Clifton West site was recently undertaken by Ultramafics Pty Ltd (Ultramafics, 1997). There are no creek or other surface drainages at the site. The ground is permeable and conducive to infiltration rather than sub-surface runoff. The subsoil groundwater gradient is relatively flat and runs from west to east towards the lake with the groundwater divide located near the coastline. Infiltration to the water table is likely to be quite rapid as the underlying dune system and limestone support deep infiltration.

The sensitive nature of the lake environment requires that any development in the Lake Clifton catchment has minimum adverse impact on the lake. In particular, EPA Bulletin 864 (EPA, 1997) specifies the following key environmental factors as relevant in protecting the lake:

1. **water balance - new developments are to be managed so that the water balance following development is as close to pre-development conditions as possible;**
2. **nutrient loads - new developments are to be managed so that phosphorus and nitrogen export to the lake is negligible.**
3. **regionally significant wetlands - new developments are to be managed so that direct impacts of humans and stock do not cause physical damage to the thrombolites, wetland vegetation, fringing wetland vegetation and dryland buffer of Lake Clifton.**

The proposed approximately 1300 lot development will comprise:

- mainly R15-R20 residential dwellings confined to a small number of nodes or hamlets;
- hamlets located away from environmentally sensitive areas;
- minimum clearance of natural vegetation;
- reticulated sewerage to export waste water from the catchment; and
- reticulated water supply, with no groundwater abstraction by individual lot holders.

The development will employ water-sensitive design principles. CBI is committed to ensuring that, when fully developed, the development will fully comply with the environmental objectives for EPA's 3 key environmental factors listed above.

The following sections of this chapter describe the assessment made to determine the effect of the proposed development on groundwater recharge, and detail the measures to be taken to ensure that there is no net change to groundwater recharge as a result of the development.

7.2 Assumptions

Calculation of the change in recharge of the groundwater aquifer is based on the method used in EPA Bulletin 788 (EPA, 1995). However, whereas the calculations in the EPA document were of necessity generalised in order to produce an 'ideal' lot size, the calculations below have been tailored to the specific conditions expected for this unique development. In particular, the following assumptions have been made:

1. the average density for the site is R15 - R20 (ie. 20 lots per ha);
2. the total area under consideration in determining the overall balance across the site (ie. from the coast to the edge of Lake Clifton) is approximately 1500 ha.
3. for R20 development, 50% of each lot is assumed to be effectively 'hard paved' - the remainder is assumed to be vegetated areas/garden (called 'pasture' in the EPA bulletin);
4. there are 40 km of road, with an average 12 m cleared width, of which 6 m is sealed; however complete revegetation of the cleared, unsealed, area will occur following development;
5. there are 40 km of bike paths, comprising 2 m cleared and sealed (crushed limestone) width;
6. there will be 4-5 'village greens', or treed lawn areas, comprising a total area of 10 ha.
7. there will be several freshwater lagoons or ponds comprising a total area of 10 ha;
8. the mean annual rainfall is 900 mm; monthly mean figures for rainfall and pan evaporation for the Medina recording station (Kwinana) were supplied by the Bureau of Meteorology.
9. there will be no groundwater abstraction for individual household uses; water supply is to be provided by a reticulated service;
10. outside water use per household is assumed to be one quarter of the average for a Perth household (without bore); this equates to about 42 kL per year[1];
11. the recharge to groundwater from residential lawn/garden watering is 24% of the applied water (Water & Rivers Commission, pers. comm.);
12. no firebreaks other than roads and cycle paths are to be constructed and;
13. clearing for services has been excluded.
14. groundwater recharge rates, as a percentage of rainfall, for native vegetation, pasture and hard surfaces are as follows (EPA, 1995)[2]:
    - recharge from land covered by native vegetation is 10% of rainfall;

[1] The average Perth house (without bore) uses about 420 kL of water per year, of which about 40%, or 168 kL, is irrigated to the garden (Water Corporation, 1995).

[2] 'Worst case' (maximum increase in recharge after clearing) figures have been used in lieu of more accurate and representative figures currently being sourced with the assistance of the Water and Rivers Commission.

- recharge from land covered by pasture (cleared areas) is 30% of rainfall; and
- recharge from land covered by hard surfaces is 80% of rainfall.

NB. These recharge rates are described in the EPA bulletin as 'worst case'.

15. no clearing will occur in areas identified as significant mature vegetation.

This vegetation consists of mature stands of native trees and sub-canopy native vegetation. Areas to be cleared are identified as 'undulating land form' and comprise low open coastal heath type vegetation interspersed with sandy swales. A further assumption has therefore been made:

16. for the purposes of estimating recharge from clearing at the site, the original vegetation is equivalent to a 50% native 50% pasture mix.

The methodology followed for this assessment has been submitted to the Water and Rivers Commission (WRC) for review and comment. WRC supports the approach of attempting to maintain the existing water balance. Recharge rates were generally considered to be reasonable, although the rate for native vegetation (assumption 14) of 10% of rainfall was possibly too conservative. Further, more detailed advice on recharge rates is to be provided by WRC.

7.3 Estimate of Vegetation Clearing

An estimate of the total area of vegetation to be cleared has been made and is set out in the table below. This is the ultimate *gross* clearance figure, before account is taken of revegetation that will occur as a result of bush enhancement and rehabilitation. These revegetation measures are discussed in greater detail in Section 7.5.

	Area Cleared (m^2)
Residential	
Residential R15 - R20,	
1300 lots x 600 m^2 x 50% cleared	390,000
Sub-Total	**390,000**
Roads & Paths	
Roads - 40 km, 6m cleared width (paved)	240,000
Paths - 40 km, 2 m cleared width	80,000
Sub-Total	**320,000**
Village Greens	**100,000**
Freshwater Lagoons/Ponds	**100,000**
Total Clearing	**910,000**

For the proposed approximately 1300 lot development approximately 15% of the development area will be cleared for dwellings.

7.4 Calculation of Change in Groundwater Recharge

In order to calculate the change in groundwater recharge at the site, the following equation, from EPA Bulletin 788 (EPA, 1995), was used -

$$\Delta R\ (total) = \Delta R\ (c) + \Delta R\ (p) + I\ (pvte)$$

where

$\Delta R\ (total)$ is change in recharge,

$\Delta R\ (c)$ is increased recharge from area cleared to pasture,

$\Delta R\ (p)$ is increased recharge from area cleared to paved,

$I\ (pvte)$ is increased recharge from private uses - garden watering.

The following table shows for the proposed development, the areas of land being cleared to 'pasture' and those being cleared to 'paved' surface.

	Area Cleared (m^2)
For R20 lots - 300 m^2 to 'paved'	390,000
For roads - to paved	240,000
Bike paths - paved	80,000
Village Greens - to pasture	100,000
Total Pasture (m^2)	100,000
Total Paved (m^2)	710,000

For I (pvte), recharge for the approximately 1300 lots is 24% of applied water, so total annual recharge from garden watering is:

. 0.25 x 42 x 1300 = 13,650 kL/yr

The recharge calculation spreadsheet is attached at Appendix A.

This gives a recharge for the proposed development, prior to the proposed measures to achieve zero increased groundwater recharge, of 406,050 kL/year.

7.5 Measures to Achieve Zero Increased Groundwater Recharge

CBI is committed to implementing a range of measures to reduce the increase in groundwater recharge resulting from the development of this site over that of pre-development conditions to effectively zero. The following sections describe these measures and estimate the reduction in increased recharge achieved for each.

7.5.1 Revegetation

The aim of this measure is to counteract the increase in recharge above pre-development conditions, through rehabilitation of existing 'pasture' type areas to native vegetation.

A long term program of native tree replanting at the Lake Clifton West site is already well established. Significant revegetation measures have already been carried out at the Lake Clifton West site, and will continue for an indefinite period to maintain the revegetated areas. Trees lost through natural attrition will be replaced. Some 46,000 trees of mainly *Eucalyptus sp.* have been planted, with species selection based on advice provided by CALM officers.

The proposed planting program would be extended to include the proposed approximately 1300 lot development (where appropriate), and would total 80,000 trees. The equivalent area of revegetation is estimated to be about 100 ha, assuming 800 stems per ha as used for woodlot plantation forest[3]. We estimate that this represents a reduction in increased recharge of approximately 180,000 kL/y, or about 44% of the increased recharge.

7.5.2 Road Verges

Road verges will be revegetated to at least shrub cover up to the edge of the road. This will reduce increased recharge resulting from road envelope clearance as well as providing water-sensitive drainage for road run-off, thereby reducing recharge from the paved road surface (revegetated swales along the roadside will encourage evapo-transpiration of road run-off, thereby reducing the assumed recharge rate from the paved surface). These will also provide effective pollutant traps for contaminants in the run-off. Drainage to vegetated infiltration basins will be used for peak rainfall events.

7.5.3 Groundwater Pumping and Irrigation

Groundwater pumping will be carried out at selected locations to stock storage freshwater lagoons that will serve as irrigation reservoirs for the village greens. They will also provide artificial wetlands, increasing the wetland habitats for the area. Based on average rainfall and evaporation data, and using Victorian EPA guidelines for pasture irrigation requirement (EPAV, 1992), we estimate that approximately 154,400 kL groundwater per year will be required for irrigation of greens to contribute to achieving pre-development hydrological conditions (see spreadsheet attached at Appendix A). This represents a further 38 % reduction in the increased recharge for the proposed development.

7.5.4 Water-Sensitive Design

The approximately 1300 lot development will embrace a range of water-sensitive design measures to assist in reducing recharge to groundwater, in keeping with CBI's commitment to achieving an environmentally sensitive development. For individual residences these will include:

- use of gutterless roofs to equalise storm flows and direct water to subsurface infiltration pipes rather than soak wells; and
- minimum clearance of lots, particularly larger ones, so that existing vegetation (coastal heath) is maintained.

Measures to be taken for roadways are outlined in Section 7.5.2.

The overall impact of water-sensitive design measures on reducing extra recharge is difficult to estimate. However, if the residential and roadside water-sensitive design measures reduce recharge from hard surfaces from the assumed 80% of rainfall to 70%, the overall effect will be to reduce the increased recharge by about 64,000 kL/y, or 16 % in the estimated increased recharge.

[3] Natural forest areas may have less stems per hectare.

7.5.5 *Conclusion*

Measures to be taken to reduce the additional recharge to the groundwater aquifer at the site caused by the clearing of vegetation for development, together with an estimate of their contribution to achieving zero additional recharge above pre-development conditions, are summarised in the table below:

Measure	Reduction in Recharge (kL/y)	Reduction in Recharge (%)
Revegetation	180,000	44
Vegetated Swale Drains	Not included	-
Groundwater Pumping	154,362	38
Water-Sensitive Design	63,900	16
Total	**398,262**	**98 %**

We therefore conclude that, taken together, the measures for reducing the increased groundwater recharge resulting from development of the approximately 1300 lot development can achieve a hydrological balance over the site to ensure that pre-development hydrological conditions are maintained. The estimates of increased recharge and its reduction are the most conservative by assuming 'worst case' recharge conditions, and are made using the same methodology employed by the EPA.

8. Nutrients

Nutrient loadings within the catchment are one of the key environmental factors considered by the EPA for any development that occurs in the Lake Clifton catchment. Water quality issues are already noted as being of concern for current freehold land abutting the eastern margin of lake from rural developments in the Coastal and Lakelands Planning Strategy (WAPC, 1997).

It is proposed that the entire approximately 1300 lot development would be reticulated with deep sewerage. Sewage is one of the major sources of nutrients from human settlement, and will therefore be exported from the catchment to the proposed Tims Thicket waste water treatment plant. This avoids disposal and build up of nutrients at point sources from septic tanks, amended soil systems or individual aerobic treatment units in the sensitive Lake Clifton catchment as would normally happen for a rural or semi rural development.

The development is based on small lots in a rural road setting. Therefore the land that is physically impacted upon is approximately 15% of the proposed total land holding for the development. This is significantly less than a rural or semi rural development where the land would be controlled by private land holders. This allows for maintaining significant amounts of existing vegetation and landforms for the area as well as effectively reducing the catchment size for nutrient loadings (up to 80%) in the Lake Clifton catchment. Further, there are no opportunities for incompatible horticulture or stock usage (a significant source of nutrients) to occur in the proposed development.

The proposed land exchange creates a significant land buffer between development and Lake Clifton. Whilst the nutrient retaining capacity of the soils in the area are relatively low, nutrient uptake by vegetation within the buffer area would be expected, providing a significant filtering mechanism for any nutrients migrating with the groundwater towards the lake.

The creation of the land buffer, avoidance of rural and semi rural land practices and the low proportion of land (15%) of land clearing will protect Lake Clifton and provide a greater degree of control of land use within the western portion of its catchment. These measures directly address concerns regarding nutrient inputs to the lake from its catchment outlined in the Coastal and Lakeleands Planning Strategy.

9. Jetty

CBI is currently investigating the option of constructing a fishing Jetty with possible boat launch facility and sheltered harbour. The proposed structures would have minimal effect on littoral sand drift along the coastline. They would enable a local launching and recreational facility that would enhance the recreational facilities that are available for the area. Further, they would give an access point that would enable more people to enjoy and utilise the Cape Bouvard Reef which is located offshore.

10. Bushfire Strategy

10.1 Major Control Strategy

- The fire containment within the site will be by major fire breaks along the north and south boundaries. These breaks will be chemically cleared as an alternate to mechanical clearing to allow the break to be utilised as emergency access across the site.
- Internal roads provide distinct cells for fire containment and fighting.
- Within the dune system the network of roads and footpaths will be utilised as firebreaks. The width of paths to be effective would need to be 3 m cleared width.
- A network of 53 hydrants on mains water supply will be installed.
- Four quick fill header tanks would be constructed to provide water into the National Park. One near the southern boundary, one along the eastern boundary and two along the water supply route through the Park to the north.

10.2 Emergency Egress

The fire escape routes have been considered on two levels:

1. Medium size event threatening pockets of residences.
2. Large event threatening most of the residences.

10.2.1 Medium Events

The development plan for the roads has allowed for dual access to most blocks and limited the cul-de-sac length to approximately 250 m. These features enable most blocks to have quick egress from a fire. The additional benefit exists in the footpath network which does not follow the roads but infills through the parkland areas and connects with the roads at culs-de-sac and mid-points along the roads. The footpath network could in emergencies be used by vehicles if road egress is not available.

10.2.2 Large Events

The development does rely upon one major road to access the site built to a sealed standard. Whether the access is to the east or north there are fire scenarios which could remove this road as an egress and trap people into life threatening situations.

The need to have an alternate emergency fire egress is essential.

For the major access option to be the northern route then an egress through the tracks in the southern section of the Yalgorup National Park is required.

For the major access option to be the eastern lake crossing then an egress through the tracks in the northern section of the Yalgorup National Park is required.

The connection point to tracks in the National Park will be unobtrusive and while clearly signed as an emergency route they will be designed to discourage *ad hoc* usage.

11. References

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Appendix A

Balance Calculation

Cape Bouvard Investments
Water Balance Calculation 1300 Lots

	1300 lots		CALCULATION
A	Area going from existing vegetation to 'paved' (m2)	710,000	
B	Area going from existing vegetation to 'pasture' (m2	100,000	
C	Annual rainfall (m)	0.9	
D	Increased recharge for area going to 'paved' (m3)	383,400	[A/2 x (0.8-0.1) x C] + [A/2 x (0.8-0.3) x C]
E	Increased recharge for area going to 'pasture' (m3)	9,000	B/2 x (0.3-0.1) x C
F	Increased recharge from garden application (m3)	13,650	1300 x 0.25 x 42
G	**Total increased recharge (m3)**	**406,050**	D + E + F

Water Balance Calculation 1300 Lots - Water Sensative Design

	1300 lots		CALCULATION
A	Area going from existing vegetation to 'paved' (m2)	710,000	
B	Area going from existing vegetation to 'pasture' (m2	100,000	
C	Annual rainfall (m)	0.9	
D	Increased recharge for area going to 'paved' (m3)	319,500	[A/2 x (0.7-0.1) x C] + [A/2 x (0.7-0.3) x C]
E	Increased recharge for area going to 'pasture' (m3)	9,000	B/2 x (0.3-0.1) x C
F	Increased recharge from garden application (m3)	13,650	1300 x 0.25 x 42
G	**Total increased recharge (m3)**	**342,150**	D + E + F

Difference **63,900**

CAPE BOUVARD INVESTMENTS
Lake Clifton Development Water Balance - Irrigation Usage

		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YEAR
MEAN EVAPORATION (Class A Pan) - Medina		mm	265	228	188	116	70	52	54	70	93	139	185	231	1691
MEAN EVAPORATION - adjusted for bird guard	A	mm	288	247	204	126	76	56	59	76	101	151	201	251	1835
RAINFALL - mean Medina	B1	mm	5	33	21	38	111	162	162	117	79	42	39	10	819
EFFECTIVE RAINFALL (from Table 7A, EPAV 1991)	B2	mm	5	33	20	29	70	100	101	77	56	35	34	10	570
POTENTIAL EVAPORATION I* x A	C1	mm	201	173	143	76	38	25	23	34	55	98	141	175	1183
IRRIGATION REQUIREMENT C1 - B2	C2	mm	196	140	123	47	0	0	0	0	0	63	107	165	841
TOTAL WATER FOR IRRIGATING 10 Ha 100 x C2	F	kL	19627	14017	12279	4652	0	0	0	0	0	6303	10651	16544	84072
NET EVAPORATION FROM 10 Ha PONDS**	D	kL	23350	17220	14820	6640	-4800	-11520	-11340	-5400	470	8310	12750	19790	70290
VOLUME OF GROUNDWATER REQUIRED D + F	E	kL	**42977**	**31237**	**27099**	**11292**	**-4800**	**-11520**	**-11340**	**-5400**	**470**	**14613**	**23401**	**36334**	**154,362**
AREA AVAILABLE FOR IRRIGATION	G	Ha													**6.5**
		UNIT	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YEAR
* Crop Co-efficient - pasture	I		0.7	0.7	0.7	0.6	0.5	0.45	0.4	0.45	0.55	0.65	0.7	0.7	
** D = 10 x (0.9A - B1) x 10															

FLORISTIC COMMUNITY TYPES AND COMPARABLE VEGETATION UNITS IN THE PROPOSED WHITE HILL ROAD TO LAKE CLIFTON WEST ACCESS ROAD ROUTE CORRIDOR

CITY OF MANDURAH

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SUMMARY

This report presents the results of a desktop study of vegetation in a 36-37 ha area within which it is proposed to construct an access road from White Hill Road to a residential development site west of Lake Clifton. This area is referred to in the study as the 'Core Study Area'. The study places the vegetation of the Core Study Area in the regional context of the broader Yalgorup area, the 'Broader Study Area'.

Results of field work in June 1998 following preparation of the desktop study report are also presented.

Reference is made to the 1:250,000 scale vegetation maps of Beard and Heddle *et al.* Beard's map has three plant formations (and associations) in the Core Study Area. These are Coastal Heath and Thicket, Tuart Woodland (e_4Mi) and *Melaleuca acerosa* Heath on Limestone (m_4Zc). The map by Heddle *et al.* has three vegetation complexes in the Core Study Area, but they are not coincident with Beard's plant formations. These three vegetation complexes are Quindalup Coastal Dune Complex (55), Cottesloe Complex – Central and South (52) and Yoongarillup Complex (56).

The principal systems of vegetation classification used in the study are the floristic community types of Gibson *et al.* and the system used by M. Trudgen in his 1:25,000 scale mapping of coastal vegetation in the City of Mandurah. There are 19 Trudgen vegetation units in the Core Study Area, which are put into ten groups that correspond with six floristic community types. These are listed in Table 4, along with brief descriptions of the ten groups of Trudgen vegetation units.

The six floristic community types in the Core Study Area are 21a, 25, 26a, 26b, 27 and 29b.

Floristic community type 29b is the floristic community type which best matches Trudgen's 1991 map and his descriptions of one of the two most extensive kinds of vegetation in the Core Study Area. The current study recognises two groups in Type 29b: Dune crests and slopes (Units AM, AsM, AsAr) and dune swales and lower slopes (Units Ar_2, Xp/Ar, Xp, ArXp, AsArXp?).

The other most extensively represented kind of vegetation in the Core Study Area is tuart woodland that corresponds to floristic community type 25. The current study recognises four groups in Type 25: Tuart and peppermint woodland (Unit EAA/EAL), Tuart and peppermint woodland with *Xanthorrhoea preissii* (Unit EgAfX), Tuart woodland with *Banksia attenuata* and *Allocasuarina humilis* (Unit EBAh) and Tuart woodland largely cleared at least of native understorey [Units Eg(PC), EgPC, EgXp(C)].

The other four floristic community types in the Core Study Area are all small and avoidable by the access road project. Each of the four corresponds to one group of Trudgen units. One is Type 21a, a *Banksia attenuata* low woodland or forest (Unit Ba_2), and the other three are limestone types: 26a (part of Unit DS), 26b (parts of Units DS and DsAt and possibly Unit Ef) and 27 (Units MG_2, AT and part of DsAt).

Table 5 lists sizes of areas covered by floristic community types and groups of Trudgen vegetation units in the Core Study Area and outside of it and from them infers potential impacts. The table lists sizes of areas that might be affected by construction of a 10 m wide access road. It also refers to proportions of each type's and group's total area in the Vegetation Map 1 area which might be directly affected by the project.

The maximum proportion of the total area of floristic community type 29b in the Vegetation Map 1 area that might be directly affected by construction of the proposed access road is calculated to be 0.0075, or 0.75%. The proportion of floristic community type 29b that might be affected in relation to its overall distribution is, however, very much less than 0.0075.

The new proposed route, which is the result of modifications made after field work, is almost all in Types 29b and 25. It now avoids all except one small area of Type 27 limestone vegetation, all Types 26 limestone vegetation and all Type 21a *Banksia attenuata* vegetation. The type 25 tuart and peppermint vegetation it traverses has no native understorey.

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FLORISTIC COMMUNITY TYPES AND COMPARABLE VEGETATION UNITS IN THE PROPOSED WHITE HILL ROAD TO LAKE CLIFTON WEST ACCESS ROAD ROUTE CORRIDOR

CITY OF MANDURAH

1.0 INTRODUCTION

This report lists and describes vegetation that might be affected by the proposed construction of a road to provide access from White Hill Road to a residential development site west of Lake Clifton. It was originally done as a desktop study which was part of a route selection process designed to minimise potential impacts of road construction on significant vegetation and rare flora. Other aspects of the desktop route selection process included a study of rare flora (Weston 1998b) and working with engineers, surveyors, aerial photography and this report to select an optimum provisional alignment for the road. The desktop phase of the selection process was followed by fieldwork along the alignment to look for significant vegetation, rare flora and habitats for them. Modifications to the provisional alignment were made to avoid rare flora, probable habitats for it and any significant vegetation that is not dominant and well represented in the general area.

This report is an updated version of the desktop study report based upon field work done between 14 and 16 June 1998. The field work consisted of walking all of the route, except some of the northern part that coincides with an existing road and track, looking for significant flora and vegetation and habitats for them. The results of the field work are presented in Section 6.

The provisional alignment upon which the desktop phase was based is shown on Vegetation Map 1, and the new alignment, which incorporates modifications based upon the field work, is shown in Vegetation Map 2.

The text and Appendices of this updated report are the same as those of its desktop phase predecessor except for correction of a few typographic errors, modifications of the Summary, the Table of Contents and Section 1.0 and the addition of Section 6. Vegetation Map 2 has also been added.

1.1 OBJECTIVES

The objectives of this desktop study are :

- to describe and discuss floristic community types and comparable vegetation units which may be represented in the corridor for a proposed road to provide access to Cape Bouvard Investment's Lake Clifton West site,
- to place the floristic community types and comparable vegetation units in a regional context, and
- to calculate the potential impact of road construction on floristic community types and comparable vegetation units.

1.2 STUDY AREA

The study area comprises the Zone of Impact, the Core Study Area, the Vegetation Map 1 area and the Broader Study Area.

The Zone of Impact is the access road alignment plus an adjacent area that might be disturbed during construction. It is centred on the blue line shown on Vegetation Map 1. The line runs from south of White Hill Road south to the Lake Clifton West development area west of Boundary Lake and Lake Clifton. The length and width of the alignment are taken to be 9 km and 7 m, respectively. The area adjacent to the alignment is 3 m wide. The Zone of Impact is, consequently, 9 km long and 10 m wide.

The Core Study Area comprises approximately 40 ha and is the corridor for the access road alignment (and Zone of Impact) plus some areas immediately adjacent to the corridor. The corridor is approximately 36 ha in area and 40 m wide. Like the Zone of Impact, the corridor is 9 km long and is centred on the blue line shown on Vegetation Map 1. A few small areas outside the corridor are included in the Core Study Area to allow for deviation of the road alignment away from vegetation that may both be significant and cover the width of the corridor.

The precise location of the road alignment within the corridor will be chosen to minimise impacts upon rare flora, floristic community types and other vegetation units (Fredriksson pers. comm.). To achieve this goal, the location of the alignment may have to be outside the corridor in a few cases, but still within the Core Study Area.

The regional context is provided by the part of Vegetation Map 1 that has vegetation units on it and by the Broader Study Area.

Vegetation Map 1 is a 1:25,000 scale vegetation map that is photocopied and modified from Trudgen (1991). The map shows most of the coastal vegetation of the City of Mandurah part of Yalgorup National Park and nearby areas. It accompanies this report and its predecessor (Weston 1998b). The portion of the map that has vegetation units on it is approximately 420 cm^2 in area, slightly more than a third of the map's total area. The 420 cm^2 area is equivalent to 2,600 ha, or 26 km^2, on the ground. This 2,600 ha area is the 'Vegetation Map 1 area'.

The Broader Study Area includes all of Yalgorup National Park plus a few nearby areas. The Broader Study Area is very much larger than the Core Study Area and the Vegetation Map 1 area.

1.3 BACKGROUND

Descriptions and maps of vegetation that include the Yalgorup area prepared in the 1970s and 1980s were based primarily upon structure of the vegetation and dominant, generally tallest species in at least the tallest stratum, or upon correlations with soil and landform units.

Maps by Beard (1979, 1981) and Trudgen (1991) are based primarily upon the first approach. Beard's 1:250, 000 scale 1979 map has three plant formations (and two associations) in the Core Study Area. These are Coastal Heath and Thicket, Tuart Woodland (e_4Mi) and *Melaleuca acerosa* Heath on Limestone (m_4Zc).

The map by Heddle *et al.* (1980) is based primarily upon the second approach, in particular the mapping by Churchward and McArthur (1980). It has three vegetation complexes in the Core

Study Area, but they are not coincident with Beard's plant formations. These three vegetation complexes are Quindalup Coastal Dune Complex (55), Cottesloe Complex – Central and South (52) and Yoongarillup Complex (56).

More recently, Gibson *et al.* (1994) used a floristic community approach to describing and classifying the vegetation of the southern Swan Coastal Plain, including the Yalgorup area. This approach is based upon total species occurrences in sampling quadrats (or plots) and similarities between the quadrats. The 509 quadrats Gibson *et al.* sampled were in bushland areas on public land where soil and landform units and plant community patterning identified by previous studies could best be sampled. Subsequently, 619 additional quadrats were sampled on public land and, for the most part, in types of vegetation that were undersampled during the earlier study (Keighery 1997).

2.0 METHODS AND SOURCES

2.1 DESCRIPTIONS AND DISCUSSIONS

The following descriptions and discussions of floristic community types and comparable vegetation units are based primarily upon descriptions, maps and other information in various reports, discussions with staff of government departments and interpretation of aerial photographs. The reports are Weston and Gibson (1997), Weston (1998a, 1998b), Trudgen (1991), Gibson *et al.* (1994), Keighery (1997) and Department of Environmental Protection (1996) and the staff are in the Departments of Environmental Protection and Conservation and Land Management.

The geomorphic elements maps in Weston (1998b) and Wells and Hesp (1989) were used for deciding which of the groups of Trudgen vegetation units, particularly the tuart ones, are Quindalup, Spearwood or Vasse. In the case of the Core Study Area, the Vasse V6 Geomorphic Element is more or less equivalent to the Yoongarillup soil and landform unit of Churchward and McArthur (1980).

Magnified stereoscopic views of pairs of 1:20 000 scale Metro Regional Area aerial photography flown in January 1998 supplemented Trudgen's map and his descriptions of vegetation.

2.2 CALCULATION OF POTENTIAL IMPACTS

The calculation of potential impacts upon floristic community types are based upon the assumption that the Trudgen (1991) vegetation units, or groups of them, in the Core Study Area have floristic community type counterparts. This assumption is supported by similarities of structure, species composition, habitats and locations between the community types and the vegetation units.

Measures of potential impacts were calculated from three primary sets of figures:

- the total length in kilometres of sections of the Core Study Area in which each of the groups of Trudgen vegetation units occurs,

- the width of the Zone of Impact, and

- the number of 1 mm squares, or their equivalents, on Vegetation Map 1 that are filled with each group of Trudgen vegetation units.

The lengths of occurrence of groups of Trudgen vegetation units in the Core Study Area and, consequently, of their floristic community type counterparts, were determined by running a K & R opisometer along the blue line on Vegetation Map 1 to work out distances in kilometres along that line and also along parallel lines in the Core Study Area, which are not shown on the map. Each length is the maximum possible length of a type or group of units in a potential Zone of Impact (there are numerous, if not an infinite number of, potential Zones of Impact).

The width of the Zone of Impact is 10 m, as stated in Section 1.2. Consequently, the figure for the kilometres length of a section of the Zone of Impact is the same as the figure for the hectares area of the same section.

To calculate coverage of the Vegetation Map 1 area by groups of Trudgen vegetation units, the map was overlain with transparent graph paper divided into 1 mm squares. Then the 1 mm squares, or their equivalents, that were filled with each group of Trudgen vegetation units were counted. The number of squares of each group of units was then transformed into hectares of coverage in the Vegetation Map 1 area by dividing the number of squares by 1600 and multiplying the resulting figure by 100. Because the map scale is 40 mm to 1 km, 1 sq km is represented by 40 mm times 40 mm: 1600 sq mm.

The proportions of the groups of Trudgen vegetation units in the Vegetation Map 1 area that are also in the Zone of Impact were calculated by dividing the number of hectares they would occupy in the Zone of Impact by the number of hectares they occupy in the Vegetation Map 1 area.

All of these figures and the equations used for calculating figures from other figures are listed in Table 5.

3.0 FLORISTIC COMMUNITY TYPES AND COMPARABLE VEGETATION UNITS

The floristic community approach to vegetation classification and description gives equal weight to all vascular plant species in plant community sampling quadrats (sites or plots), which are uniformly 10 m by 10 m squares. These are referred to in this report as Gibson quadrats. The presence or absence of individual species in the quadrats is, with the aid of computerised multivariate analysis techniques, used to define floristic community types (or other groupings) based on shared species and groups of species having high frequencies of co-occurrence.

Gibson *et al.* (1994) used analyses of their 509 southern Swan Coastal Plains survey quadrats to define 43 floristic community types. Analyses of subsequent 613 quadrats led to 23 additional floristic community types being defined.

The most accurate way to determine which floristic community types are in the Core Study Area would be to select, sample and analyse Gibson quadrats using the techniques described by Gibson *et al.* (1994) and Keighery (1994). It is possible, however, and more practicable in this case, to infer floristic community types. Inferences can be made either from information on the area's floristics and its geographical location (as in Keighery *et al.* 1997) or from existing vegetation

maps and descriptions such as Trudgen's (1991). For this study, community floristic types are inferred mainly from Trudgen's vegetation maps and descriptions for both the Core Study Area and the Vegetation Map 1 area.

Trudgen's units are not directly comparable with floristic community types because they are defined more by species which are dominant or most abundant (see Trudgen 1991, p. 9) than are floristic community types. Trudgen's units and groups of his units are, however, sufficiently comparable to floristic community types for the purposes of this study.

The Trudgen vegetation units in the Core Study Area and their inferred floristic community type counterparts are listed in Table 4.

3.1 REGIONAL CONTEXT

3.1.1 Floristic Community Types

Floristic community types have not been mapped, but there are 22 Gibson quadrats are in the Broader Study Area (Gibson *et al.* 1994). They cover nine community types (13, 17, 18, 21a, 26a, 26b, 27, 29a and 29b), which are listed in Table 1. The 22 quadrats are listed in Table 2.

There is an additional community type described in Gibson *et al.* which undoubtedly is also in the study area. This is Type 25, the nearest quadrat of which is outside the Broader Study Area. This type and the quadrat are also listed in Tables 1 and 2. The north-south distributions of these ten floristic community types and information about their habitats are given in Table 3.

The original Gibson *et al.* (1994) southern Swan coastal plain study sampling of seasonal wetlands did not adequately represent their great heterogeneity. Also, because the study was mostly limited to public lands, it undersampled Quindalup dunes, where there are few reserves and little other public land (Keighery 1997). Consequently, floristic community types may not have been defined for some of the seasonal wetland and Quindalup dune vegetation in at least the Broader Study Area. Furthermore, some of the vegetation there may fit one or more of the newer community types listed by Keighery (1997), such as 19a and S11, even though none of their defining quadrats is known to be located in the study area or near it.

3.1.2 Trudgen Vegetation Units

The vegetation study of Trudgen (1991) covers all of the Core Study Area in much greater detail and at a much larger scale than Gibson *et al.* However, it covers only the coastal, northern third or less of the Broader Study Area, from the City/Shire boundary about 2 km south of the Core Study Area to Mandurah. Most of the vegetation units in the Core Study Area are shown on Trudgen's vegetation maps as occurring only south of a point less than 2 km north of White Hill Road.

More specifically, Trudgen (1991, p. 11) comments that "From just north of the White Hills Road a large series of Q2 and Q1 dunes extends southwards, and these are somewhat different, probably partly because they are taller." He also comments (p. 58) that the Q2 dune occurrence continues southward from the study area to near the north end of Lake Preston, from where it gradually tapers off.

Trudgen's map indicates that limestone, other Spearwood and Vasse vegetation units southwards from just south of White Hill Road are also different.

3.2 CORE STUDY AREA

3.2.1 Trudgen Vegetation Units

The ten groups of Trudgen vegetation units in the Core Study Area are listed in Table 4 along with the floristic community types of which they are counterparts, some of their dominant species and the corresponding geomorphic elements. The 19 Trudgen vegetation units contained in the ten groups are also listed in the table.

3.2.2 Floristic Community Types

Table 4 lists the six floristic community types in the Core Study Area and the comparable Trudgen vegetation units from which their occurrence there was inferred. The floristic community types are 21a (*Banksia attenuata*), 25 (tuart), 26a (limestone), 26b (limestone), 27 (limestone) and 29b (Quindalup dunes and swales).

Floristic community type 29b is the floristic community type which best matches Trudgen's 1991 map and his descriptions of the most extensive kind of vegetation in the Core Study Area. The current study recognises two groups in Type 29b: Dune crests and slopes (Units AM, AsM, AsAr) and dune swales and lower slopes (Units Ar_2, Xp/Ar, Xp, ArXp, AsArXp?).

The second most extensively represented kind of vegetation in the Core Study Area is tuart woodland that corresponds to floristic community type 25. This study recognises four groups in Type 25: Tuart and peppermint woodland (Unit EAA/EAL), Tuart and peppermint woodland with *Xanthorrhoea preissii* (Unit EgAfX), Tuart woodland with *Banksia attenuata* and *Allocasuarina humilis* (Unit EBAh) and Tuart woodland largely cleared at least of native understorey [Units Eg(PC), EgPC, EgXp(C)].

The other four floristic community types in the Core Study Area are all small and avoidable by the access road project. Each of the four corresponds to one group of Trudgen units. One is Type 21a, a *Banksia attenuata* low woodland or forest (Unit Ba_2), and the other three are limestone types: 26a (part of Unit DS), 26b (parts of Units DS and DsAt and possibly Unit Ef) and 27 (Units MG_2, AT and part of DsAt).

3.3 CONSERVATION AND RESERVATION STATUS

3.3.1 Floristic Community Types

Conservation and reservation status codes provided by Gibson *et al.* (1994) of floristic community types in the Broader Study Area are listed in Table 1. The floristic community types proposed by English and Blyth (1997) for inclusion on the Threatened Ecological Community Database are also indicated in the table.

Gibson *et al.* describe floristic community type 19 as one restricted to the Becher Point area between Rockingham and Mandurah, but, according to Keighery and Trudgen (pers. comms.), it or its subdivision Type 19a may occur in or near the Broader Study Area. Type 19 is sedgelands in Quindalup Holocene swales between linear dune features (Gibson *et al.* 1994 and Keighery 1997). English and Blyth (1997) list Type 19 as Critically Endangered, Priority 1 and proposed for inclusion on the Threatened Ecological Community Database (Rank No. 9).

Conservation and reservation statuses of the six Core Study Area floristic community types are described here. Gibson *et al.* (1994) considered Types 21a, 26b and 27 to be well reserved and at low conservation risk and Types 25 and 29b to be poorly reserved and susceptible. Type 26a, listed by Gibson *et al.* as unreserved and susceptible, now has a proposed conservation status of critically endangered (Weston and Gibson 1997). Gibson *et al.* regarded Type 27 as largely restricted to the Yalgorup area, but it is now known also to be well-represented in the Yanchep area (Weston and Gibson 1997). Floristic community types 25, 26a and 29b are proposed by English and Blyth (1997) for inclusion on the Threatened Ecological Community Database (Rank No. 99, 72 and 101, respectively).

3.3.2 Trudgen Vegetation Units

Trudgen (1991) does not provide codes for conservation and reservation status of his vegetation units, but he does supply general assessments on the conservation value and reservation status of the vegetation. Also, he notes that two of his units that are represented in the Core Study Area have limited distributions in his study area.

According to Trudgen (1991, pp. 57), stands of tuart in the study area, particularly those with understories of native plants, are of very high conservation value. Trudgen (p. 58) also rates the conservation value of Q2 dune vegetation as very high, even though he considers it to be well represented in Yalgorup National Park. He gives it a very high rating at least partly because there is a north-south transition in the vegetation on the dunes in his study area. He rates the conservation value of vegetation on the Q1 dunes and limestone areas as high.

Trudgen notes that Unit AT has a limited distribution in his study area and that he observed Unit Xp/Ar at only one site. The AT unit is most extensive on limestone near White Hill Road west of the Core Study Area. The Xp/Ar unit is intermediate between Xp and Ar units and is in a broad swale between Q2 and Q1 dunes and very low limestone rises with heath that is mapped by Trudgen as MG_2.

4.0 POTENTIAL IMPACTS

Table 5 gives five sets of figures concerning potential impacts of the access road construction on vegetation. Four of the sets of figures were used to calculate two measures of potential impact on each of ten groups of Trudgen vegetation units and each of six comparable floristic community types.

The two measures are:

- the maximum total area, in hectares, of sections of the Zone of Impact occupied by each group of Trudgen vegetation units and floristic community type, and
- the proportions of Zone of Impact group and type vegetation areas in relation to vegetation areas in the Vegetation Map 1 area of which they are parts.

The four sets of figures used for calculating the two measures are:

- the maximum total length, in kilometres, of sections of the Core Study Area in which each of the groups of Trudgen vegetation units and floristic community types occurs,

- the maximum total area, in hectares, of sections of the Zone of Impact occupied by each group of Trudgen vegetation units and floristic community type,

- the number of 1 mm squares, or their equivalents, on Vegetation Map 1 that are filled with each group of Trudgen vegetation units and floristic community type, and

- the total area, in hectares, in the Map 1 area of each group of Trudgen vegetation units.

The first set of figures and the width of the Zone of Impact (10 m) were used to calculate the second set of figures and the first measure of impact: the maximum sizes of the areas of vegetation that construction of the access road could affect directly. The first set of figures is in Column 3 of Table 5 and the second is in Column 4 of Table 5.

The total length of the sections of the Zone of Impact listed in Column 3 is greater than the length of the Core Study Area (or of the Zone of Impact, which is the same length as the Core Study Area). This is because some of the groups of units occur parallel to each other in the same section of the Core Study Area.

The third set of figures was used to calculate the fourth set. It is in Column 5 of the table.

The second and fourth sets of figures were used to calculate the second measure of impact. This measure is the proportion of largest possible occurrences in the Zone of Impact to the total area on the Map 1 area of each group of units in the Core Study Area. The second and fourth sets of figures are in Columns 4 and 6, respectively. Proportions of each of the ten groups of Trudgen vegetation units and six floristic community types in the Core Study Area are given in Column 7.

The maximum proportion for floristic community 29b, with a much larger area of vegetation that will be affected by road construction than the area of vegetation of any other floristic community type, is 0.0075, or 0.75%.

The proportion of the Vegetation Map 1 area of each group of units and comparable floristic community types that construction of the road would directly affect is actually less than the corresponding figure in Column 7. The reason is that the Core Study Area length figures upon which the measure of impact figures are based are maximums for each community floristic type and group of Trudgen vegetation units. The actual lengths for some, such as Types 21b and 26a, will be zero.

Furthermore, Trudgen's 1991 vegetation map, of which Vegetation Map 1 is almost the southern part (Trudgen's map extends approximately 2 km further south), covers coastal vegetation which is only in the City of Mandurah. Most, if not all, of the vegetation units represented in the Core Study Area undoubtedly extend beyond, in some cases well beyond, the limits of both Vegetation Map 1 and Trudgen's set of maps. The report by Gibson *et al.* (1994) shows distributions of all of the floristic community types represented in the Core Study Area as extending well beyond the Broader Study Area.

5.0 DISCUSSION

At least ten defined floristic community types occur in the Broader Study Area. There may be others there which are not yet defined or recorded.

Six floristic community types – 21, 25, 26a, 26b, 27 and 29b – are inferred to occur in the Core Study Area because Trudgen's vegetation map shows comparable vegetation units there.

The actual number and nature of floristic community types that would be affected by construction, use and maintenance of the access road can be minimised by aligning the road to avoid as many types of soils, landforms and vegetation as possible. It would be impossible to avoid Type 29b Quindalup dune vegetation and some Type 25 tuart vegetation. It should, however, be possible to avoid the other four floristic community types represented in the Core Study Area, as well as a large part of the tuart vegetation.

Stereoscopic interpretation of recently flown aerial photography suggests that it would be possible to find an access route within the corridor or near it which would avoid totally the small areas of Type 21a *Banksia attenuata* vegetation and the three limestone floristic community types, Types 26a, 26b and 27. Possible deviations of the route outside the corridor, but still within the Core Study Area, to accomplish this would be few, if any.

It may also be possible to avoid damage to most, if not all, of the tuart vegetation, by using existing tracks and firebreaks running south from White Hill Road, then southwest and west, mostly through partly cleared tuart.

The Vegetation Unit Xp/Ar area is the only part of the Core Study Area mapped by Trudgen as Quindalup vegetation that is not shown on the Wells and Hesp (1989) and Weston (1998b) map as Quindalup Qp1 geomorphic element. It is, instead, shown as Quindalup Qp2 long-walled discrete parabolic dunes and Spearwood S2b lower dune slopes with common limestone outcrop.

Field work will be needed to assess the significance of the anomalous Xp/Ar vegetation. If it does turn out to be significant, it can be avoided by shifting the road alignment eastward or westward up to a few hundred metres.

Minimising the width of the track to 7 m or less and obtaining road materials from totally cleared areas would help to minimise damage to tuart woodland and other native vegetation.

A winter field survey through the Core Study Area to help with route selection is being planned. It will be a vegetation, rare flora and habitat survey through the Core Study Area undertaken with the aim of selecting an environmentally optimum route which is probably, as much as possible, restricted to sand dune slopes and relatively dry sandy flats.

6.0 RESULTS OF FIELD WORK

As a result of observations made during the 14-16 June field work the pegged provisional route was shifted westward at several points and eastward at two points to avoid all areas of limestone vegetation except one. The one exception is a *Dryandra sessilis* scrub which may be a representation of floristic community type 27, Species poor mallees and shrublands on limestone.

This scrub is at what was, at the time of the field work, between the 6900 m and 6950 m pegs, at a northing of approximately 6376350. This is a narrow neck in a depression and in a population of *Dryandra sessilis* and *Hakea* sp. Yalgorup which becomes denser and broader on the slopes either side of the neck. For the route to avoid the *Dryandra – Hakea* vegetation entirely, it would have to be deviated several hundred metres westward and would have to go over crests of high dunes. If it stays in the depression and goes through the neck, impact on the population could probably be restricted to damage to fewer than 20 plants of each species, out of a population which probably exceeds 1000 plants of each species.

Floristic Community Type 29b (*Acacia* shrublands on taller Quindalup dunes) is the principal, described Floristic Community Type represented along the route, especially in the southern one-half to two-thirds of it. The maximum proportion of the total area of Type 29b which is shown on Vegetation Maps 1 and 2 that might be affected by construction of an access road no more than 10 m wide along the route shown on Vegetation Map 2 should be no more than the figure calculated during the desktop phase, 0.0075. The proportion of Type 29b that might be affected in relation to its overall distribution would, however, be very much less than 0.0075.

Floristic Community Type 25 (Southern *Eucalyptus gomphocephala – Agonis flexuosa* woodlands) is represented in part of the route south of the limestone road, but with an almost 100% weedy ground layer.

So long as the route is on the limestone road and no wider than it, it avoids floristic community type 21a (*Banksia attenuata*) entirely.

The route selected through the Quindalup Qp2 long-walled discrete parabolic dunes and Spearwood S2b broad swale or basin with the anomalous Xp/Ar vegetation avoids limestone outcrop, *Dryandra sessilis* scrub and other unusual vegetation. Also, it minimises impacts on parabolic dunes around the basin by crossing them over low points in their crests.

7.0 ACKNOWLEDGEMENTS

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Table 1
Floristic Community Types which are or may be in the Broader Study Area and their Conservation and Reservation Status

(based upon information in Gibson *et al.* 1994 and Keighery 1997)

Key

Column 1: Codes of Floristic Community Type

Column 2: General descriptions of Floristic Community Types
Descriptions are taken from Keighery (1997, Table 1).

Column 3: Threatened Ecological Communities (from English and Blyth 1997)
V – Vulnerable, Priority 3 and proposed for inclusion on the Threatened Ecological Community database, Y - proposed for inclusion on the Threatened Ecological Community database

Column 4: Reservation Status (from Gibson *et al.* 1994)
P – Poorly reserved, U – Unreserved, W – Well reserved

The reservation status of community type 26a is now probably 'poorly reserved', rather than 'unreserved'.

Column 5: Conservation Status (from Gibson *et al.* 1994)
C – Critically endangered, L – Low risk, S – Susceptible, V – Vulnerable

Weston and Gibson (1997) recommended that the conservation status of community type 26a be changed from 'susceptible' to 'critically endangered'.

Column 6: Floristic Community Types recorded by Gibson *et al.* (1994) as being in or near the Broader Study Area

Supergroup 2 – Seasonal Wetlands

13	Deeper wetlands on heavy soils		W	L	X
17	*Melaleuca rhaphiophylla – Gahnia trifida* seasonal wetlands		W	L	X
18	Shrublands on calcareous silts	V	P	V	X
21a	Central *Banksia attenuata – Eucalyptus marginata* woodlands		W	L	X

Supergroup 4 – Uplands centred on Spearwood and Quindalup Dunes

Spearwood Dunes					
25	Southern *Eucalyptus gomphocephala–Agonis flexuosa* woodlands	Y	P	S	
26a	*Melaleuca huegelii – M. acerosa* shrublands of limestone ridges	Y	U/P	S/C	X
26b	Woodlands and mallees on limestone		W	L	X
27	Species poor mallees and shrublands on limestone		W	L	X
Quindalup Dunes					
29a	Coastal shrublands on shallow sands	Y	P	S	X
29b	*Acacia* shrublands on taller dunes	Y	P	S	X

Table 2
Quadrats of Floristic Community Types which are in the Study Area or Nearby

(based upon information in Gibson *et al.* 1994 and Keighery 1997)

Key

Column 1: Codes of Floristic Community Types
Column 2: Quadrat (Site, Plot) Codes
Column 3: Meaning of Quadrat Codes
Column 4: Bushland Areas
Column 5: Latitudes (in degrees)
Column 6: Longitudes (in degrees)
Column 7: Altitudes (in metres)

Supergroup 2 – Seasonal Wetlands

13	McLART-1	McLarty N. R.	Near Yalgorup – C51	32.6938	115.705	5
17	ELLIS-1	Ellis [Road]	Yalgorup N P – C54	32.9305	115.716	5
18	ELLIS-2	Ellis [Road]	"	32.9311	115.713	5
18	ELLIS-3	Ellis [Road]	"	32.9306	115.715	5
21a	CLIF-1	Lake Clifton Townsite	Near Yalgorup N P	32.8190	115.696	40

Supergroup 4 – Uplands centred on Spearwood and Quindalup Dunes

Spearwood Dunes						
25	CORON-2	Coronation? (Treasure/ McClarty SF block)	State Forest 16 (C56) near Yalgorup N P	32.8706	115.727	40
26a	CLIF-2	Lake Clifton Townsite	Near Yalgorup N P	32.8171	115.687	35
26a	CLIF-3	Lake Clifton Townsite	"	32.8165	115.688	35
26b	WHILL-5	White Hill	Yalgorup N P – C54	32.6907	115.619	5
26b	YALG-1	Yalgorup N. P.	"	32.9149	115.690	20
26b	YALG-2	Yalgorup N. P.	"	32.9155	115.691	20
26b	YALG-6	Yalgorup N. P.	"	32.9170	115.695	30
26b	YALG-7	Yalgorup N. P.	"	32.9179	115.698	20
27	WHILL-3	White Hill [Road]	"	32.6918	115.619	20
27	WHILL-4	White Hill [Road]	"	32.6915	115.619	10
27	YALG-3	Yalgorup N. P.	"	32.9157	115.693	40
27	YALG-4	Yalgorup N. P.	"	32.9156	115.693	40
27	YALG-5	Yalgorup N. P.	"	32.9165	115.695	30
27	YALG-8	Yalgorup N. P.	"	32.9169	115.698	20
Quindalup Dunes						
29a	PRES-1	Preston	"	32.8775	115.664	20
29b	NPRES-1	North Preston	"	32.8364	115.643	40
29b	WHILL-1	White Hill [Road]	"	32.6925	115.612	20
29b	WHILL-2	White Hill [Road]	"	32.6918	115.611	20

Table 3
Distributions and Habitats of Floristic Comuunity Types which are or may be in the Broader Study Area

(based upon information in Gibson *et al.* 1994)

Key

Column 1: Floristic Community Type codes

Column 2: Distributions and Habitats

Supergroup 2 – Seasonal Wetlands

13	Mainly between Serpentine and Busselton; deeper wetlands on heavy soils, primarily Bassendean and Pinjarra Plain
17	Rockingham to west of Busselton; mainly swales in Quindalup and Spearwood dunes
18	Southern Yalgorup National Park near Ellis Road; a calcareous silt flat, dampland (sensu Semeniuk 1987)
21a	Mainly between Perth and Capel; Bassendean, Spearwood and alluvial soils

Supergroup 4 – Uplands centred on Spearwood and Quindalup Dunes

Spearwood Dunes	
25	Woodmans Point to south of Capel; the southern tuart woodland and forest
26a	North of Perth and the Yalgorup area; skeletal soil on slopes and tops of limestone ridges
26b	North of Perth and the Yalgorup area; deeper soil on lower slopes and in pockets on limestone ridges
27	Yalgorup and Yanchep areas; mostly Yoongarillup limestone ridges
Quindalup Dunes	
29a	Seabird to Garden Island, with variants at Trigg and Yalgorup; shallow sands over limestone close to the coast
29b	Seabird to Yalgorup; larger dunes, varying dominants include *Acacia rostellifera, Acacia lasiocarpa* and *Melaleuca acerosa*

Table 4
Floristic Community Types, Comparable Trudgen Vegetation Units and Geomorphic Elements in the Core Study Area

(based mainly upon analysis of Vegetation Map 1, Weston 1998b, Trudgen 1991 and Gibson *et al.* 1994)

Key

Column 1: Codes of Floristic Community Types
Column 2: Codes and Groups of Comparable Trudgen Vegetation Units
See Trudgen (1991) for definitions of the codes and descriptions of the units.
Column 3: Dominant species (from Trudgen 1991)
Column 4: Geomorphic Elements (from Wells and Hesp 1989 and Weston 1998b)

Supergroup 2 – Seasonal Wetlands

21a	Ba_2	*Banksia attenuata* with *Melaleuca acerosa* and *Acacia pulchella*; scattered tuart	Spearwood S2b

Supergroup 4 – Uplands centred on Spearwood and Quindalup Dunes

Spearwood Dunes			
25	EAA/EAL	Tuart and peppermint (Unit EAA/EAL is not described by Trudgen)	Spearwood S2b/ Quindalup Qp2
25	EBAh	Tuart, *Banksia attenuata* and *Allocasuarina humilis*	Spearwood sand over limestone, S2a and S2b
25	EgAfX	Tuart, peppermint and *Xanthorrhoea preissii* (not described by Trudgen)	Vasse V6
25	Eg(PC), Eg PC, EgXp(PC)	Tuart cleared of native understorey except for, in second case, *Xanthorrhoea preissii*	Spearwood S4a and, in second case, Vasse V6
26a	Part DS	*Dryandra sessilis, Melaleuca huegelii, M. acerosa, Templetonia retusa, Grevillea preissii*	Spearwood S1a
26b	Parts DS & DsAt, Ef?	*Dryandra sessilis, Acacia truncata, Templetonia retusa, Eucalyptus foecunda?*	Spearwood S1a
27	MG_2, AT, DsAt [part]	*Acacia truncata, Melaleuca acerosa, Grevillea preissii, Hakea trifurcata*	Spearwood S2b
Quindalup Dunes			
29b	AM, AsM	Dune crests and slopes: *Acacia saligna, A. truncata, A. rostellifera, Melaleuca acerosa*	Quindalup Qp1
29b	Ar_2, Xp/Ar, Xp, ArXp, AsArXp?	Dune swales and lower slopes: *Acacia rostellifera, Xanthorrhoea preissii, Melaleuca acerosa, Lomandra maritima* (ArXp and AsArXp are not described by Trudgen)	Quindalup Qp1

Table 5
Areas and Impacts
Floristic Community Types and Comparable Trudgen Vegetation Units

(based mainly upon analysis of Vegetation Map 1 and the other tables)

Key

Column 1: Codes of Floristic Community Types
Column 2: Codes and Groups of Comparable Trudgen Vegetation Units
Column 3: Length (in kilometres: km) **of Parts of Core Study Area with each Floristic Community Type and Group of Units**
Column 4: Maximum Areas (in hectares: ha) **of Direct Impact of Road 10 m** (0.01 km) **wide** (Zone of Impact) **on Groups and Types** (Col 3 km x 0.01 km x 100)
Column 5: Number of 1 mm Squares (mm^2) **in which each Group of Units and Comparable Floristic Community Type is shown on Vegetation Map 1**
Column 6: Total Area (in hectares: ha) **in the Vegetation Map 1 Area of each Group and Type** (Col. 5 mm^2 / 1600 mm^2 x 1 km^2 x 100; based on map scale of 40 mm = 1 km)
Column 7: Proportion of each Group and Type Area on Vegetation Map 1 which is in Potential Zone of Impact (Col. 4 / Col 6)

21a	Ba_2	0.03 km	0.03 ha	650 mm^2	40.63 ha	0.0007
21a		**0.03 km**	**0.03 ha**	**650 mm^2**	**40.63 ha**	**0.0007**
Spearwood Dunes						
25	EAA/EAL	0.48 km	0.48 ha	350 mm^2*	21.88 ha	0.0219*
25	EBAh	0.33 km	0.33 ha	1150 mm^2	71.88 ha	0.0045
25	EgAfX	0.56 km	0.56 ha	1175 mm^2	73.44 ha	0.0076
25	Eg(PC), Eg PC, EgXp(PC)	1.75 km	1.75 ha	3875 mm^2	242.19 ha	0.0072
25		**3.12 km**	**3.12 ha**	**7525 mm^2**	**470.31 ha**	**0.0066**
26a	part DS	0.02 km	0.02 ha	125 mm^2	7.81 ha	0.0026
26a		**0.02 km**	**0.02 ha**	**125 mm^2**	**7.81 ha**	**0.0026**
26b	Ef, parts DS, DsAt	0.25 km	0.25 ha	1125 mm^2	70.31 ha	0.0036
26b		**0.25 km**	**0.25 ha**	**1125 mm^2**	**70.31 ha**	**0.0036**
27	MG_2, parts AT, DsAt	0.35 km	0.35 ha	375 mm^2	23.44 ha	0.0149
27		**0.35 km**	**0.35 ha**	**375 mm^2**	**23.44 ha**	**0.0149**
Quindalup Dune						
29b	AM, AsM	2.50 km	2.50 ha	6400 mm^2	400.00 ha	0.0063
29b	Ar_2, Xp/Ar, Xp, ArXp, AsArXp?	4.95 km	4.95 ha	9600 mm^2	600.00 ha	0.0083
29b		**7.45 km**	**7.45 ha**	**16,000 mm^2**	**1,000.00 ha**	**0.0075**

*or 1125 mm^2 and a proportion of 0.0068? The part of Vegetation Map 1 covered by Unit EAA/EAL, which is presumably a mosaic of Units EAA and EAL, is 350 mm^2. However, the parts of the map covered by Units EAA alone and EAL alone are, respectively, 525 mm^2 and 250 mm^2, an additional total of 775 mm^2. (350 + 775 = 1125)

POTENTIAL RARE FLORA IN THE PROPOSED WHITE HILL ROAD TO LAKE CLIFTON WEST ACCESS ROAD ROUTE CORRIDOR

CITY OF MANDURAH

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SUMMARY

A table of 22 taxa (species and subspecies) of rare flora which might occur in the Yalgorup area, along with habitat and other relevant information was compiled from CALM rare flora database printouts and other information. Then14 rare taxa were selected from the longer list as being the only ones of the 22 likely to occur in or near the 40 m wide route corridor for access to the Lake Clifton West development site from White Hill Road. These taxa are:

Astroloma sp. Yalgorup	(P2)	*Hibbertia spicata* subsp. *leptotheca*	(P3)
Blennospora sp. Ruabon	(P3)	*Jacksonia sericea*	(P3)
Conostylis pauciflora subsp. *pauciflora*	(P4)	*Lasiopetalum membraneum*	(P2)
Eryngium pinnatifidum subsp. *palustre* ms	(P2)	*Lepidium pseudotasmanicum*	(P4)
Eucalyptus argutifolia	(DRF)	*Platysace ramosissima*	(P3)
Hakea sp. Yalgorup	(P4)	*Rorippa* sp. Yalgorup	(-)
Haloragis aculeolata	(P2	*Stylidium maritimum*	(P3)

Four of these rare taxa – *Astroloma* sp. Yalgorup, *Stylidium maritimum, Eryngium pinnatifidum* subsp. *palustre* and *Hakea* sp. Yalgorup – were recorded by Trudgen (1997) as being in or near the access route corridor, and two other species, *Conostylis pauciflora* subsp. *pauciflora* and *Lasiopetalum membranaceum* may well be at least near the corridor. The *Conostylis, Stylidium, Lasiopetalum* and *Hakea* are or might be in the principal types of habitats in the corridor: sand dune slopes and ridges and relatively dry sandy flats, while the *Stylidium, Lasiopetalum* and *Hakea* also may be on S2b type limestone habitats at the northern end of the corridor and northwest of Lake Clifton. The *Astroloma* and a majority of the other species may occur on the two small areas of S1a type limestone outcrop crossed by the southern part of the corridor. *Eryngium pinnatifidum* subsp. *palustre* was recorded by Trudgen (1997) in the southern part of the area and, in the northern area, probably in the corridor itself. He recorded it in swales which the access route should be able to avoid.

It would be easiest to recognize these rare plants when they are in flower, which is mainly in the August-October period. Most of the shrubs and some of the perennial herbaceous plants can, however, often be identified at any time of the year. For instance, it would probably be possible to identify the *Conostylis, Stylidium, Lasiopetalum* and *Hakea* in autumn, although they would be much less conspicuous then.

The *Eryngium* and four of the less expected taxa – the *Blennospora, Platysace, Rorippa* and, possibly, *Haloragis* – would probably be impossible to recognize or identify in late autumn, as would any rare orchids that might, most unexpectedly, be in the corridor.

During the 14-16 June field work one population of the Priority 4 species *Hakea* sp. Yalgorup, was found that the provisional route could not avoid without causing other damage. The population is in limestone scrub which was, at the time of the field work, between the 6900 m and 6950 m pegs, at a northing of approximately 6376350. This is a narrow neck in a depression and in a population of *Dryandra sessilis* and *Hakea* sp. Yalgorup which becomes denser and broader on the slopes either side of the neck. For the route to avoid the *Hakea* entirely, it would have to be deviated several hundred metres westward and would have to go over crests of high dunes. If it stays in the depression and goes through the neck, impact on the population could probably be restricted to damage to fewer than 20 plants of the species, out of a population which probably exceeds 1000 plants.

No other plants of Priority or Declared Rare Flora were found along the route, but there were a few individuals of *Stylidium maritimum*, a Priority 3 species, west of the route.

There were also a few populations of *Astroloma microcalyx* west of the route. Trudgen (1991) found this species to be common on limestone areas, but he regarded it as a species of particular interest because he was the first to find it south of the Fremantle area (Trudgen 1991).

Trudgen (1997) previously recorded plants of *Astroloma* sp. Yalgorup (P2), *Conostylis pauciflora* subsp. *pauciflora* (P4), *Eryngium pinnatifidum* subsp. *palustre* ms (P2) and *Platysace ramosissima* (P3) in the vicinity, and populations of some of them were within a few hundred metres of the route. I saw no sign of any of them nor likely habitat for most of them.

TABLE OF CONTENTS

POTENTIAL RARE FLORA IN THE PROPOSED WHITE HILL ROAD TO LAKE CLIFTON WEST ACCESS ROAD ROUTE CORRIDOR CITY OF MANDURAH

1.0 INTRODUCTION

This report lists rare flora recorded in the broader Yalgorup National Park area and discusses which flora should be looked for during a rare flora survey of a corridor within which it is proposed to construct a road to provide access from White Hill Road to a residential development site west of Lake Clifton. The report was originally prepared from a desktop study which was part of a route selection process designed to minimise potential impacts of road construction on significant vegetation and rare flora. Other aspects of the desktop route selection process included a study of vegetation done after this report was prepared and working with engineers, surveyors, aerial photography and this report to select an optimum provisional alignment for the road. The desktop phase of the selection process was followed by fieldwork along the alignment to look for significant vegetation, rare flora and habitats for them. Modifications to the provisional alignment were made to avoid rare flora, probable habitats for it and any significant vegetation that is not dominant and well represented in the general area.

This report is an updated version of the desktop study report based upon field work done between 14 and 16 June 1998. The field work consisted of walking all of the route, except some of the northern part that coincides with an existing road and track, looking for significant flora and vegetation and habitats for them. The results of the field work are presented in Section 5.

The provisional alignment upon which the desktop phase was based is shown on Vegetation Map 1 and the Geomorphic Elements Map. The new alignment, which incorporates modifications based upon the field work, is shown in Vegetation Map 2.

The text and Appendix of this updated report are the same as those of its desktop phase predecessor except for correction of a few typographic errors, modifications of the Summary, the Table of Contents and Section 1.0 and the addition of Section 5. Vegetation Map 2 has also been added.

1.1 LOCATION

The project area for this introductory, desktop study is a 40 m wide, 9 km long band centred on the blue line shown on the three maps accompanying this report as running from south of White Hill Road south to the Lake Clifton West development area west of Boundary Lake and Lake Clifton. This band is the corridor for the access road to the Lake Clifton West development site.

1.2 OBJECTIVES

The objectives of this project are:

- preparation of a table listing Declared Rare Flora, Priority Flora and other rare flora recorded from the general area, along with their recorded locations, habitats and other relevant information, and

- examination of maps and aerial photographs which cover the route of the corridor to determine which flora listed in the table might occur in the corridor.

2.0 METHODS

The first phase of the project was preparation of a table of Declared Rare Flora, Priority Flora and other rare flora with distributions that may include the general area. This table was prepared from the CALM printouts in Appendix 1 of the report by Trudgen (1997) and confirmation of these printouts from the December 1997 update of the CALM rare flora database and from the other sources described in Appendix A of this report. This table, Appendix A's Table A1, lists 22 species and subspecies, along with conservation codes, distributions, localities, growth forms, habitats and flowering times.

The second phase was preparation of maps showing aspects of habitats in the 40 m wide access route corridor. The centre line of this access corridor is shown on two accompanying maps photocopied from the reports by Wells (1989) and Trudgen (1991). This centre line is, essentially, Trudgen's Option 4 (Trudgen 1997).

The maps from the reports by Wells (1989) and Trudgen (1991) give indications of habitat types in the corridor and how the corridor might be shifted to avoid some of them. The maps show the geomorphic elements (landforms and soils) and vegetation in the corridor and in the areas east and west of it.

The third phase of the project, determining which species listed in Table A1 might occur in the project area, was done by comparing information in Table A1 (along with supplementary sources), particularly about habitats, with the map information. Interpretation of magnified stereoscopic views of 1:20 000 scale Metro Regional Area aerial photography flown in January 1998 was used to refine inferences about types and locations of habitats.

3.0 RESULTS

The results of the examination of the accompanying maps, Table A1 and associated information, including Wells (1989), Trudgen (1991) and aerial photographs, are presented in Section 3. Section 3.1 describes types of habitats in the project area, while Section 3.2 lists rare species that might occur in the project area and groups them by habitat type.

3.1 HABITAT TYPES

The listing and description of habitat types in this section is based upon examination of the accompanying geomorphic elements and vegetation maps, which were published at scales of 1:50 000 (Wells and Hesp, 1989) and 1:25 000 (Trudgen 1991), respectively.

I have enlarged the geomorphic elements map to 1:25 000 to facilitate comparison of the two maps and have severely edited the descriptions of the mapped units. The full descriptions of the units and more information about them are in Wells (1989).

3.1.1 GEOMORPHIC ELEMENTS

The corridor is mainly within the Quindalup Dune System and the Spearwood Dune and Plain System, with 1 km of the corridor north of Lake Clifton in the Vasse Estuarine and Lagoonal System. The corridor traverses three units of the first system, three units of the second and one unit of the third. Of these seven units, five (Qp1, Qp2, Qd, S4a, V6) have sandy soils with no surface limestone and two (S1a, S2b) have limestone outcrops or surfaces as well as sandy soils. Depth to rock in the S1a and Qd units is 50-100 cm and in the S2b is 25-100 cm. All of the units have low risk of inundation or waterlogging.

Most of the southern two-thirds of the corridor, west of Lake Clifton, is in the Quindalup Qp1 unit, with two occurrences each of units S1a, S2b and Qp2, and one of Qd. The part of the corridor north of Lake Clifton is V6, S4a and S2b.

Trudgen (1991, p. 47) remarks on the relatively thin soil at the northern end of the corridor and the unit EBAh possibly being an intergrade between Spearwood Dunes and limestone types.

3.1.2 VEGETATION TYPES

According to the vegetation map in Trudgen (1991), the project area has five major vegetation units: Older (Q1 and Q2) Quindalup Dunes, Limestone Areas, Tuart Units, and Cleared and Parkland Cleared. The Quindalup units are mainly of the shrubs *Acacia saligna, A. rostellifera, A. cochlearis, Xanthorrhoea preissii* and *Melaleuca acerosa.* The Limestone Areas units are mainly of the shrubs *Melaleuca acerosa, Grevillea preissii, Dryandra sessilis, Acacia truncata* and *Templetonia retusa.* The Tuart and the Cleared and Parkland Cleared units are mainly of tuart and peppermint trees and *Acacia rostellifera* and *Xanthorrhoea preissii* shrubs, with weedy ground layers and, in some areas, *Lomandra maritima* tussocks, *Desmocladus flexuosus* sedges, *Hibbertia hypericoides* shrubs and associated species. Trudgen recognizes an open variant of tuart vegetation in the northern end of the corridor. This variant, Unit EBAh, has a woodland of *Banksia attenuata* with tuart as and emergent and an understorey of *Allocasuarina humilis, Hibbertia hypericoides, Desmocladus flexuosus* and other less common species.

Most of the southern two-thirds of the corridor, west of Lake Clifton, is in Quindalup vegetation units comprising mainly AM, Ar_2, AsM and Xp, with small areas of Limestone units MG_2, DS, At and Ef. The part of the corridor northwest and north of Lake Clifton is mainly Cleared and Partly Cleared tuart vegetation (EgPC), with large areas of Tuart units EAA/EAL and EgAfX in the south and EBAh at the northern end of the corridor.

Almost all of the southern two-thirds or more of the corridor is in Quindalup vegetation units, with small areas of Limestone units and, along the eastern boundary, Tuart units. The northern quarter to one-third has Tuart units and Limestone units of *Hakea prostrata, Hakea trifurcata, Acacia truncata* and *Templetonia retusa.*

3.2 RARE SPECIES

The 22 rare species listed in Table A1 as having distributions which might include the general Yalgorup area are treated here in the following two groups:

Included rare species	14 species which have previously been recorded in or near the project area and for which there may be habitats in or near the access route corridor, and

Excluded rare species	8 species which have previously been recorded nowhere near the project area and for which habitats in or near the access route corridor are unlikely.

3.2.1 INCLUDED RARE SPECIES

This section groups 14 rare species (and subspecies) that should be looked for during a survey of the access route corridor, depending upon what habitats are represented in it. These species and their conservation codes are:

Astroloma sp. Yalgorup	(P2)	*Hibbertia spicata* subsp. *leptotheca*	(P3)
Blennospora sp. Ruabon	(P3)	*Jacksonia sericea*	(P3)
Conostylis pauciflora subsp. *pauciflora*	(P4)	*Lasiopetalum membraneum*	(P2)
Eryngium pinnatifidum subsp. *palustre* ms	(P2)	*Lepidium pseudotasmanicum*	(P4)
Eucalyptus argutifolia	(DRF)	*Platysace ramosissima*	(P3)
Hakea sp. Yalgorup	(P4)	*Rorippa* sp. Yalgorup	(-)
Haloragis aculeolata	(P2)	*Stylidium maritimum*	(P3)

Definitions of the DRF and P conservation codes are given at the end of Appendix A.

The species are grouped below into four habitat types, and nearby locations where they have been recorded are noted. Some species are grouped at least twice because they occur in at least two types of habitat.

The Limestone units, particularly Geomorphic Element S1a, are, with 10 of the 14 rare species, the habitat richest in rare species. Furthermore, the only DRF species among the fourteen, *Eucalyptus argutifolia*, has been found in the Yalgorup area only in Geomorphic Element S1a.

There is more habitat information on these species in Table A1.

Other rare flora, both coded and uncoded, may also occur in the area, without having been identified there by botanists. For instance, the comprehensive list of flora of the region in Trudgen (1991) does not have three rare species recently found west of Lake Clifton: *Eryngium pinnatifidum* subsp. *palustre, Eucalyptus argutifolia* and *Hakea* sp. Yalgorup (Trudgen, 1997; Weston, 1998).

3.2.1.1 Sand Dune Slopes and Ridges and Dry Sandy Flats

The four species and subspecies listed below, especially the *Conostylis*, might occur on Quindalup and Spearwood sand slopes and ridges and relatively dry, deep sandy flats. The *Conostylis* is most common in woodlands with heath and herbaceous understoreys. The other three species are more likely to be found on heavier soils and limestone outcrops.

Conostylis pauciflora subsp. *pauciflora*	recorded by M Trudgen: 4 small populations north of Location B, Section 1, Option 1; habitat not specified.
Hakea sp. Yalgorup	see Limestone Areas below.
Lasiopetalum membranaceum	recorded by M Trudgen: 5 small populations north of Location B, Section 1, Option 1; habitat not specified.
Stylidium maritimum	recorded by M Trudgen: 1 population in Option 2.

3.2.1.2 Seasonally Wet Flats and Dune Swales

The following three species and subspecies might be found on rocky, loamy, silty or clayey soils in low-lying areas that are periodically water-logged or shallowly inundated, possibly including some interdunal swales, which, however, are few and small in the project area. The southern, occurrence of Geomorphic Element S2b and part of the occurrence of the same unit north of it may have some of these habitats.

Blennospora sp. Ruabon	---
Eryngium pinnatifidum subsp. *palustre*	recorded by M Trudgen: 2 small populations in swales south of Locations H and I, Section 1a, Option 1, and 3 populations in swales in Option 2.
Haloragis aculeolata	---

Trudgen's population 'c' of *Eryngium pinnatifidum* subsp. *palustre*, at AMG 371400E, 6380035N, may be in the corridor.

3.2.1.3 Limestone Outcrops

The areas of Geomorphic Element S1a limestone outcrops in the corridor may have occurrences of the following ten species and subspecies.

Astroloma sp. Yalgorup	recorded by M Trudgen: 1 population on slope in Option 2 not far from plants recorded by him in 1991; habitat otherwise unspecified.
Eucalyptus argutifolia	recorded by A Weston: 2 populations on limestone outcrops (S1a) south of Boundary Lake and west of Lake Clifton.
Hakea sp. Yalgorup	recorded by M Trudgen: 1 small population north of Location C, Section 1, Option 1; habitat not specified, and 7, mainly large, populations on lower slopes, on upper slopes, with *Dryandra sessilis* and in unspecified habitats in Option 2.
Haloragis aculeolata	---
Hibbertia spicata subsp. *leptotheca*	[recorded by Weston in June 1998 on S1a limestone well south of Boundary Lake]
Jacksonia sericea	---
Lasiopetalum membranaceum	see Sand Dune Slopes above.
Lepidium pseudotasmanicum	see Tuart Forest below.
Platysace ramosissima	may also be on Spearwood sand.
Stylidium maritimum	see Sand Dune slopes above.

At least the four northern Trudgen populations of *Hakea* sp.Yalgorup may be in the corridor. The largest of these, 'e' and 'g,' were at AMG 371660E, 6380235N and AMG 371455E, 6380079N.

3.2.1.4 Tuart Forest or Woodland

Some of the following five species may still be in tuart forest and woodland in the corridor even though a large proportion of it has been cleared and has weedy understories.

Haloragis aculeolata	---
Jacksonia sericea	---
Lasiopetalum membranaceum	see Sand Dune Slopes above.

Lepidium pseudotasmanicum	should also be looked for with peppermint, on sand over limestone and in other habitats.
Rorippa sp. Yalgorup	recorded by G Keighery on long unburnt undisturbed deep moss at bases of tuart trees on brown sandy clay; location not specified.

Also, *Conostylis pauciflora* subsp. *pauciflora* may be in the tuart open woodland at the northern end of the corridor.

3.2.2 EXCLUDED RARE SPECIES

This section gives reasons why eight of the 22 rare species listed in Table A1 are very unlikely to occur in near the corridor.

3.2.2.1 Waroona Species

Five of the species which are listed in Table A1 probably because their ranges of distribution include Waroona appear not to have been recorded west of the Peel-Harvey Inlet and are very unlikely to be in or near the corridor. These species and their habitats are:

Aristida ramosa	mainly lateritic or clayey soils in marri woodland in the Darling Range, ca. 4 km north of Waroona and ca. 20 km northwest of Gingin.
Diuris purdiei	seasonally wet semiswamps on sand over clay, usually in summer-burnt *Regelia* and *Pericalymma* shrublands.
Hibbertia silvestris	mainly on lateritic and pisolytic gravel soils in the Darling Range, often in disturbed areas.
Myriophyllum echinatum	clayey soils on winter-wet flats.
Schoenus sp. Waroona	clay or sandy clay in winter-wet flats on eastern side of coastal plain (Rye 1997).

It is unlikely that any of these species occurs in the broader Yalgorup area.

3.2.2.2 *Conostylis pauciflora* subsp. *euryrhipis*

Conostylis pauciflora subsp. *euryrhipis* is recorded by Hopper *et al.* (1987) as being common in heath on consolidated dunes between Cervantes and Yanchep, with no reference to it being recorded south of Perth. The record on the CALM list of the subspecies' occurrence at Yalgorup probably predates the original published description of the subspecies, in Hopper *et al.* (1987), or is based upon an incorrect identification.

It is very unlikely that this subspecies occurs anywhere in the Yalgorup area.

3.2.2.3 *Diuris micrantha*

The previous record in the CALM database of *Diuris micrantha* occurring in or near Yalgorup was probably a mistake for 'Yarloop'; 'Yarloop' has taken the place of 'Yalgorup' on the CALM list.

Although it is unlikely to occur anywhere in or near the corridor, any potential habitat for it should be noted. It is the only species listed in Table A1 which has a shallowly winter-wet sandy clayey soil with short dense, flat-leafed *Lepidosperma* sedgeland.

Diuris micrantha is a small-flowered donkey orchid that flowers earlier than most species of donkey orchid, in August and September.

3.2.2.4 *Eucalyptus rudis* subsp. *cratyantha*

Because neither subspecies of this conspicuous plant, commonly known as flooded gum, has been recorded in or near the corridor, *Eucalyptus rudis* subsp. *cratyantha* is highly unlikely to occur there.

4.0 DISCUSSION

Fourteen rare taxa (species and subspecies) have been selected from the longer list of 22 in Appendix A as being the only ones likely to occur in or near the corridor. These taxa are:

Astroloma sp. Yalgorup	(P2)	*Hibbertia spicata* subsp. *leptotheca*	(P3)
Blennospora sp. Ruabon	(P3)	*Jacksonia sericea*	(P3)
Conostylis pauciflora subsp. *pauciflora*	(P4)	*Lasiopetalum membraneum*	(P2)
Eryngium pinnatifidum subsp. *palustre* ms	(P2)	*Lepidium pseudotasmanicum*	(P4)
Eucalyptus argutifolia	(DRF)	*Platysace ramosissima*	(P3)
Hakea sp. Yalgorup	(P4)	*Rorippa* sp. Yalgorup	(-)
Haloragis aculeolata	(P2	*Stylidium maritimum*	(P3)

Four of these rare taxa – *Astroloma* sp. Yalgorup, *Stylidium maritimum, Eryngium pinnatifidum* subsp. *palustre* and *Hakea* sp. Yalgorup – were recorded by Trudgen (1997) as being in or near the access route corridor, and two other species, *Conostylis pauciflora* subsp. *pauciflora* and *Lasiopetalum membranaceum* may well be at least near the corridor. The *Conostylis, Stylidium, Lasiopetalum* and *Hakea* are or might be in the principal types of habitats in the corridor: sand dune slopes and ridges and relatively dry sandy flats, while the *Stylidium, Lasiopetalum* and *Hakea* also may be on S2b type limestone habitats at the northern end of the corridor and northwest of Lake Clifton. The *Astroloma* and a majority of the other species may occur on the two small areas of S1a type limestone outcrop crossed by the southern part of the corridor. *Eryngium pinnatifidum* subsp. *palustre* was recorded by Trudgen (1997) in the southern part of the area and, in the northern area, probably in the corridor itself. He recorded it in swales which the access route should be able to avoid.

It would be easiest to recognize these rare plants when they are in flower, which is mainly in the August-October period. Most of the shrubs and some of the perennial herbaceous plants can, however, often be identified at any time of the year. For instance, it would probably be possible to identify the *Conostylis, Stylidium, Lasiopetalum* and *Hakea* in autumn, although they would be much less conspicuous then.

The *Eryngium* and four of the less expected taxa – the *Blennospora, Platysace, Rorippa* and, possibly, *Haloragis* – would probably be impossible to recognize or identify in late autumn, as would any rare orchids that might, most unexpectedly, be in the corridor.

Stereoscopic interpretation of recently flown aerial photography suggests that it would be possible to find an access route within the corridor which would be restricted to the types of sand habitats where the only rare flora expected are *Conostylis pauciflora* subsp. *pauciflora, Stylidium*

maritimum, Lasiopetalum membranaceum and *Hakea* sp. Yalgorup, and to two small areas of S1a type limestone outcrops which represent a type of habitat in which a majority of the 14 rare flora have been recorded, including the DRF eucalypt. To avoid the S1a outcrops would require deviating the route no more than 100 m westward at that point.

I have been commissioned to undertake a rare flora and habitat survey through the corridor soon with the aim of selecting a route which is, as much as possible, restricted to sand dune slopes and ridges and relatively dry sandy flats. During the survey, I will record any locations where I find plants of any of the 14 taxa listed above, as well as any other, unexpected rare flora, both coded and uncoded.

5.0 RESULTS OF FIELD WORK

As a result of observations made during the 14-16 June field work the pegged provisional route was shifted westward at several points and eastward at two points to avoid all areas of limestone vegetation except one. The one exception, as well as all of the limestone areas the route alignment was shifted to avoid, were areas of *Dryandra sessilis* scrub. Most of these areas, including the one area the modified route goes through, also have populations of the Priority 4 species *Hakea* sp. Yalgorup, and most of these populations are large, like the ones recorded by Trudgen (1997).

The population of *Hakea* sp. Yalgorup in the route is scrub at what was, at the time of the field work, between the 6900 m and 6950 m pegs, at a northing of approximately 6376350. This is a narrow neck in a depression and in a population of *Dryandra sessilis* and *Hakea* sp. Yalgorup which becomes denser and broader on the slopes either side of the neck. For the route to avoid the *Hakea* entirely, it would have to be deviated several hundred metres westward and would have to go over crests of high dunes. If it stays in the depression and goes through the neck, impact on the population could probably be restricted to damage to fewer than 20 plants of the species, out of a population which probably exceeds 1000 plants.

No other plants of Priority or Declared Rare Flora were found along the route, but there were a few individuals of *Stylidium maritimum*, a Priority 3 species, west of the route.

There were also a few populations of *Astroloma microcalyx* west of the route. Trudgen (1991) found this species to be common on limestone areas, but he regarded it as a species of particular interest because he was the first to find it south of the Fremantle area (Trudgen 1991).

Trudgen (1997) previously recorded plants of *Astroloma* sp. Yalgorup (P2), *Conostylis pauciflora* subsp. *pauciflora* (P4), *Eryngium pinnatifidum* subsp. *palustre* ms (P2) and *Platysace ramosissima* (P3) in the vicinity, and populations of some of them were within a few hundred metres of the route. I saw no sign of any of them nor likely habitat for most of them.

6.0 ACKNOWLEDGEMENTS

The assistance of Greg Keighery, Brendan Lepschi, Malcolm Trudgen and staff of the Western Australian Herbarium is gratefully appreciated. Access to the Western Australian Herbarium collections was essential for carrying out the project and is greatly appreciated.

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APPENDIX A

Rare Flora with Distributions which may include the Yalgorup Area

(compiled April 1998)

Table A1 lists 22 species of rare flora recorded in the general vicinity of Yalgorup National Park, along with information about their conservation codes, distributions, localities where they have been recorded, growth forms, habitats and flowering times. The information about distributions, localities, growth forms, habitats and flowering times is not always comprehensive. For instance, the localities are often selections and do not include all of the localities given for a listed species in the CALM printouts, which are also often only selections. Information about growth form and habitat is at least indicative and should be useful in assessing how likely rare flora is to occur at particular locations in the project area.

The table lists three R species (gazetted Declared Rare Flora), one P1 species (Priority One), four P2 species and subspecies (Priority Two), eight P3 species and subspecies (Priority Three), five P4 species and subspecies (Priority Four) and one apparently rare species which is known from only one population but has not been assigned a conservation code by CALM. All three of the R species area also V species (Threat: Vulnerable), two of them are V (ESP: Vulnerable), and one of them is E* (ESP: Endangered) (presumably 'Threat' is for 'Scientific Ranking Panel for Western Australia's Threatened Flora and Fauna' and 'ESP' is for the Commonwealth 'Endangered Species Protection Act'). A copy of CALM's definitions of the R and P conservation codes follows the table.

Table A1 contains all 18 of the rare flora listed in the CALM Declared Rare and Priority List appended to Trudgen (1997) plus four additional taxa (species and subspecies) recorded in or near Yalgorup National Park. The four additional taxa are *Diurus micrantha*, *Eryngium pinnatifidum* subsp. *palustre*, *Eucalyptus argutifolia* and *Rorippa* sp. Yalgorup. The *Diuris* is listed in the 1994 CALM Declared Rare and Priority Flora List as including Yalgorup in its distribution; the *Eryngium* was found in Route Options 1a and 2 by Trudgen in October 1997, the *Eucalyptus* was found by me west of Lake Clifton in March 1998 and the *Rorippa* was found somewhere in the Yalgorup area by G Keighery, possibly in 1997.

The CALM list in Trudgen is an October 1997 printout from a database which was updated in October 1996. The date on the most recent update printout is December 1997. Consequently, I have brought the CALM printout in Trudgen up to date by checking it against the current, December 1997 CALM list and by searching the current database for Yalgorup, Clifton, Mandurah and Waroona.

Table A1 was compiled from CALM printouts and database referred to above, examination of herbarium specimens and their labels in the Western Australian Herbarium, consultations with other botanists, observations made during my field work and information in Marchant *et al.* (1987), Hoffman and Brown (1995), Hopper *et al.* (1987), Trudgen (1997) and Rye (1997). These references are listed in the report to which this is Appendix A.

Table A1 Declared Rare and Priority Flora Taxa with Distributions which may include the Yalgorup Area, principally between White Hill Road and the Lake Clifton West Development Site (April 1998)

Species / Family	Codes	Distribution and Localities	Growth Form; Habitats	X	Flowers
Aristida ramosa POAC	P1	Near Waroona, Serpentine, Gingin, eastern states	Tufted grass; Marri woodland on brown sandy clay	-	Jun,Nov
Astroloma sp. Yalgorup (MET #?: no specimen in W. A. Herbarium) EPAC	P2	Yalgorup (>300 m WNW of Duck Pond, W of Lake Clifton)	Shrub; Limestone, ? (no specimen in WA Herbarium)	T	?
Blennospora sp. Ruabon (BJK & NG 20) ASTE	P3	Yalgorup, Austin Bay NR, Ruabon, Kooljerrenup NR, Busselton, L Muckinburra	Small annual; Under *Melaleuca* spp; seasonally wet grey clay; on flats &, perhaps, between dunes	-	Oct-Nov
Conostylis pauciflora subsp. *euryrhipis* HAEM	P3	Yanchep, Lancelin, Seabird, (Yalgorup?)	Stoloniferous herb; In heath on coastal stable dunes	-	Jul
Conostylis pauciflora subsp. *pauciflora* HAEM	P4	Yarloop, Dawesville, Yalgorup NP	Stoloniferous herb; Eucalypt, peppermint, banksia woodlands on deep grey sand on lower and middle slopes of stabilised dunes	T	(Jun-) Aug-Oct
Diuris micrantha ORCH	R V,E*	Yalgorup, Medina, Yarloop, Yunderup, Manjimup, Bowelling	Dwarf Bee Orchid; Sandy clayey soil, shallowly winter-wet short dense *Lepidosperma* sedgeland	-	Aug-Sep
Diuris purdiei ORCH	R V,V	Perth-Waroona; E of Harvey Estuary	A donkey orchid; Seasonally wet semi-swamp on sand over clay, usually in burnt *Regelia* and *Pericalymma* shrublands	-	Sep-Nov
Eryngium pinnatifidum subsp. *palustre* ms APIA	P2	Gingin-Serpentine, Kenwick, Bullsbrook	Herb; *Melaleuca* shrublands on winter-wet sandy-clay flats; (MET: swales in Quindalup dunes)	T	Oct-Nov
Eucalyptus argutifolia MYRT	R V,V	W of Lake Clifton, Jurien, Yanchep, Lancelin, Seabird	Yanchep Mallee; Limestone	-	Mar-Apr
Eucalyptus rudis subsp. *cratyantha* MYRT	P4	Mandurah-Yallingup, Eagle Bay, Meelup, Busselton	Tree similar to typical Flooded Gum but buds and nuts larger; same habitats as Flooded Gum	-	Jun-Sep?
Hakea sp. Yalgorup (BK & NG 897) MYRT	P4	W of Lake Clifton, Yalgorup	Shrub w. leaves narrower than *H. undulata*; Limestone heath	T	Aug-Oct
Haloragis aculeolata HALO	P2	Yalgorup N.P., Yanchep (Toolbrunup, Cannington)	Herb; Shelley sand or brown clay over limestone, with tuart, flooded gum, *Acacia, Melaleuca* shrubs and/or *Gahnia trifida*	-	Dec-Apr
Hibbertia silvestris DILL	P4	Dwellingup-Pemberton, Waroona, Collie, Barlee Brook, Glenoran, Dickson	Low, often dense and rounded, shrub; Generally on laterite	-	Aug-Mar
Hibbertia spicata subsp. *leptotheca* DILL	P3	Yalgorup-Lancelin, Burns Beach, Yanchep	Mound or semi-prostrate small shrub; Mainly limestone heath	-	Sep-Nov (Jul-Dec)
Jacksonia sericea FABA	P3	Wanneroo-Pinjarra, Perth Mandurah, Neerabup NP	Low, usually prostrate shrub; Sandy soil in woodlands, usually low in the landscape	-	Nov-Feb
Lasiopetalum membranaceum STER	P2	Yanchep-Ludlow, Yalgorup, Capel	Small shrub w. cordate leaves; Sand, mainly over limestone and in tuart woodland	X	Sep-Dec
Lepidium pseudotasmanicum BRAS	P4	Wongan Hills – Esperance, mainly in and near Porongurup R; Lake Clifton, Yanchep, eastern states	Herb to 50 cm tall; Various habitats, including tuart forest on sand over limestone	-	Oct-Jun
Myriophyllum echinatum HALO	P3	Austin Bay NR, Waroona, Harvey, Tutunup, Ruabon	Small herb, disk large, yellow, rays sm, white; Clay on winter-wet flats	-	Oct-Nov
Platysace ramosissima APIA	P3	Yalgorup, W of Duck Pond, Boonanarring, Gingin	Perennial herb with ribbed or angular stems; Heath on Spearwood sand or limestone	X	Oct-Nov
Rorippa sp. Yalgorup (GJK 14,455) BRAS	-- rare	Yalgorup (only one population known)	Short annual; Undisturbed, long unburnt deep moss at bases of tuart trees on brown sandy clay	-	Sep?
Schoenus sp. Waroona (GJ Keighery 12235) CYPE	P3	Waroona, Kenwick, Harvey, Austin Bay	Annual < 3 cm; Clay or sandy-clay winter-wet flats	-	Oct
Stylidium maritimum STYL	P3	Yalgorup – Breton Bay	Tufted, linear-leaved triggerplant; Sand dunes and depressions in limestone	T	Sep-Dec

X Column – X: *Lasiopetalum membranaceum* recorded at 32^41'-42', 115^37'-38', *Platysace ramosissima* at 32^45.5', 115^37.5 (CALM's Summary of Threatened Flora Data); T: Found by M Trudgen in Route Option 2 in October 1997 (the *Conostylis* plants were identified as hybrids between *C. p.* subsp. *p.* and *C. candicans* subsp. *calcicola*).

THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

DECLARED RARE AND PRIORITY FLORA LIST

for Western Australia

KJ Atkins 3 December, 1997

CONSERVATION CODES

R: Declared Rare Flora - Extant Taxa

Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.

X: Declared Rare Flora - Presumed Extinct Taxa

Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.

1: Priority One - Poorly known Taxa

Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

2: Priority Two - Poorly Known Taxa

Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

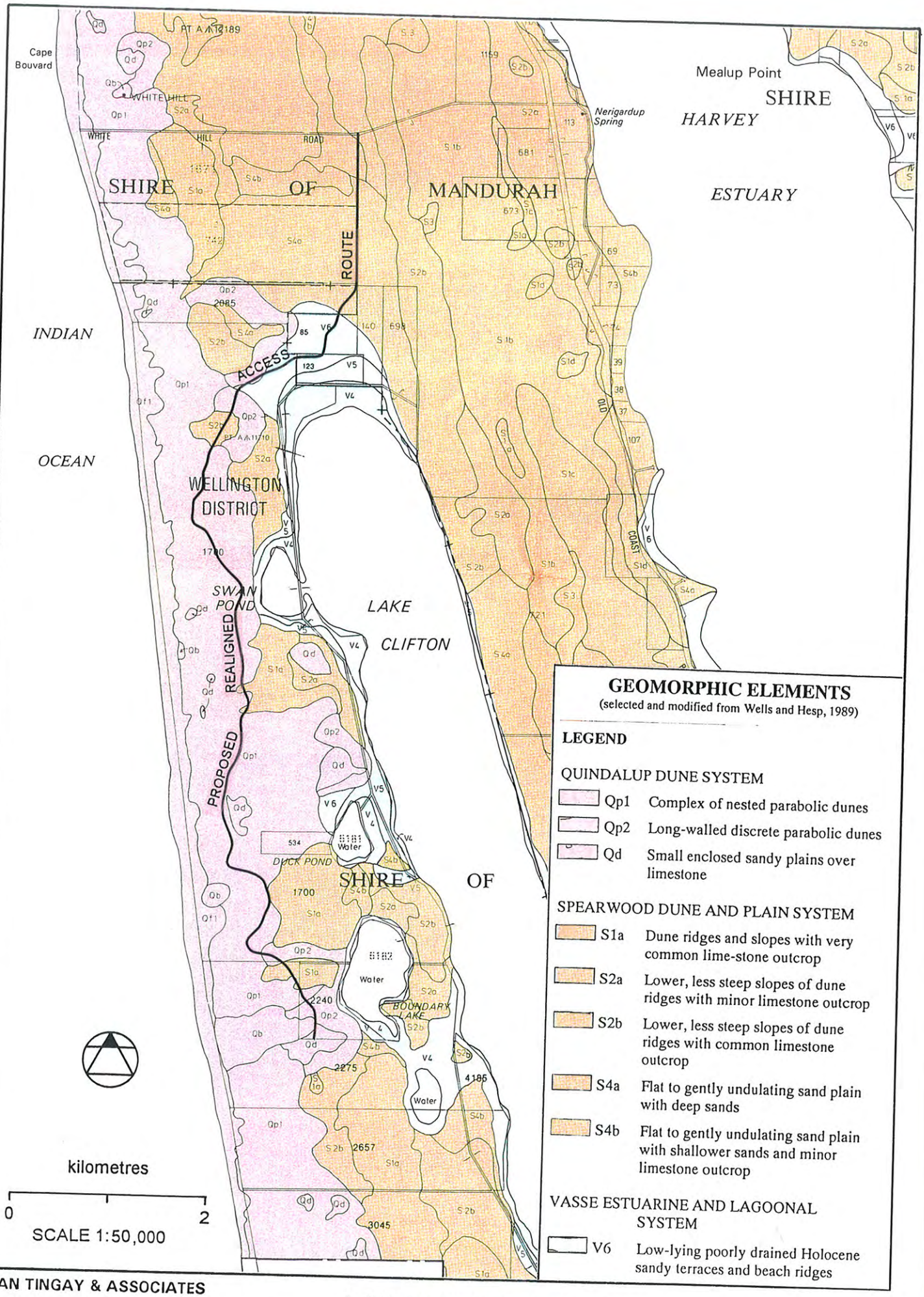
3: Priority Three - Poorly Known Taxa

Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.

4: Priority Four - Rare Taxa

Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Note, the need for further survey of poorly known taxa is prioritised into the three categories depending on the perceived urgency for determining the conservation status of those taxa, as indicated by the apparent degree of threat to the taxa based on the current information.



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ALAN TINGAY & ASSOCIATES

LAKE CLIFTON LAND EXCHANGE PROPOSAL
GEOMORPHIC ELEMENTS

VEGETATION MAP 1

LEGEND

- Urban Development
- The Strand
- Limestone Areas
- Peppermint (Agonis flexuosa) Units
- Tuart (Eucalyptus gomphocephala) Units
- Spearwood Dunes
- Cleared and Parkland Cleared
- Yoongarillup Plain – Seasonally Damp to Wetland Areas
- Q2 and Q1 Age Quindalup Dunes and Swales Between Older (Q2 and Q1) Quindalup Dunes
- Q4 and Q3 Age Quindalup Dunes and Swales Between Younger (Q4 and Q3) Quindalup Dunes
- Intergrades, Limestone to Spearwood Dunes and Intergrades, Limestone Types to Quindalup Dune Types
- 'Blue Line' Centre line of preliminary route, Zone of Impact and Core Study Area

SCALE

0 500m 1 kilometre

1:25 000

N

Swan Pool

Duck Pond

Boundary Lake

CLIFTON

LAKE

Limestone (not mapped)

Not mapped

Not mapped

Outside Study Area

Outside Study Area

COAST ROAD

OLD COAST ROAD

WHITE HILLS ROAD

HARVEY ESTUARY

VEGETATION MAP 2

LEGEND

- Urban Development
- The Strand
- Limestone Areas
- Peppermint (Agonis flexuosa) Units
- Tuart (Eucalyptus gomphocephala) Units
- Spearwood Dunes
- Cleared and Parkland Cleared
- Yoongarillup Plain – Seasonally Damp to Wetland Areas
- Q2 and Q1 Age Quindalup Dunes and Swales Between Older (Q2 and Q1) Quindalup Dunes
- Q4 and Q3 Age Quindalup Dunes and Swales Between Younger (Q4 and Q3) Quindalup Dunes
- Intergrades, Limestone to Spearwood Dunes and Intergrades, Limestone Types to Quindalup Dune Types
- 'Blue Line' Proposed access road route

SCALE

0 500m 1 kilometre

1:25000

N

Boundary Lake

Duck Pond

Swan Pool

CLIFTON

LAKE

HARVEY ESTUARY

Limestone (not mapped)

Not mapped

Not mapped

Outside Study Area

Outside Study Area

COAST ROAD

OLD COAST ROAD

WHITE HILLS ROAD

Cape Bouvard Investments

Lake Clifton West - Proposed Land Exchange

An Overview of the Environmental Issues

March 1998

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Document Status					
Rev No.	Author	Reviewer	Approved for Issue		
			Name	Signature	Date
0	S Leverton	D Tucker	S Leverton		4.3.98

Contents

Maps

1. Planning and Management Context

Cape Bouvard Investments Pty Ltd (CBI) owns an 800 ha property 20 km south of Mandurah between Lake Clifton and the Indian Ocean, and bounded to the north and south by the Yalgorup National Park. Lake Clifton is 20 km long, 1-2 km wide, and contains the largest known occurrence of micobialites in a lake environment in the southern hemisphere. The lake, together with others in the area, is also an important habitat for local and migratory birds and is listed as a designated wetland in the Ramsar International Convention (UNESCO) to which Australia is a signatory. The lake and the coastal environment of the area therefore represent recognised habitats of the highest conservation value.

Conservation of these environmental values accorded to the Lake Clifton area is the central theme in both the Western Australian Planning Commission's (WAPC) Coastal and Lakelands Planning Strategy (WAPC, 1997) and the Yalgorup National Park Management Plan (CALM & NPNCA, 1995).

The WAPC's Coastal and Lakelands Planning Strategy, published in December 1997, presents a broad strategy for the future use and development of the coastal area between Mandurah and Bunbury, including the environmentally sensitive coastal lakes system. The strategy is open for public comment until the end of March, 1998.

The Yalgorup National Park Management Plan, produced by the Department of Conservation and Land Management (CALM) for the National Parks and Nature Conservation Authority (NPNCA), provides a management framework for the protection of the environmental values of the Yalgorup National Park, which includes Lake Clifton.

2.Lake Clifton West - Existing Environment

The CBI land, Lake Clifton West, encompasses the three basic geomorphic elements characteristic of the coastal strip west of Lake Clifton. The ocean dunes of some 1-2 km in width comprise the Quindalup Dunes, made up of a complex pattern of parabolic dunes of rapidly draining calcareous Safety Bay Sand. The system is relatively fragile and susceptible to erosion from wind and wave action along the coastal margin (100-200 m from the shore). The vegetation of the Quindalup Dunes is characterised by mainly salt-tolerant heaths and closed scrub along the coastal margin (the younger Q4 and Q3 dunes).

Further inland the vegetation of the older Q2 and Q1 Dunes varies with distance to the beach, position on the dune, and the height and age of the dune. It comprises principally low shrubland to low open heath on dune crests, with *Acacia spp.* and *Melaleuca spp.* on the slopes and in many of the swales (Trudgen, 1991).

The Quindalup Dunes give way to the Spearwood Dune ridges further inland. These are made up of siliceous sands overlying Tamala Limestone and extend in

parts to the western edge of Lake Clifton and beyond. The topography is flat to gently undulating plain. Vegetative cover is characterised by open forests of Jarrah, Marri and Tuart over *Banksia spp.*, Peppermint and Sheoak. The vegetation of the Spearwood Dune ridges are broadly categorised into the Cottesloe and Yoongarillup vegetation complexes, depending on the characteristic mix of tree species. The Yoongarillup complex is located closer to the lake.

Areas of lagoonal deposits, known as Vasse Estuarine deposits, are located around the lake shore. These flats comprise highly saline soils subject to periodic inundation, and are important in supporting the ecology of the lake and shoreline.

Map 1 shows the vegetation types mapped for the northern area around Lake Clifton (from Trudgen, 1991).

3.Lake Clifton West - The Proposed Development

The proposed development at Lake Clifton West will be an environmentally integrated settlement comprising residential clusters and a small coastal hamlet. The development will be situated within the eastern portion of the Quindalup Dune system (Q2 and Q1 age dunes) and will avoid the more fragile Q4 and Q3 age dunes (see Map 1). The reasons for locating the development on the coastal rather than lake side of the property are:

- to provide a protective buffer of undeveloped land between residences and the sensitive Lake Clifton environment;
- to encourage use of the coastal areas and beach, rather than the lake, as the primary focus for low impact recreational activity by residents;
- to co-locate services such as roads, water and sewerage in this area and away from the lake; and
- to avoid the Spearwood Dune system to the east, thus preserving its unique natural features and in particular the stands of Tuart, the only eucalyptus species endemic to the Swan Coastal Plain.

In recognition of the need for extreme care to be exercised to protect the dune environment, development will be carried out to ensure:

- there is minimal clearing of vegetation, particularly in relation to the significant stands of Peppermint around blowouts to the north of the property;
- there is no clearing of coastal vegetation within the Q4 and Q3 dunes, with stabilisation works implemented to conserve these dunes;
- beach access will be strictly controlled through fencing and other barriers;
- the existing landform and topography of the older Q2 and Q1 dunes will essentially remain unaltered; and
- buildings will be integrated into the existing landform in a manner that preserves the visual amenity of the landscape.

To achieve the high level of environmental sensitivity desired for this development, all houses will be provided with reticulated water and sewerage services, opportunity for private gardens will be minimised, road verges will be vegetated and dune conservation ensured. This will help to assure maintenance of the delicate water balance in the area by which the ecology of Lake Clifton is maintained through infiltrating groundwater from the catchment.

4.Proposed Land Exchange

It is proposed that the eastern portion of the CBI property, broadly encompassing the Spearwood Dune Ridge section and lake fringing vegetation, be transferred for incorporation into the Yalgorup National Park in exchange for an area of coastal land contiguous with and north of the property to be transferred to CBI for environmentally sustainable development (hatched area on Map 1).

For CBI the land exchange will guarantee its ability to ensure the highest quality facilities and services for the proposed development, in keeping with the ethos of minimum environmental impact. These will include the provision of water and wastewater services to ensure maintenance of the delicate water balance in the catchment, and the complete removal of sewage nutrients from the catchment. This will be achieved whilst allowing for a reasonable return on the investment.

5.The Land for Exchange - Environmental Values

5.1Vegetation Types

The parcel of land CBI is offering for exchange comprises an area of some 500 ha made up of the following broad vegetation complexes (proportions of each are shown in brackets)(estimated from 'Map 5 - Vegetation Complexes' in CALM & NPNCA, 1995):

Quindalup Complex (12 %)

Cottesloe Complex (45 %)

Yoongarillup Complex (43 %)

The high conservation value Vasse Lagoonal Deposits are also shown by the Planning Strategy to occupy a significant proportion of this land (Figure 3.15, WAPC, 1997).

About 60 % of this 500 ha area was mapped in detail with respect to the distribution and characteristics of its vegetation by Trudgen, 1991 (Map 1). Estimates of areas of significant vegetation units within this mapped area were:

Tuart Units (74 ha)

Peppermint Units (7.8 ha)

Melaleuca spp Unit (79 ha)

Banksia attenuata Unit (20 ha)

Recent vegetation mapping work, including site transect surveys and specimen collection for identification, has been carried out by Weston on this parcel of land (Weston, 1998). Weston's findings confirm the very high conservation value of the area as previously identified by Trudgen. Importantly, Weston noted a number of vegetation units and species in two areas of particular conservation significance, the north-eastern limestone and sand heaths between Boundary Lake and Lake Clifton, and the central and southern limestone heaths and other complexes. These had not been previously recorded, and included the Declared Rare Flora *Eucalyptus argutifolia*. Also represented was a community of *Melaleuca spp.*, which is proposed for inclusion on the Threatened Community Database.

The area of National Park proposed for transfer to CBI is approximately 225 ha and comprises primarily Quindalup Complex (Q2 and Q1 age). Within this complex is included approximately a Peppermint vegetation unit of approximately 10 ha, representing approximately 4-6 % of the total area. The Q4 and Q3 Quindalup Dune areas along the coastal strip will remain part of the National Park.

5.2Priority Flora

The Yalgorup National Park Management Plan lists one Declared Rare Flora species, six Priority 2 species, and two Priority 3 species occur in the Park (CALM & NPNCA, 1995). Most of these occur in the Cottesloe Complex, with the Tuart forests also containing a number of priority flora.

Recent work by M Trudgen (Trudgen, 1997) included a field assessment of areas within the section of National Park north of CBI's property, as part of a rare and priority flora survey of possible access routes. In assessing land along the route through the mostly Quindalup Dunes complex (now the northern access route preferred by CALM) Trudgen noted the route crossed the potential habitat of two Priority 2, three Priority 3 and one Priority 4 species. However, all habitats except that for one Priority 3 species (*Stylidium maritima*) occurred within either the Cottesloe Vegetation complex or in areas of Tuart woodland, neither of which will be impacted by the construction of the proposed settlements. *Stylidium maritima* was recorded elsewhere in the Park by Trudgen when surveying other route options.

It is noteworthy to add that Trudgen found 'parkland cleared' areas for most of the length of another northern access route option through the Park. These are areas from which most of the original native flora, particularly ground layers, has been cleared. This altered habitat has been grazed in the past and shows signs of heavy weed infestation.

5.3Significant Fauna

A number of rare and significant terrestrial fauna exist in the area. The Yalgorup National Park Management Plan identifies a number of possum species (Ring-

tailed Possum, Brush-tailed Possum, Pygmy Possum) whose populations are believed to have declined with the clearing of woodland areas. Small populations of Bandicoots and Chuditch have been identified in the Park. Conservation of these species within the Park is limited by the long narrow shape of its boundaries, and the small area of the islands of vegetation associations (CALM &NPNCA, 1995).

Lake Clifton and the surrounding vegetation supports over 100 species of birds. In addition, the lake provides a major habitat for local and migratory water birds including water fowl and waders. The lake supports one of the largest populations of Musk Duck in the area, and significant numbers of Black Swan.

6.The Benefits of the Exchange

6.1Protection of Microbialites

The land exchange will have considerable benefits for the conservation of environmental values in the area. Most importantly, by providing a continuous reserve of National Park land around the western side of Lake Clifton, it will assist in the preservation of the important microbialite communities of Lake Clifton which is a primary goal in the conservation strategy of the Yalgorup National Park Management Plan. The existence of 'buffer' land around the lake will ensure that CALM can exercise control over land use and therefore assure the protection of Lake Clifton in perpetuity.

Recent observations of algal growth in the water column of the Lake have led to the suggestion that development pressures in the catchment are already compromising the long term viability of the sensitive lake ecosystem. Including further tracts of lake shoreline into the National Park will provide long term surety and control against any future environmentally insensitive land uses on freehold land bordering the lake. Whilst planning controls may provide protection against some inappropriate uses on freehold land, they can not prevent the land degrading effects of vegetation clearing, or the significant off-site impacts of, for instance, poorly managed hobby farming.

Long term surety of land use control will also prevent the likelihood of incremental land degradation through a series of small events such as continued sub-division of lots, or the progressively poor performance or failure of on-site sewage treatment systems.

6.2Net Increase in Conservation Value of National Park

The proposed land exchange will result in a significant net increase in the conservation and environmental values of the Yalgorup National Park. These are detailed under the following sections:

Vegetation Type

An estimate of the areas of broad vegetation complexes and significant vegetation units existing within the northern section of the Yalgorup National Park (where detailed vegetation mapping has occurred) before and after the proposed land exchange is set out in Table 1:

Vegetation Complex/ Significant Vegetation Unit	Area in Park (northern section) (ha)	
	Before Exchange	After Exchange
Quindalup Complex (Q2 and Q1 age)	570	355
Quindalup Complex (Q4 and Q3 age)	10	10
Cottesloe Complex	933	1150
Yoongarillup Complex	1450	1665
Tuart Units	430	504
Peppermint Units*	45	43
Melaleuca spp Unit	150	229
Banksia attenuata Unit	80	100

Table 1: Proportion of Vegetation Types Before and After Exchange (Northern Section)

It is clear from these estimates that the land exchange will result in a significant increase in the areas of high conservation value Cottesloe and Yoongarillup vegetation complexes in the Park. The Cottesloe and Yoongarillup Complex areas being offered for inclusion into the National Park contain numerous stands of high quality Tuart forest over Peppermint or *Acacia*, *Banksia spp.* and *Melaleuca* vegetation units. The diversity of the vegetation both increases its conservation value and provides more favourable habitat potential for fauna species.

Whilst Table 1 shows some reduction in the Quindalup Complex (Q2 and Q1), as a proportion of the overall area of this complex within the region this reduction is minimal. This is demonstrated in the following two tables.

Table 2 shows estimates of the relative proportions of the broad vegetation complexes within the whole Yalgorup National Park, before and after the proposed land exchange.

Vegetation Complex	Proportion of Park Land (%)	
	Before Exchange	After Exchange

Quindalup	8	6.6
Cottesloe	17	18
Yoongarillup	30	31
Vasse	3	3
Karrakatta	2	2
Bassendean	0	0

Table 2: Proportion of Vegetation Types Before and After Exchange (Yalgorup National Park)

A further approximately 2,630 ha of Quindalup Complex exists west of Lake Preston, currently outside of the Yalgorup National Park. About half of this has been identified as being vegetated (Figure 3.15, WAPC, 1997). If this vegetated area is included in considering changes to this vegetation complex on a regional scale, CBI's proposed environmentally sustainable development reduces the availability of this complex regionally by about 10 %. It is emphasised that within the CBI settlement area itself, vegetation clearing will be confined to only a very small fraction (15%) of the land, thereby reducing the loss of this vegetation type still further.

Table 3 of the Yalgorup National Park Management Plan (CALM & NPNCA, 1995) shows the proportion of each vegetation complex now existing throughout the state that is currently included in WA's conservation estate, and the fraction of that proportion which is included in Yalgorup National Park. This table is reproduced below, with the inclusion of a third column of figures representing the situation after the proposed land exchange.

Vegetation Complex	Before Exchange		After Exchange	
	In Conservation Estate (%)	Proportion Reserved in Yalgorup NP (%)	In Conservation Estate (%)	Proportion in Yalgorup NP after Exchange (%)
Quindalup	7	64	6.1	59
Cottesloe	8	77	8.7	78
Yoongarillup	14	72	14.7	73
Vasse	14	34	14	34
Karrakatta	5	48	5	48

Table 3: Proportion of Vegetation Types in the Conservation Estate, Before and After Exchange

After considering the consequences of the proposed land exchange on vegetation type at the local, regional and statewide levels, we conclude that the land exchange will result in an increase to the National Park of the high conservation value Cottesloe and Yoongarillup vegetation complexes without any appreciable overall reduction in the Quindalup complex, and with the preservation of that portion of the Quindalup Complex (Q4 and Q3) of highest conservation value.

Priority Flora

Priority flora predominate within the vegetation complexes included in the land to be exchanged. By closing the band of fringing vegetation around the western shore of Lake Clifton and including these vegetation types within the Parks boundaries, the land exchange will secure an extended and contiguous zone of high floristic diversity in the Park to support the conservation of these Priority species. Where some cleared areas exist on the land proposed for exchange, these are well suited to being revegetated to natural state, providing further opportunity for habitat creation.

Fauna

Animal species diversity usually increases both with plant species diversity and a range of foliage heights. The proposed land exchange will significantly add to the complement of floristically diverse land within the Park and thereby increase the number and range of animal habitats available.

In addition, the linkage of vegetation 'islands' will provide corridors for the movement of animals over their normal range, and will encourage the development of multiple communities and populations. The land exchange therefore has strategic importance in helping to establish and maintain robust populations of animals through this part of the Park by providing both habitats, and a 'land bridge' between sections of the Park.

The importance of the lake and littoral system to bird life is strongly emphasised in the National Park Management Plan. Greater numbers of species are present where habitats remain undisturbed, and birds in these areas are dependent on the presence of the vegetative canopy provided by taller stands of trees. The land exchange will provide more of this type of habitat to the Park. The Management Plan also notes that waterbirds, and particularly shallow waders, are easily disturbed by humans and stock, and a buffer of fringing vegetation around the lake is important to minimise this. Fringing vegetation also provides important nesting and foraging areas, and acts as a filter to maintain water quality in the lake (CALM & NPNCA, 1995).

6.3Reduction of Nutrient Inputs to Lake Clifton

CBI has already undertaken considerable revegetation works on cleared areas of the land proposed for incorporation into the National Park. This has been done in close consultation with CALM experts. The vesting of this land under CALM management, as is proposed with the land exchange, will enable this work to continue. Ultimately the land will provide a fully vegetated buffer zone which is contiguous with National Park land to the north and south and will serve to reduce the vulnerability of the lake to nutrient inputs.

6.4Control of Access to Lake Clifton

Under the proposed land exchange, access to the lake through the 'buffer' areas can be strictly controlled by CALM, thus helping to minimise impacts and preserve the fringing Vasse Lagoonal system. Walking trails will be able to be constructed along the full length of the western side of the lake.

6.5Control of Vehicle Use in National Park

The residential development planned by CBI will be serviçed by a sealed road from the north, the route of which has been carefully selected to ensure minimum impact to the environmental values of neighbouring National Park land. This road will also provide controlled vehicle access to the National Park areas and allow for the current access road (No. 228), which passes through significant and critical areas of lake frontage and vegetation, to be closed. This accords with recommendations made in the Coastal and Lakelands Planning Strategy (WAPC, 1997). Such closure will also help curtail the currently uncontrolled 4WD vehicle movements in the area.

6.6Long Term Development Surety

As mentioned above, the residential development on the Quindalup Dune system will be carried out using innovative design, incorporating water-sensitive design principles, in a manner that has low impact on the landform, landscape and vegetation of the area. It is proposed as an 'ultimate capacity' development, not to be exceeded by future subdivisions or further development.

7.References

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Maps

N

REALIGNED ACCESS ROAD

C.B.I.

LEGEND

	NATIONAL PARK %	CBI
QUINDALUP COMPLEX	8	42
COTTESLOE COMPLEX (CENTRAL & SOUTH)	17	30
VASSE COMPLEX	3	0
KARRAKATTA COMPLEX (CENTRAL & SOUTH)	2	0
YOONGARILLUP COMPLEX	30	28
BASSENDEAN COMPLEX (CENTRAL & SOUTH)	0	0
WATER BODIES	40	0
NATIONAL PARK BOUNDARY		
PROPOSED ADDITIONS		

Source: Darling vegetation complexes by Heddle, Loneragan & Havel August 1978

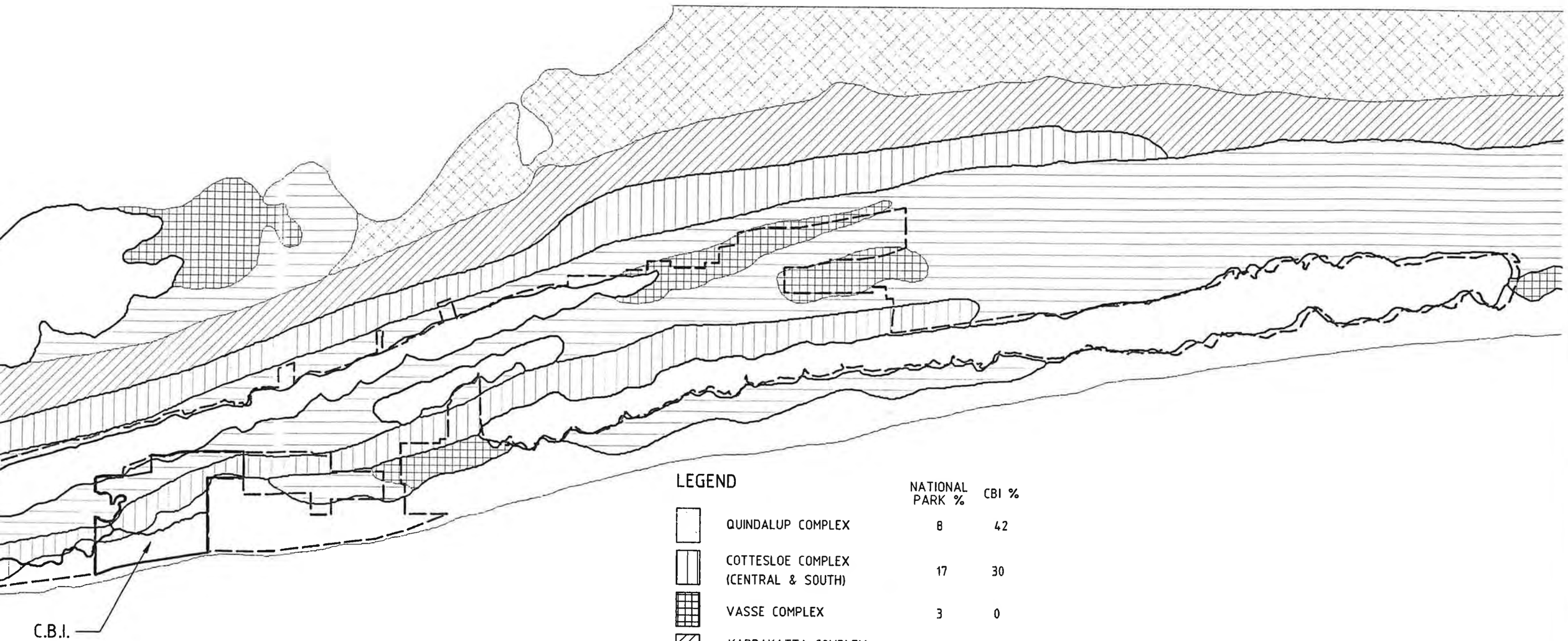
GHD

MJH/MRC 27/2/98
5254-05-00
CAD: FIG9.DGN

1000 500 0 1000 2000 3000 m

SCALE 1:10,000

FOR CAPE BOUVARD INVESTMENT
LAKE CLIFTON WEST



LEGEND

	NATIONAL PARK %	CBI %
QUINDALUP COMPLEX	8	42
COTTESLOE COMPLEX (CENTRAL & SOUTH)	17	30
VASSE COMPLEX	3	0
KARRAKATTA COMPLEX (CENTRAL & SOUTH)	2	0
YOONGARILLUP COMPLEX	30	28
BASSENDEAN COMPLEX (CENTRAL & SOUTH)	0	0
WATER BODIES	40	0
NATIONAL PARK BOUNDARY		
PROPOSED ADDITIONS		

Source: Darling vegetation complexes by Heddle, Loneragan & Havel August 1978

000 2000 3000 m

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FOR CAPE BOUVARD INVESTMENTS
LAKE CLIFTON WEST

VEGETATION COMPLEXES YALGORUP NATIONAL PARK

MAP 2

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