POINT GREY DEVELOPMENT PROJECT

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME



1987

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for MALLINA HOLDINGS LIMITED

Dames & Moore Job No. 14932-003-071 July 1987

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POINT GREY DEVELOPMENT PROJECT ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

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

The Environmental Review and Management Programme (ERMP) for the proposed Point Grey Development Project, has been prepared by Dames & Moore in accordance with Western Australian Government procedures. The report will be available for comment for 10 weeks, beginning on Friday 10 July, 1987, and finishing on Monday 21 September 1987.

Comments from government agencies and from the public will assist the EPA to prepare an Assessment Report in which it will make a recommendation to Government.

Following receipt of comments from government agencies and the public, the EPA will discuss the issues raised with the proponent, and may ask for further information: The EPA will then prepare its assessment report with recommendations to Government, taking into account issues raised in the public submissions.

Zoning of the land contained within the Point Grey Project is controlled by the Shire of Murray's West Murray Town Planning Scheme. In accordance with the Town Planning and Development Act, 1928, Council has resolved to amend the West Murray Town Planning Scheme to include the land in a variety of zones to facilitate development of the project. The Amendment is No. 58 to the West Murray Town Planning Scheme, and it too, will be available for public inspection.

The statutory public submission period for both the Town Planning Scheme Amendment and the ERMP will run in parallel. It is intended that the closing date for submissions on Amendment No. 58 will be two weeks after the EPA's assessment report on the ERMP has been released to the public. This will allow interested members of the public the opportunity to review the EPA's assessment of the project before commenting on the Town Planning Amendment.

WHY WRITE A SUBMISSION?

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

All submissions received will be acknowledged.

DEVELOPING A SUBMISSION

You may agree or disagree, or comment on, the general issues discussed in the ERMP or with specific proposals. It helps if you give reasons for your conclusions, supported by relevant data.

You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific proposals in the ERMP

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

POINTS TO KEEP IN MIND

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

Attempt to list points so that the issues raised are clear. A summary of your submission is helpful. Refer to each point to the appropriate section, chapter or recommendation in the ERMP. If you discuss sections of the ERMP, keep them distinct and separate, so there is no confusion as to which section you are considering.

Attach any factual information you wish to provide and give details of the source. Make sure your information is accurate.

Please indicate whether your submission can be quoted, in part or in full, by the EPA in its Assessment Report.

REMEMBER TO INCLUDE

YOUR NAME / ADDRESS / DATE

THE CLOSING DATE FOR SUBMISSION IS: September 21, 1987. SUBMISSIONS SHOULD BE ADDRESSED TO:

The Chairman, Environmental Protection Authority 1 Mount Street PERTH WA 6000 Attention: Mr P. Skitmore



AERIAL OBLIQUE OF POINT GREY

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EXECUTIVE SUMMARY

GENERAL

Mallina Holdings Ltd (the Proponent) proposes to develop an urban settlement at Point Grey, located within the Shire of Murray and on the shores of the Peel-Harvey Estuary, Western Australia. The proposed development site is a 1083ha area of elevated, undulating land that overlooks the Peel-Harvey Estuary. Approximately two thirds of the land has supported intermittent agricultural activities since the 1840s. The remaining area is uncleared woodland and fringing foreshore vegetation.

Point Grey is adjacent to the Peel Inlet - Harvey Estuary, a large body of water that has recently become eutrophic in response to increase nutrient inputs from surrounding agricultural areas. One of the most visible responses of the Peel-Harvey ecosystem to nutrient enrichment has been seasonal algal blooms. These blooms frequently accumulate on foreshores, decompose and create offensive odours. This recent trend has caused considerable community concern, and resulted in a range of Government research investigations that will be used to define a overall management policy for the Estuary.

PROPOSED CONCEPT AND DEVELOPMENT ALTERNATIVES

The Proponent has evaluated the land use alternatives for the area, and concluded that there were two broad options. The first is to continue the pursuit of farming activities and the second is to develop the site and establish some form of urban settlement.

The farming option was examined and it was concluded that the existing management policy would have to be substantially upgraded and agricultural activities intensified if the operation were to become a viable economic proposition. This would involve clearing the forested southern area of the property and an expansion of the fertiliser programme to increase grazing production.

The option involving urban development was considered in detail in a study conducted by Dames & Moore (1986). The principal aim of that study was to determine the environmental capacity of the site and the surrounding estuarine ecosystem to support urban development. Particular attention was placed on assessing the potential constraints imposed by urban nutrient loading and the development of a water supply. The most environmentally acceptable and economically feasible option was seen to be a staged development involving five land use categories with a total population of approximately 9000. In broad terms, the proposal conforms with the preferred development option defined by the Mandurah and Districts Planning Study, which consisted of a series of development nodes, conservation reserves and natural buffer zones, and envisaged a population of 12,000 to 15,000 (Town Planning Department, 1984).

The proposed Point Grey development concept that forms the basis for this Environmental Review and Management Programme (ERMP) is also in agreement with the planning preferences of the Shire of Murray, which regards the site as one of the only areas of elevated land within the Shire, that overlooks the Estuary and is suitable for residential development. Council has supported the proposal and has initiated an amendment to its West Murray Town Planning Scheme (Amendment No. 58) to facilitate development of the first phase of the project.

DESCRIPTION OF PROPOSAL

The main features of the proposal are outlined below:

- o Thomas Peel College: The development will be centred around an international academic institution, providing live-in, short diploma courses in English Language, Secretarial and Commercial studies, and Basic Computing. The College will cater for 1000 full-time, fee-paying students, primarily of international origin. The College will be entirely funded by private sources and financial assistance will not be sought from Government. Construction of the College will commence in year 1 of the development, and continue for about eighteen months.
- Residential neighbourhoods: The northern cleared area of the Point Grey site is to be developed as residential neighbourhoods. Approximately 2820 residential lots, ranging in size from 700 to 1200m², will be provided for an anticipated population of 7200. Each lot will be fully serviced with reticulated water, deep sewerage, electricity, telephone and roads. Development is envisaged over a 30 year period.
- Tourist and holiday development: Four locations have been selected for tourist and holiday facilities. All units will be fully serviced. Development will commence in year 2 and proceed over 30 years.

- Large Leisure Living Lots: The proposal includes 300 leisure living lots for a 450ha area of uncleared land in the south of the Point Grey site. The lot sizes will range from 1.0 to 1.5ha. These lots will be provided with reticulated water supplies, electricity etc, however, due to the low density and favourable site conditions, sewerage facilities will consist of septic tanks. Strict development controls will apply to ensure the retention of natural vegetation. All lots are expected to be sold within five years, with full occupancy occurring in about thirteen years.
- Golf course: A 50ha site has been allocated for an 18 hole golf course. This facility will be established at the commencement of the development and will be a focal point within the residential component of the development.
- Open space and foreshore reserves: Significant areas of land will be retained as public open space. A 50m wide reserve will be established around the foreshore perimeter of the site, thus upgrading the fragmented reserve system that presently exists. Approximately 100ha of land will be ceded free of cost to the Crown, and will form part of the reserve system.

ENVIRONMENTAL ASSESSMENT AND MANAGEMENT

The main environmental issues have been identified as the potential nutrient impacts on the Peel-Harvey Estuary and the implications for the Government's estuarine management policy; the development of a water supply; impacts on conservation reserves; issues relating to the change in land use of the site from agriculture to essentially urban; and the sociological effects on the surrounding community.

NUTRIENTS

The assessment of nutrient impacts on the environment has considered the phosphorus and nitrogen loading to the site as a result of a number of agricultural scenarios, together with the potential load resulting from the development, both with and without the establishment of environmental management. Comparison of potential nutrient loadings to the site are given in Table 1. This indicates that nutrient management programmes can reduce the total phosphorus input to the Point Grey site to an estimated maximum of 4.5t/yr at full development. This is only 70% of the fertiliser load calculated for agricultural maintenance of the existing farm using Department of Agriculture recommended application rates. Further reductions may be achieved by encouraging the use of native gardens and by implementing a soil testing programme aimed at determining the optimum level of fertiliser application to the golf course, public parks and gardens, and College campus.

TABLE 1

COMPARISON OF PHOSPHORUS LOADING

	A	GRICULTURAL LAN	ID USE		PROPOSED POINT GREY DEVELOPMENT		
	FULL (11 AGRICUL DEVELOF (t/y	D83ha) TURAL PMENT r)	EXISTI AGRIC DEVE (NG (720ha) CULTURAL LOPMENT (t/yr)			
YEAR	CONVENTIONAL PHOSPHORUS (P) APPLICATION RATES*	RECOMMENDED PHOSPHORUS (P) APPLICATION RATES**	CONVENTIONAL PHOSPHORUS (P) APPLICATION RATES*	RECOMMENDED PHOSPHORUS (P) APPLICATION RATES**	POTENTIAL PHOSPHORUS LOADING WITHOUT MANAGEMENT (t/yr)	POTENTIAL PHOSPHORUS LOADING WITH MANAGEMENT (t/yr)	
1	19.5	11.2	13.0	6.3	2.8	2.7	
10	19.5	11.2	13.0	6.3	3.9	2.7	
20	19.5	11.2	13.0	6.3	5.7	3.4	
50	19.5	11.2	13.0	6.3	7.3	4.5	

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* 16 - 18kg/ha/yr

** Department of Agriculture

A similar calculation for nitrogen indicated that the proposed development would lead to a 50% reduction in loading compared with the current level of farming.

WATER SUPPLY

The study has identified three potential groundwater supply sources, and they are:

- o the surficial aquifer on Point Grey,
- o the Waroona Mound, a surficial aquifer in Quaternary sands located 15km southeast of the project site, and
- o the Leederville Formation, a multi-layered aquifer fully saturated with groundwater.

An evaluation of these sources has demonstrated that the total supply requirements for the Point Grey development can be obtained from the extensive, low salinity Waroona Mound.

During the early stages of the development (e.g. the construction phase of the College) it is proposed to utilise the Upper Leederville aquifer for part or all of the initial water requirements.

The drawdown effects resulting from the development of the Waroona Mound and Upper Leederville Formation have been assessed, and are unlikely to have any significant environmental impacts on surface water hydrology, or on the long term water quality of the aquifers.

There is inadequate storage within the surficial aquifer on-site for the water requirements of the development.

CONSERVATION RESERVES

The Point Grey development site adjoins five 'C' class reserves. Only one is reserved for conservation purposes. The remainder are uncleared and retain conservation values.

Foreshore reserves also occur intermittently around the Peninsula, although substantial areas are presently unclassified.

The proposal seeks to create a 50m wide reserve around the entire perimeter of the foreshore, thus combining the existing, fragmented system into a continuous unit that can be properly managed. The Proponent has agreed to cede approximately 100ha of land, free of cost to the Crown, to facilitate the development of the foreshore reserve.

The ERMP discusses in detail the management procedures that will be adopted to retain the conservation value of the reserves. These procedures address issues such as fire management, dieback disease control, rubbish disposal, foreshore management and human impacts.

SOCIOLOGY

The sociological effects of a 1000 student College and an associated urban settlement at Point Grey have been assessed. Some of the important benefits that will result from the project relate to:

- capital construction cost of about \$87 million for the College and residential developments,
- o foreign exchange earnings of between \$15 and \$20 million per year,
- o creation of employment opportunities,
- o stimulation of tourist growth in the region,
- residential opportunities for the increasing industrial workforce of the Pinjarra area, and
- increased public access to the southern areas of the Peel-Harvey Estuary for recreational pursuits.

The most significant sociological impacts are likely to result from the predicted increased population pressure on the foreshore regions and the adjacent waterway system. The environmental management programme will ensure that access to the foreshore (e.g. boat launching facilities) will be restricted to resilient sites, and that the more sensitive sites will be fenced or fortified to prevent foreshore degradation and erosion. The boat launching sites that form part of the development concept will assist in relieving the congestion frequently experienced at other boat launching facilities on the Estuary, and improve the accessibility of the southern sections of the Harvey Estuary and Peel Inlet for recreational fishing.

Any potential conflict between recreational and professional fishermen over fin fish is unlikely to be significant, since the professionals generally fish for bait fish such as yellow-eyed mullet, rather than table species such as whiting and cobbler that are popular amongst recreational fisherman.

Management measures designed to reduce the human impacts on the site and in nearby areas, are discussed in the ERMP.

IMPLEMENTATION OF MANAGEMENT PROGRAMME

The Proponent has undertaken to prepare a management programme that will require the regular recording of environmental data, evaluation of results and, where necessary, amendment of management policies. A site manager will be located on Point Grey to carry out these tasks.

CONCLUSIONS

The proposed Point Grey development has been conceived in terms of the environmental capacity of the site and surrounding ecosystem to support urban development. Extensive environmental, groundwater, planning and engineering investigations have been carried out to ensure that the environmental impacts of the project will be minimal

A comprehensive environmental management programme has been devised that, when implemented, will reduce the nutrient inputs presently flowing through to the Estuary from the Point Grey site largely as a result of existing and historical agricultural activities.

The environmental management programme is therefore in accordance with the Government objective of reducing the overall amount of nutrient flowing into the Peel-Harvey Estuary.

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME POINT GREY

1.0 INTRODUCTION

1.1 GENERAL

Mallina Holdings Ltd (the Proponent) proposes to develop an urban settlement at Point Grey, located within the Shire of Murray and on the shores of the Peel Inlet - Harvey Estuary, Western Australia (Figure 1). The development concept envisages residential neighbourhoods, large leisure living lots and holiday developments, integrated around a College campus to be known as the Thomas Peel College. Development is planned over a 25 to 30 year period.

1.2 BACKGROUND AND OBJECTIVES OF THE PROPOSAL

The Point Grey area is a 1083ha area of elevated undulating land that overlooks the Peel-Harvey Estuary. Appoximately two thirds of land has supported agricultural activities since it was first settled by Europeans in the 1840s. The remainder is uncleared woodland (Frontispiece).

The Proponent has evaluated the land use alternatives for the area, and concluded that there were two broad options. The first was to continue the pursuit of farming activities and the second was to sub-divide the site and establish some form of urban settlement.

The farming option was examined and it was concluded that the existing management policy would have to be substantially upgraded and agricultural activities intensified if the operation were to become a viable economic proposition. This would involve clearing of the southern regions of the property and an expansion of the fertiliser programme to increase grazing production.

The alternative option involving urban development was considered in detail in a study conducted by Dames & Moore (1986). The principal aim of that study was to determine the environmental capacity of the site and the surrounding estuarine ecosystem to support urban development. Particular emphasis was placed on assessing the potential constraints imposed by the disposal of sewage effluent and the development of a water supply.

The most environmentally acceptable and economically feasible option comprised a staged development involving five land use categories and a total population of approximately 9000. In broad terms, the proposal conforms with the preferred development option for Point Grey defined by the Mandurah and Districts Planning Study, which consisted of a series of development nodes, conservation reserves and natural buffer zones, and envisaged a population of 12,000 to 15,000 (Town Planning Department, 1984).

The proposed Point Grey development concept that forms the basis for this Environmental Review and Management Programme (ERMP) is also in broad agreement with the planning preferences of the Shire of Murray, which regards the site as one of the few areas of elevated land within the Shire, that overlooks the Estuary and is suitable for residential development.

1.3 PROPOSED POINT GREY DEVELOPMENT

The main features of the proposal are outlined below:

- o Thomas Peel College: The development will be centred around an international academic institution, providing live-in, short diploma courses in English Language, Secretarial and Commercial studies, and Basic Computing. The College will cater for 1000 full-time, fee-paying students, primarily of international origin. The College will be entirely funded by private sources and financial assistance will not be sought from Government. Construction of the College will commence in year 1 of the development, and continue for about eighteen months.
- Residential neighbourhoods: It is proposed to develop the northern region of the Point Grey site as residential neighbourhoods. Approximately 2820 residential lots, ranging in size from 700 to 1200m², will be provided for an anticipated population of 7200. Each lot will be fully serviced with reticulated water, deep sewerage, electricity, telephone and roads. Development is envisaged over a 30 year period.
- Tourist and holiday development: Four locations have been selected for tourist and holiday facilities. All units will be fully serviced. Development will commence in year 2 and proceed over 30 years.

- Large Leisure Living Lots: The proposal includes 300 leisure living lots for a 450ha area of uncleared land in the south of the Point Grey site. The lot sizes will range from 1.0 to 1.5ha. These lots will be provided with reticulated water supplies, electricity etc, however, sewerage facilities will consist of septic tanks due to the low density and favourable site conditions. Strict development controls relating to removal of vegetation will apply. All lots are expected to be sold within five years, with full occupancy occurring in about thirteen years.
- o Golf course: A 50ha site has been allocated for an 18 hole golf course. This facility will be established at the commencement of the development and will be a focal point within the residential component of the development.
- O Open space and foreshore reserves: Significant areas of land will be retained as public open space. A 50m wide reserve will be established around the foreshore perimeter of the site, thus upgrading the fragmented reserve system that presently exists. Approximately 100ha of privately designated land will be ceded free of cost to the Crown, and will form part of the reserve system.

1.4 STATUTORY REQUIREMENTS AND APPROVALS

The Environmental Impact Assessment procedure is a formalised process designed to provide information to the Environmental Protection Authority (EPA) and the public about proposed developments which have the potential to generate significant environmental effects.

The Environmental Protection Act, 1986 was proclaimed on 20 February 1987 and this proposal will be assessed under that new legislation. The new procedures formalise the review process that evolved under the previous legislation (Environmental Protection Act, 1971 - 1980) and provide for enforcement of management commitments made by the Proponent.

Following referal of a proposal to the EPA, the Authority determines the level of environmental assessment required, and, in conjunction with the Proponent, develops guidelines for the appropriate environmental report. In the case of the Point Grey proposal, the EPA required that an ERMP be produced. The guidelines for the document are given in Section 12.

An ERMP is a public document and submissions by interested persons and groups are encouraged in order to assist the Authority in its assessment of the proposal and in framing its advice to the Minister for the Environment. Zoning of the land contained within the Point Grey Project is controlled by the Shire of Murray's West Murray Town Planning Scheme. In accordance with the Town Planning and Development Act, 1928, Council has resolved to amend the West Murray Town Planning Scheme to include the land in a variety of zones to facilitate development of the project. The Amendment is No. 58 to the West Murray Town Planning Scheme. Submissions by the public on planning related issues relevant to the Town Planning

Scheme Amendment are to be lodged with the Shire of Murray during the prescribed submission period, whilst submissions on the Environmental Review and Management Programme are to be lodged with the EPA.

Following discussions with the State Planning Commission and the EPA (formerly the Department of Conservation and Environment), it has been agreed that the statutory public submission periods for both the Town Planning Scheme Amendment and the ERMP can run in parallel. Special provisions will be made to ensure that the closing date for submissions on Amendment No. 58 will be two weeks after the EPA's assessment report on the ERMP has been released to the public. This will allow interested members of the public the opportunity to review the EPA's assessment of the project before commenting on the Town Planning Amendment. The recommendations of the EPA on the ERMP will be forwarded to the Minister for Planning for consideration, prior to his determination of the Town Planning Scheme Amendment.

Other legislation pertaining to the project and this ERMP includes:

- o Wildlife Conservation Act, 1950 1980
- o Aboriginal Heritage Act, 1972 1980
- o Conservation and Land Management Act, 1984
- o Water Authority Act, 1984
- o Metropolitan Water Authority Act, 1982
- o Rights in Water and Irrigation Act, 1914
- o State Planning Commission Act, 1985
- o Bush Fires Act, 1954 1981
- Agriculture and Related Resources Protection Act, 1976 1981
 - o Soil and Land Conservation Act, 1945 1982
 - o Town Planning and Development Act, 1928
- Waterways Conservation Act, 1976
- o Environmental Protection Act, 1986
- o Country Areas Water Supply, 1947 1979.

1.5 PURPOSE AND STRUCTURE OF THE ERMP

The purpose of this ERMP is to promote the public understanding of the proposed Point Grey development project and to enable the EPA to give advice to the Government on the environmental acceptability of the project.

The document has been prepared as two volumes. Volume One is the main text, and describes the details of the proposal, the alternative land use options for the site, the probable environmental impacts, and procedures that will be implemented by the Proponent to enhance the positive effects and minimise the magnitude and duration of any negative impacts.

The principal environmental concerns of the proposed project have been identified in a letter from the Minister for Environment, dated 20 October 1986. These concerns involve a range of complex issues concerning nutrient disposal and water supply, and a series of detailed studies have been undertaken in order to properly address these concerns. These studies are reported at Technical Appendices in Volume Two of this document. The objective of these Appendices is to present, in greater detail, the assessment of the potential impact of these issues, and recommend management methods.

2.0 NEED FOR THE DEVELOPMENT

The proposed development at Point Grey offers a range of benefits to the local, regional and state community. These benefits can be broadly grouped under five headings. They are:

- o urban growth,
- o education and foreign exchange,
- o tourism and recreation,
- o conservation, and
- o employment.

Each is discussed in terms of environmental impact in Section 6.0 of this document, however, an outline is presented below in order to emphasise the extent of the benefits in the local, regional and national context.

2.1 URBAN GROWTH

The rate of population growth in the Mandurah, Murray and Waroona Shires is substantially higher than the state-wide average (Section 5.5.1) and this is reflected by the number of housing commencements recently recorded for the Peel-Harvey hinterland (Section 5.5.4; Feilman Planning Consultants, 1987).

Mandurah recorded the highest growth rates for both of the above sets of statistics, and this is probably a reflection of the town's proximity to the Estuary, the ocean and metropolitan Perth, and the availability of nearby services and facilities.

The availability of attractive, residential land within the Shire of Murray that is capable of absorbing the above growth trends, is limited. The introduction of elevated, residential land, located close to the Estuary, will therefore provide important development alternatives for the Shire of Murray.

2.2 EDUCATION AND FOREIGN EXCHANGE

An important initial focus for the development is an international business college for about 1000 overseas fee-paying students. This component of the project introduces a new concept to Western Australia. The concept is based upon the fact that education plays a major role in the growth of many developing countries, forming a major item of public expenditure where billions of dollars are budgeted yearly to train, upgrade and educate young students.

A study commissioned by the Proponent and performed by WAITEC (the commercial arm of Curtin University of Technology) demonstrates the enormous market demand for school/tertiary level education. In three countries sampled, the following estimates were given:

- Malaysia population 15 million, with 18.5% in school/tertiary level, and US\$580 million allocated for training and education.
- Thailand population 51 million, with 18.6% in school/tertiary level, and US\$205 million allocated for training and education.
- Indonesia population 156 million, with 18.5% in school/tertiary allocated for training and education (WAITEC, 1986).

Australia lags behind many countries in recognising the potential economic advantages associated with the education of overseas students, including Canada, France, the United Kingdom, West Germany and the United States of America. This situation is probably a result of the more traditional view of an export industry based upon natural resources and primary products rather than education.

The potential amount of foreign exchange that could be generated by education services is demonstrated by Singapore's recent efforts to become a regional centre for language and commercial schools. In 1986, this country accepted about 8000 students generating US\$17.5 million per year, with suggestions that this figure could rise to 20,000 by 1995, which would be the equivalent of US\$44 million in gross tuition receipts and up to US\$127 million if indirect receipts are included (WAITEC, 1986).

The Thomas Peel College concept has been designed to capture a small portion of this export by offering a blend of courses for 1000 students. It is estimated that the College will generate about \$15 million annually in direct receipts.

2.3 TOURISM AND RECREATION

The Mandurah region is the focus for one of the most popular tourist/holiday destinations outside the Perth Metropolitan area (WA Tourism Commission, 1986). Much of the attraction is the Peel-Harvey Estuary and the associated fishing and boating activities. The facilities that serve the recreation pursuits are generally concentrated along the western foreshore of the Harvey Estuary and the northern margins of Peel Inlet.

During holdiay periods, these facilities (principally boat launching sites) often become over-crowded. The Peel Inlet Management Authority (PIMA) has recognised this problem and has recommended that additional launching sites, together with appropriate car parking facilities, be established along selected foreshore areas. The Point Grey development includes four potential locations for boat launching facilities. When established, these facilities will substantially ease congestion along the more populated foreshore margins of the Estuary, and improve general access to the eastern regions of the waterway.

2.4 CONSERVATION

The Point Grey development adjoins five 'C' class reserves, and although only one of them is designated for conservation, the others are uncleared and retain conservation value. Foreshore reserves also occur intermittently around the peninsula, and in their uncleared state, help protect the shoreline from erosion.

The Proponent plans to cede about 100ha of foreshore land to join up the fragmented reserved land around the development site. The areas proposed to be ceded, when combined with the existing Crown reserves, will form a continuous vegetated belt around the site with the 'C' class reserves linked by the linear foreshore reserve. The total combined area of the reserves will be in excess of 200ha.

The Point Grey development will therefore favour the conservation of foreshore areas by forming a continuous parcel of land that can be carefully managed by a single authority. The formulation of these reserved areas will also enable the public to utilise areas that have previously been inaccessible. Another positive impact of the development is that the southern woodland areas will remain largely uncleared as a result of development restrictions that will be imposed upon people purchasing leisure living lots. If the Point Grey development does not proceed, it is likely that this area would need to be cleared in order to maintain a viable farming operation. Existing agricultural activities are only operating at maintenance levels, and would be required to be significantly upgraded to become a commercial operation.

2.5 EMPLOYMENT

The Point Grey development will result in considerable economic benefit to the Mandurah, Murray and Waroona Shires. It is currently estimated that the project will generate a construction workforce peaking at about 430. Once completed, the College will generate employment opportunities for approximately 80 people, including teaching and administrative staff, and service employees including cleaning, maintenance, landscaping/gardening, security and kitchen staff. A significant and immediate multiplier effect will be created by the demand for servicing the following facilities: food and beverage supplies; school consumables; building and ground maintenance; and laundry and fuel supplies.

3.0 EVALUATION OF ALTERNATIVES

The Point Grey region has a long history of agriculture and grazing. The area was first settled in the 1840s, and farming activities have continued virtually uninterrupted since then.

The Mandurah and Districts Planning Study Draft Report, published and released for public comment in 1984, recognised the development potential of the Point Grey site and the land extending southwards to Lake McLarty (Town Planning Department, 1984). The Study considered five long term development options for the area, and they were:

- o no change to the existing land use; this option was not supported because it was recognised that a viable farming operation would require additional clearing and the application of greater quantities of fertiliser to the overall detriment of the Estuary,
- total conservation reserve; this option presented significant environmental benefits, however, it was not favoured because of the high acquisition costs of the land,
- o special rural development; this option was rejected because of the difficulties associated with servicing the site and managing the rural activities,
- total urban development; this option, which envisaged the creation of an urban settlement for 22,000 people, was not favoured because of the perceived long term limits to expansion, and
- a balanced conservation/urban development; this option included a series of development nodes designed to accommodate a potential population of 12,000 to 15,000 people, with conservation reserves and natural bushland areas forming buffer zones between the major population areas. This was the preferred option nominated by the study.

The Proponent's preliminary economic and planning investigations indicated two broad options. The first was to continue the pursuit of farming activities and the second involved sub-dividing the site and creating an urban settlement.

The farming option was examined, and it was concluded that the existing management policy would have to be substantially upgraded and agricultural activities intensified if the property were to become an economic proposition. This would probably require the clearing of the south of the property and an expansion of the fertiliser programme to improve the production of pasture. The option of sub-dividing the land and creating an urban settlement was examined, and a number of important variables requiring detailed consideration were defined (Dames & Moore, 1986). They were:

- o the potential environmental effect of increased nutrient levels in the nearby Estuary that could result from the application of garden fertilisers and the disposal of waste water effluent,
- o the need to define a development that comprised a combination of land uses, that was economically viable, commercially feasible and environmentally acceptable,
- the potential development and population impact upon adjacent waterways and reserves,
- o the availability of suitable water supplies,
- o the Shire of Murray's indication that any development proposal would need to comprise a significant residential component, and
- o the relatively isolated location of the area.

These variables were then used to define the environmental capacity of the site to support development (Dames & Moore, 1986). A range of possibilities were considered, including the sub-division of the entire site into special rural allotments. (In that instance, difficulties associated with disposing a large amount of sewage effluent via septic tanks, and developing a suitable water supply, could not be solved economically or in an environmentally acceptable manner).

A variety of other land uses, land use configurations and development densities were considered and evaluated in accordance with the environmental capability of the site. The most environmentally acceptable and economically feasible option comprised a staged development involving five land use categories, culminating in a total population of about 9000, and centred around an international business College. This option forms the basis for the ERMP and is described in detail in Section 4.0. In broad terms, the development concept is similar to the preferred option outlined in the Mandurah and Districts Planning Study, and described above. The major difference is that the Planning Study envisaged a total population of 12,000 to 15,000 which is 30% to 60% higher than that proposed for the present development.

4.0 DETAILED DESCRIPTION OF THE DEVELOPMENT

4.1 GENERAL CONCEPTS

The Point Grey project has been designed as a new residential and holiday settlement on the shores of the Harvey Estuary and Peel Inlet. The project site is the only elevated land adjoining the Harvey Estuary or Peel Inlet suitable and available for urban development, since remaining water frontage land is either designated for conservation purposes, or is low lying and generally unsuitable for development. Furthermore, the Shire of Murray regards the site as being the most appropriate parcel of land for a major urban settlement that lies within its municipality and adjoins the Estuary.

The site also represents one of the few water based locations within close proximity to the Perth Metropolitan area that is suitable for a large scale development.

The Point Grey concept plan is illustrated in Figure 2 and comprises:

- o the Thomas Peel College,
- o residential nodes,
- o special residential leisure living lots,
- o tourist/holiday accommodation sites,
- o an 18 hole golf course,
- o shopping, education and community infrastructure, and
- o foreshore and recreation reserves.

A total residential population of about 9000 people is envisaged, with a staged development programme extending over 25 to 30 years (Table 2, Figure 3).

TABLE 2

PROPOSED POPULATION AND URBAN DEVELOPMENT CONCEPT FOR POINT GREY

C	OLLEGE	SPECIAL RESIDENTIAL LEISURE LIVING LOTS		RESIDENTIAL LOTS	
Units	Population	Units	Population	Units	Population
1	1080	300	770	2820	7200

4.2 THOMAS PEEL COLLEGE

The focal point for the development will be the "Thomas Peel College", a \$50 million international College, situated on a 50ha site, with views over the Peel Inlet towards Mandurah and the Darling Ranges (Figure 2).

The concept of an international post-secondary College offering intensive full-time short courses in English Language, Secretarial, Commerical and Basic Computing studies, to serve students from Asia and Europe, has been extensively researched by WAITEC on behalf of Mallina Holdings Ltd. The results of that study confirmed that the College is commercially feasible and would provide a service that is in great demand from overseas students. The project will represent a significant foreign income earner for the State.

The College will initially provide qualifications to a diploma level for 1000 students, and will be serviced by about 80 academic and administrative staff. In addition, support staff will be required to provide security, maintenance, cleaning, medical and student care services.

The College will be privately owned and funded, and will be administered without Government assistance.

The following description outlines the main components and infrastructure that will be developed as part of the College complex.

- o The main administration building; comprising lecture theatres, administration offices, restaurant, coffee shop, cafeteria, kitchens, library, medical/dental facilities, computer centre, workshop and maintenance facilities and College supply store.
- Four academic buildings; comprising classrooms, academic staff offices, language laboratories and student common rooms.
- o Thirty two two-storey, residential blocks; planned to house 1000 students. Each block will comprise 16 study/bedrooms, together with a common room for each floor.
- Sports and recreational facilities; comprising a sports pavilion, all-weather day and night tennis court and a soccer field. An amphitheatre is planned in the same area.

- Lodge and seminar accommodation; a 48 room, two-storey lodge, including two seminar/multipurpose rooms, and a car park for students and visitors.
- Academic, administration and staff residential accommodation; including a landscaped precinct containing several two and three bedroom residential dwellings, providing accommodation for the College Director and other staff.
 - Commercial facilities located near the College; including a multi-purpose general store, together with a small service station. Additional facilities will be provided as demand warrants.

4.3 RESIDENTIAL DEVELOPMENT

It is proposed to develop approximately 430ha of land for normal residential development and associated uses. This land is located over the predominantly cleared and farmed northern portion of the site (Figure 2, Frontispiece). The gently undulating land is ideally suited for residential development and poses no significant engineering constraints.

Proposed lot sizes will range in area from about 700 to 1200m² and will be fully serviced with:

- o reticulated water,
- o roads,
- o sewerage reticulation,
- o electricity, and
- o telephone.

The subdivision of the residential land will be designed around a structured hierarchy of roads and will accommodate:

- o primary school sites,
- a district shopping facility,
- o neighbourhood shopping,
- o statutory public open space requirements, and
- o standard civic and community facility sites.

Emphasis will be placed upon designing the subdivision to complement the natural features and to maximise views of the waterway system.

4.4 SPECIAL RESIDENTIAL LEISURE LIVING ALLOTMENTS

It is proposed to develop the southern half of the property into large leisure living allotments. The majority of this region of the property is naturally timbered, elevated, undulating land that will be set aside for 1.0 to 1.5ha residential lots. In the eastern region of the Leisure Living Zone, the land grades into a low-lying alluvial plain. Here, the density of the leisure living lots will be considerably reduced, with sizes averaging about 5ha.

An overall total of 300 leisure living lots are envisaged, covering an area of approximately 420ha.

This concept achieves the objective of retaining much of the natural vegetation and provides the public with a full range of lot sizes and shapes. Strict development controls are proposed under Council's Town Planning Scheme Amendment for the area (Section 13). These will ensure that the only clearing permitted within allotments will be to facilitate construction of a house, access to that house, and firebreaks as required by by-laws and as recommended by the Western Australian Bush Fires Board.

Larger than normal building setbacks will also apply, to reinforce preservation of the high visual amenity of the area. These lots will be provided with a reticulated water system, roads and a telephone system.

Development of the allotments will be staged. Approximately 100 will be released for sale during the first year of the development, with 50 being released each year thereafter. All lots are expected to be sold by year 5, with full occupancy expected by year 13.

4.5 TOURIST HOLIDAY ACCOMMODATION

Four strategically located sites, all adjacent to the Peel-Harvey Estuary, have been set aside for tourist/holiday accommodation. Commencement of this component of the project is scheduled for year 2, with full development occurring over a 30 year period. The Mandurah and Pinjarra region has long been identified and utilised as a major tourist holiday destination by people living within the Perth Metropolitan area and in the South-West of the State. The Perth Region Tourism Study, which surveyed both residents and visitors to the Perth Metropolitan area, identified the Mandurah region as the most important tourist attraction outside the Perth Metropolitan area (WA Tourism Commission, 1986).
With the growth in leisure time and changing work patterns, and the fact that the region is just over one hour's drive from Perth, it is anticipated that the Mandurah region will continue to be a major tourist and holiday destination.

The Point Grey site offers excellent potential for tourist/holiday accommodation. The proposed Perth-Bunbury Highway, to be located 9km to the east of Point Grey, further enhances the potential of the site, offering access to Perth, Mandurah, Bunbury and the South-West.

If the Dawesville Channel is constructed, the attractiveness of the Point Grey site as a tourist/holiday destination is likely to increase, because of the improved boating access to the Indian Ocean, and the southern regions of Harvey Estuary.

4.6 OPEN SPACE AND FORESHORE AREAS

The proposal nominates significant areas of foreshore/open space to complement existing reserves and provide adequate land to protect the foreshore environment. The plan has nominated selected foreshore areas for public access and utilization, including boat launching sites.

The proposed foreshore reserves around the Estuary will not fall below the minimum 50m width adopted as a policy by the Peel Inlet Management Authority (PIMA). Where the foreshore reserve adjoins the proposed boat launching sites, it has been widened to accommodate associated uses (e.g. parking and toilets).

Two major areas of land adjacent to the Estuary are to be ceded free of cost to the Crown for future reservation. The first, totalling just over 40ha and located on the tip of Point Grey, is designed to provide a reserve to conserve areas of vegetation and provide access for the general public (Figure 2).

The Shire of Murray Council has indicated its desire to provide a look-out on the northern portion of the knoll (forming part of the tip of Point Grey and included within this reservation), to give the general public opportunity to experience the panoramic views over the Peel Inlet and Harvey Estuary. This site also coincides with a former Aboriginal camping place and is of sentimental attachment to the Aboriginal people. Its reservation should provide for public access to all people. It is proposed that the area be called the Windjan Memorial Reserve. The second major foreshore area to be ceded, located to the east of the proposed Thomas Peel College and adjacent to Robert Bay, comprises just over 30ha of low lying land (Figure 2).

A number of smaller parcels of land will also be ceded to the Crown to form part of continuous foreshore reserve that will be a minimum of 50m wide.

The total land area ceded is therefore about 100ha, or 9% of the total land area owned by the Proponent. The areas, when combined with the existing Crown reserves, will form a continuous green belt around the foreshore of the site. The total combined area of the reserves will be in excess of 200ha, or over 18% of the development site.

The total open space system will therefore provide for the retention and protection of areas of environmental significance, allow public access to selected areas, and provide a means for managing foreshore areas.

4.7 BOATING FACILITIES

As the Point Grey project is developed and the population grows, there will be an increasing demand for controlled access to the foreshore and the Estuary. The proposal has therefore identified the need for boating facilities to accommodate dinghies and small leisure craft.

The Proponent has identified four potential sites (Figure 2) on the basis of the conservation status of the foreshore, proximity to relatively deep water (>1.0m), composition of the substrate of the foreshore margins and the location of the proposed tourist nodes. Access to these sites will be provided by the Proponent.

At each site, it is envisaged that there would be provision for a car park, a concrete boat ramp and possibly a jetty. It is likely that these facilities would be developed on the foreshore reserves by the local authority, in consultation with various state government agencies such as Marine and Harbours, PIMA and Department of Conservation and Land Management (CALM), although the Proponent may choose to install the first of the facilities themsleves.

4.8 ASSOCIATED WORKS

Investigations of the engineering aspects of the proposed Point Grey development have been completed. The objectives of these investigations were to assess:

- o options for sewage collection, treatment and effluent disposal,
- o options for water supply for domestic water use and irrigation,
- o feasible sewerage and water supply systems to serve the development,
- requirements for on-site and off-site roads and drainage, including the estimation of traffic usage, and
- o availability of public utility services to serve the development.

This section summarises the results of the investigations and provides an outline of the servicing arrangements considered appropriate for the development.

4.8.1 Water Supply

4.8.1.1 Alternative Water Supply Sources

The existing water supply in the Mandurah region comprises a reticulation scheme operated and maintained by the Water Authority of Western Australia (Water Authority) to serve the major portion of the Mandurah Shire and a large portion of the West Murray area. Options for a water supply to the Point Grey development includes either an extension of the Water Authority's existing scheme via Pinjarra or via Dawesville across the Harvey Estuary, or a local groundwater supply.

Discussions with officers of the Water Authority have indicated that a supply from the existing scheme will necessitate considerable upgrading of existing trunk mains and could require the augmentation of reservoir facilities. This, together with the long length of connecting watermains to the site, would involve very high initial headworks costs. In terms of the viability of the development, such costs could not be justified without considerable subsidization by the Water Authority.

It is apparent, therefore, that a local groundwater supply offers the most viable option for the development.

Three alternative groundwater supply options are available and they are:

- use of the deep freshwater aquifer in the Leederville Formation either at or near to the Point Grey site, or further to the southeast to intercept throughflow,
- o use of the shallow surficial aquifer in Quaternary sands to the southeast of the site (the Waroona Mound), or
- o conjunctive use of both the surficial aquifer and the Leederville Formation (Figure 4).

Unpublished studies undertaken by the Geological Survey of Western Australia have identified a major shallow groundwater resource in the surficial aquifer some 12 to 15km to the southeast of Point Grey. This resource, called the Waroona Shallow Groundwater Mound, contains potable water over an area of 120km².

Water storage within the aquifer, assuming an average thickness of 10m and effective porosity of 20%, is estimated at 240,000 megalitres (ML) with a present annual recharge (10% of rainfall), excluding drainage, of 12,000ML. This compares to the development's full water supply demand (domestic and irrigation) of about 2100ML/yr.

An extraction programme utilising water from the Leederville Formation represents the most economic alternative because substantially less headworks would be necessary compared with those involved with piping water from the surficial aquifer, located southeast of the site. However, an additional groundwater investigation is required to fully evaluate the Leederville Formation. This work is expected to comprise:

- an evaluation of the nature of the aquifer in terms of its geometry, water storage and hydraulic boundaries,
- test pumping and modelling studies to predict the impacts of pumping and confirm the concept of utilising a borefield to meet the development's total supply requirements, and
- evaluation of potential intrusion of poorer quality water to the aquifer and determination of current and expected rates of net recharge under the proposed scheme.

Such a study is impractical and uneconomic at this stage of the project feasibility study. It is therefore proposed that the initial construction supply will be obtained from the Leederville aquifer and that this supply, together with the known reserves in the surficial Waroona Mound aquifer, will be investigated and developed progressively to provide the water supply requirements for the total development.

Preliminary estimates suggest that water requirements during the construction period will amount to 50 to 100ML/yr, with peak week demand approximating 3 to 5ML/week. Pump testing of the Miami 1/80 bore indicated a water supply capacity of 0.9ML/day. This document has been prepared in the knowledge that sufficient reserves exist in the surficial aquifer to meet the total project demand, but that groundwater from both the identified aquifer systems will be considered as a potential supply.

4.8.1.2 Public Water Supply Demand

Each type of land use proposed in the development will be serviced by a reticulated water supply system as part of a comprehensive scheme for the overall development (Table 3).

Domestic water supply demand estimates have been prepared to enable the preliminary sizing of headworks. The estimated demands are shown in Table 4 and are based on the population assumptions described in Table 3.

Water supply requirements are for domestic consumption, College grounds irrigation, irrigation for parks and gardens and irrigation of the golf course. The total supply requirement is predicted to increase to about 6ML/day (on average) over the first 50 years of the development.

LAND USE	POPULATION	EQUIVALENT WATER SUPPLY SERVICES
Thomas Peel College	1080	400
Large leisure living lots	770	360
Residential	7200	2820
Tourist facilities	Transient*	595
Schools and shopping centres	-	45
TOTAL		4220

TABLE 3

ASSUMED POPULATION FOR WATER DEMAND ESTIMATES

Based on a maximum of 1000 accommodation units

TABLE 4

YEAR	AVERAGE ANNUAL DEMAND (ML)	PEAK WEEKLY DEMAND (ML)	
1	254	13	
5	515	27	
10	752	39	
15	989	51	
20	1172	61	
Total Development	1518	79	

ESTIMATED DOMESTIC WATER SUPPLY DEMAND FOR DEVELOPMENT

4.8.1.3 Water Supply System

Water supply to users will be via a conventional system of reticulation and trunk watermains operating under a gravity supply from a reservoir. Two high level systems will be required; one in the elevated area within the large leisure living lot area and the other in the area surrounding the reservoir. These will be supplied via either on-line booster pumping stations or elevated storage tanks. The economics of each alternative will be the subject of detailed design investigations.

The construction of the headworks facilities will be staged to suit the development programme. This will include the systematic expansion of the groundwater well system and upgrading of pumping facilities. An elevated reservoir tank of approximately 7.5ML capacity will be constructed to serve the initial stages of development. This tank would be covered to prevent contamination. Further development will require a progressive increase in this capacity to ultimately reach 20ML. This will be achieved through the construction of additional tanks, which will be staged in size and time to optimise overall costs. Following more detailed planning and engineering investigations, it may prove to be more appropriate to locate further reservoir stages throughout the development, if the associated additional cost can be offset by savings in trunk watermains costs.

It is expected that treatment of the water supply will be required to reduce the iron content. This would be carried out prior to storage in the reservoir tanks and would be via an aeration system. Chlorination of the water would also be carried out prior to storage.

All headworks, and trunk and reticulation watermains constructed to serve the development, will be designed in accordance with Water Authority requirements so that they can utimately be taken over by the Water Authority, as has successfully occurred in other land developments such as Chittering Country Estate and Yanchep.

4.8.2 Roads and Traffic Estimates

4.8.2.1 Traffic Forecasts

An assessment has been made of the requirements for roads to serve the proposed development. This includes both new roads to be constructed on-site, together with the roadworks required to provide access to the site.

The on-site road system to serve the proposed development will comprise a hierarchy ranging from primary roads to local access roads. To assess the function and standard of the primary roads, an estimate has been made of the traffic which is likely to be generated by the development. The estimate has been extended to also include the likely traffic usage of the off-site access road.

Predicted traffic volumes were assigned to the road network assuming a distribution to suit the locations of the developments facilities. The assignment of traffic to the offsite access road has been based on surveys carried out by the Main Roads Department (MRD) on the primary access roads north and south of Mandurah and between Mandurah and Pinjarra (MRD, 1985).

In estimating and assigning the generated traffic, consideration has been given to the likely demographic characteristics of the proposed community, which is expected to include a significant percentage of retired people and holiday/weekend residents. In addition, the College students are not expected to own or have regular access to cars. Overall, therefore, the average traffic generation per dwelling is expected to be significantly less than the figure normally adopted for the Perth Metropolitan area.

The estimated traffic growth for the total development and the off-site access road is indicated in Tables 5 and 6.

TABLE 5

FORECAST TOTAL ON-SITE TRAFFIC GENERATED BY DEVELOPMENT

YEAR	DAILY TRAFFIC (vehicles)
1 to 5	1000 to 3000
6 to 10	3000 to 6000
11 to 20	6000 to 10 000
21 onwards	10 000 to 16 000

TABLE 6

FORECAST ACCESS ROAD TRAFFIC

YEAR	DAILY TRAFFIC (vehicles)
1 to 5	300 to 1000
6 to 10	1000 to 2000
11 to 20	2000 to 4000
21 onwards	4000 to 6000

4.8.2.2 Access Road

The development site is located 20km west of the Pinjarra townsite. Vehicle access is currently via the existing Greenlands and Carrabungup Roads (Figure 5). Greenlands Road extends between the South Western Highway and Lake Mealup Road and varies in construction standard from a 6m sealed carriageway for the eastern 3.5km to a 3.7m sealed carriageway for the remainder. In both cases the carriageway is bounded by 1.5m gravel shoulders. Carrabungup Road comprises a 9m wide unsealed gravel pavement. Both roads are within a 20m wide road reserve.

The existing alignment of Carrabungup Road includes two right-angle bends between Lake Mealup Road and Boggy Bay Road. An alternative access road route is available via Edges Road which is a direct extension of Carrabungup Road east of Boggy Bay Road. Edges Road comprises a 20m wide unmade road reserve. At its eastern end, the reserve connects to Greenlands Road at the Edges Road stormwater drain.

The existing road construction includes a number of bridges and piped culverts at crossings of existing open drainage channels. In most cases, these structures are of reinforced concrete and in good condition. The exception is a timber bridge at the Robert Bay Drain, which is in a poor condition.

The existing access road will be upgraded to accommodate the anticipated traffic growth that will result from the development. A staged upgrading programme is proposed, and this will ultimately provide access to the future Perth - Bunbury Highway which will pass 9km east of the site.

The standard of road construction will comprise a gravel and crushed limestone pavement and a two-coat seal to meet the requirements of the Shire of Murray. Road drainage will be via table drains and culverts directed to the drainage channels existing in the area.

Future widening of the access road will be related to the growth of traffic volume. The need and timing will be resolved in consultation with the Shire of Murray.

4.8.2.3 Regional Roads and Access

Present access to the site from Perth is via Mandurah on the Mandurah and Pinjarra Roads or via the South Western Highway. Future access will be via the Perth - Bunbury Highway which is scheduled for construction in 15 to 20 years (MRD, pers. comm.).

Predicted traffic generation (Table 6) on the access road has been compared with published traffic count station data (MRD, 1985) for several locations on the South Western Highway. These data are presented in Table 7.

TABLE 7

MRD STATION NO.	LOCATION	AADT*	EXISTING FACILITIES	TRAFFIC CAPACITY
4444	SW H'way, north of Pinjarra	2953	9m carriageway	7000
4025	SW H'way, south of Pinjarra	3241	9m carriageway	7000
4841	Pinjarra Road, west of Pinjarra	7268	current 9m carriageway proposed 2 x 9m dual carriageway	7000 12,000

REGIONAL ROAD DATA

* AADT - Average Annual Daily Traffic 1984/85

The forecast access road traffic (Table 6) has been compared with the traffic counts, compound growth rates and current spare capacity (Table 7). Traffic to and from Point Grey will remain at about one third of existing traffic on the regional roads during years 1 to 20 of development and the total traffic will be within the capacity of the regional roads. In the longer term, year 20 onwards, sufficient additional capacity would be available with the new Perth-Bunbury Highway.

4.8.3 Sewage Collection and Treatment

A comprehensive wastewater collection and treatment system will be provided for the College, residential and tourist components of the development. A system of gravity reticulation sewers, pumping stations and pressure mains will discharge wastewater to a treatment plant. The sewerage system will be designed and constructed to the Water Authority's criteria and eventually handed over to be operated by the Water Authority. The lay out for the sewerage supply is shown on Figure 6.

The type and degree of sewage treatment depends largely upon the available methods of final disposal and the nature of the receiving environment. For normal land or receiving water disposal, secondary treatment is generally adequate for human health and environmental purposes. For the Point Grey development, the environmental sensitivity of the site and the surrounding region is such that a tertiary process is necessary.

This facility will be developed in two stages:

- o a temporary treatment plant, and
- o a permanent plant.

The temporary treatment plant is planned to service about 2000 people accommodated in the College and the first stage of the residential and tourist areas. The process will incorporate a two-part treatment process. The first will involve an extended aeration method, which is a form of activated sludge treatment. This method has the characteristics of stable operation; low waste sludge production; high quality effluent with respect to biological oxygen demand (BOD), total dissolved solids (TDS) and bacterial content; and relatively simple operational requirements. Alternatively, lined oxidation ponds may be used if economically viable. The second part of the process is a chemical treatment which involves the use of aluminium, calcium or ferric salts to bind soluble phosphates with hydroxides to form insoluble complexes which then settle out.

The second stage of the establishment of a sewage treatment facility will be the construction of a permanent plant. This facility will replace the temporary plant and be designed to service future residential development.

The plant will probably be constructed in two stages. The timing of each stage will depend on the actual rate at which the residential and tourist population increases. The size of each stage will be determined by a detailed economic and technical analysis to be carried out as part of the development planning process.

In preliminary planning, it has been assumed that the first stage of the permanent plant will need to be operational at the beginning of year 6, and that the full plant would be constructed in two equal-sized stages. The second stage would probably not be required before year 15. For the process design and operation of both temporary and permanent plants, the resultant treated effluent will have a nitrogen concentration of 10mg/L and a target phosphorus concentration of 2mg/L. The effluent will be disposed of by irrigating elevated, open ground areas (e.g. the golf course). Holding ponds will be constructed with impermeable linings to prevent uncontrolled leakage of treated effluent to the groundwater. This procedure will allow temporary storage during wet weather. This will prevent the possibility of effluent flowing overland and directly into the Estuary.

Sludge from the treatment plants will be treated on-site to an innocuous form and dried. It can be disposed of either by selling for use in compost mixes, as is currently done in Perth, or by burying in an approved sanitary landfill site.

In the design of both the temporary and the permanent treatment plants, careful attention will be given to avoiding the entry of any untreated or partially treated sewage to the groundwater system or the Estuary. Provisions will be made for any spills or overflows to be automatically collected in sumps and pumped back into the treatment system. Similarly, any rainfall likely to be contaminated by falling on plant items will be collected and recirculated within the system. To avoid problems resulting from breakdown of equipment, back-up plant will be provided and installed ready to operate whenever required. Tanks and ponds within the treatment plant will be sealed to prevent seepage to the ground, and adequate storage will be built in to allow for power failures or other plant stoppages.

4.8.4 Solid Waste Disposal

PIMA policy presently discourages the siting of sanitary landfill sites for rubbish disposal within 2km of the Peel-Harvey Estuary (Waterways Commission, 1986). Solid waste disposal for the Point Grey development will therefore be at an approved location, off-site.

Table 8 shows estimates of solid waste generation expected from the development, based on average figures from municipal areas in the Perth region.

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TABLE 8

YEAR	QUAN	ITITY
	(kg/day)	(L/ yr)
1	180	115 *
2	1130	415
3	1680	610
4	1990	730
5	2310	845
10	3890	1420
20	6300	2300
30	8380	3060
Full Development	14 700	5370

ESTIMATED SOLID WASTE GENERATION

* Year 1 includes an estimated 50t builders rubble from College construction

For the first 5 years of development, solid waste will be collected at an on-site transfer station for collection and disposal by the Shire of Murray at their existing approved site north of Pinjarra. Wet refuse will be collected from the site on a daily basis, whereas dry refuse will be collected weekly. This approach is the same as that presently operating at Dwellingup and the Shire of Murray has indicated that the haul distance involved is not regarded as a problem. The estimates in Table 8 allow for normal levels of builders' rubble associated with the gradual development of new subdivisions. About 50t of builders' waste will result from site clean up during construction of the College. Disposal of this material in an approved site will be a condition of the building contract.

The new site located north of Pinjarra is expected to have a life of about 10 years and it is recognised that, unless a regional waste recycling or incineration facility is developed, an additional site will be required. Under an agreement between the Proponent and the Shire of Murray, the Proponent has agreed to provide financial assistance to enable the Shire to select and purchase a suitable waste disposal site. Rubbish collected by the Shire of Murray would continue to be financed by rate income. There are no natural watercourses on the Point Grey site due to the sandy soil conditions which allow high infiltration and little surface runoff to the Peel-Harvey Estuary. Within the eastern, low-lying area of the project site, and throughout the area between the site and Pinjarra, a number of open drainage channels have been constructed. These drains are under the control of the Water Authority of Western Australia.

For the access roadworks (Section 4.8.2.2), it will be necessary to construct drainage structures at these channels to provide adequate waterway crossings for new road sections. Box or pipe culverts or bridge structures will be provided, depending on the waterway areas required and the economics of each system. Longitudinal drainage of the access road will be via open table drains graded to the main lateral channels.

Stormwater drainage within the residential areas of the site will be via a conventional system of road gullies and underground pipes. For the large leisure living lots, table drains and pipe culverts at road crossings will be constructed.

In all cases, the stormwater drainage system will be designed to avoid the direct disposal of runoff to the Peel-Harvey Estuary. Within each stormwater catchment, it is proposed that a system of compensating/recharge basins will be constructed to allow for the disposal of stormwater via infiltration to the groundwater system.

The drainage catchments and appropriate location of recharge basins are shown on Figure 7. For each basin, the design criteria adopted by many Perth local authorities are proposed. They are summarised as follows:

- o the top water level (TWL), corresponding to the discharge hydraulic grade line, will have a minimum surface area of 1m² per 40m² of contributing impervious area,
- o the volume below the TWL shall contain 40% of the runoff from a 72 hour, 1 in 10 year design storm, and
- o the basin site and adjacent area to hold 70% of the flow from a 72 hour, 1 in 100 year storm without flooding behind the building line of any lots.

For residential areas, the equivalent impervious area for pipe drainage and basin design will be 80% of the area of the road reserve. Runoff from roofs will be connected to individual home owners' soak wells, designed to the Shire's building criteria. Pipework and basin systems will be designed to avoid direct discharge of runoff to the waterway system. In land - locked low areas, stormwater overflow will either discharge onto areas of open space or detention basins. Almost all stormwater runoff will be intercepted above RL 3m AHD (Figure 7). For the limited areas below this contour (i.e. boating facilities and associated car parks), gully pits will intercept debris flowing towards the Estuary.

There are two small catchments where natural drainage from the project site is presently directed towards Lake Mealup (Figure 7). The horizontal and vertical alignments of roads in these sub-areas will be adjusted so that any stormwater runoff from the rural standard roads will not discharge into the two sub-areas.

For all stormwater works, pipework, pits and basins, the operation and maintenance will become the responsibility of the Shire of Murray, as is normal with all subdivision developments.

4.8.6 Public Utility Services

4.8.6.1 Electricity

The existing overhead rural electricity supply to the site will need to be replaced with a high voltage system. This will comprise an overhead connection to the existing system at Coolup, and will include all associated substations and switching gear.

The supply will be staged to suit development. For the first stage, up to year 5, a 4 to 5 Mega Volt Ampere supply via a 22kV overhead line will have capacity to serve the College and initial lot development. Beyond this, a further 22kV line will be required to serve up to 80% of the development. For the total development, a zone substation will probably be required.

Once on-site, it is envisaged that the supply to the large leisure living lots will be via an overhead system. For residential areas, the reticulation could be via an overhead or underground scheme.

The provision of the reticulation system will be at the Proponent's cost under the State Energy Commission's normal schemes for residential overhead or underground supply. Telecom are currently upgrading the Pinjarra telephone exchange. The exchange is 15km from the Point Grey site and can be readily extended.

A trunk cable will need to be constructed to connect the development to the exchange, together with the provision of the associated switching and control gear. These facilities will be provided in stages to suit the development programme. The reticulation of the telephone supply within the development will be via an underground system.

4.8.7 Site Works

It will be necessary to locate roads and other facilities in sympathy with the existing topography, vegetation and foreshore reserves. The objectives will be to maximise the natural potential of the site by minimising the extent of earthworks and clearing.

The provision of roads and building areas on the low lying estuarine flats will possibly require filling and drainage. Whilst this is costly, drainage provided by the Robert Bay Drain and the availability of on-site sources of fill material, should make this operation feasible, if necessary. Design fill levels will take into account the likely flood levels of the Peel-Harvey Estuary system. The 100 year flood level for the site is 1.6m AHD (Water Authority of Western Australia, pers. comm.) and fill levels will need to be between 0.5 to 1.0m above this, depending on the land use involved. Additional allowance above this flood level will be required if the Dawesville Channel is constructed.

4.9 THE CONSTRUCTION PERIOD

4.9.1 Thomas Peel College

4.9.1.1 Operations

Construction of the Thomas Peel College will span 18 months, with the building workforce peaking at approximately 430. It is estimated that the workforce for the College will be drawn from nearby centres on the following basis:

0	Pinjarra area	10%
о	Mandurah area	10%
ο	Bunbury	10%
ο	Rockingham	20%
0	Perth	50%

It is anticipated that up to 60% of the workforce may require on-site camp facilities, commuting from Perth on a weekly cycle. Daily commuting from Perth may result in these on-site camp facilities for the College construction workforce being reduced to serve 100 workers.

Water supply for the College construction and camp site will be provided from the existing Water Authority bore on-site (Miami Bore), located near the junction of the Robert Bay Drain and Carrabungup Road.

All access to the site will be via Greenlands, Carrabungup and Edge Roads, which are to be upgraded to sub-base standard during the College construction period.

Maintenance of the roadway will be carried out by the Proponent during the College construction period, with the final sealing of roads taking place following completion of the College.

4.9.1.2 Employment

Figure 8 illustrates the predicted manning levels of the construction workforce during the building of the Thomas Peel College. As indicated on the figure, manning is anticipated to peak at 430 workers with an average of 200 to 250 workers being on-site during the bulk of the 18 months construction period. Supplies for the workforce (food, fuel and other consumables) are likely to be provided from Pinjarra or Mandurah.

4.9.1.3 Site Housing Facilities

On-site housing for workers during the College construction period is planned to comprise a number of transportable accommodation units. Each will house five workers, sited in groups of 4, with one toilet facility per 20 persons.

Effluent from the toilets will be disposed of via septic tanks directly into the ground. Site mess facilities will also be provided. The site for the camp is estimated to occupy approximately 1.4ha and will be located approximately 500m from the construction site.

The demand for on-site accommodation for construction workers engaged in developing the Point Grey subdivision and associated civil works infrastructure is anticipated to be minimal, particularly after year 1. The small demand generated can be accommodated by an extension to the College workforce camp.

4.9.2 Subdivision Development

4.9.2.1 Operations

Construction of subdivision works will occur in stages for the anticipated 30 year duration of the development. The access road will be upgraded before most other works to ensure secure and continuous access is available for construction traffic. A series of contracts would be let each year for small successive stages for items such as sewers, roads, drains, wastewater treatment facilities and the water supply system.

4.9.2.2 Employment

Peak employment will generally average 15 to 20 people for most phases of the development. Major works in years 1 and 5 will require approximately 69 and 54 people respectively.

About 50% of site employees will probably come from Perth, with the balance originating from local regional centres. A higher proportion of Perth-based employees will occur for specialist works such as wastewater and water supply facilities.

4.9.2.3 Site Housing and Facilities

Most employees will probably commute to site from the regional centres and Perth. However, it is likely that on-site housing would be provided for 30% to 40% of peak employee numbers each year. This would result in about 10 employees residing on-site most years, with up to 40 being housed during peak construction periods in years 1 and 5.

5.0 THE EXISTING ENVIRONMENT

5.1 REGIONAL GEOGRAPHY AND LAND USE

The hinterland of the Point Grey project area is defined as the Shires of Mandurah, Murray and Waroona (Figure 1) which form the South West Statistical Division as defined by the Australian Bureau of Statistics. The major focus of the project is a large body of water which comprises two geomorphological components: the Peel Inlet and the Harvey Estuary, referred to throughout this document as either the Peel-Harvey Estuary or simply, the Estuary.

The Peel-Harvey Estuary occupies a shallow depression in a flat-lying part of the Swan Coastal Plain. The Plain is about 25km wide and reaches an elevation of 70m at the foot of the Darling Scarp. The Scarp rises abruptly to heights over 300m and is deeply dissected by the Serpentine, Murray and Harvey River systems. These rivers meander westwards across the gently sloping Swan Coastal Plain after their fall from the Darling Scarp. The Rivers flow into the Estuary prior to their discharge to the sea via the Mandurah Channel.

The Plain comprises sandy aeolian and finer textured fluviatile deposits and these sandy and fine textured soils are generally used for dryland grazing and flood irrigation respectively. Irrigation is via constructed channels fed from storage dams on small rivers rising above the Darling Scarp. The irrigation channels double as drainage channels flowing into the Peel-Harvey Estuary in winter. Dairy farming is most common on irrigated pastures, with minor areas used for vegetable production. Beef cattle and sheep are more common on dryland pastures. Phosphate fertilisers are widely used on the nutrient deficient soils of the coastal plain and nutrient residues are transported through to the Estuary by river and drainflow.

Some grazing and fruit growing is carried out on the face of the Darling Scarp, but the undulating hills behind are largely forested. These hills are mantled with laterite, which overlies weathered clay and granitic basement. Forestry, bauxite mining and surface water supply catchments are important land uses in the hills.

Much of the eastern margin of the Peel-Harvey Estuary is low lying, swampy and uncleared. Large tracts of this land to the east of the Peel Inlet and south of the Harvey Estuary have been reserved or recommended for reservation for the purpose of wildlife conservation. Proposed aquatic reserves cover Austin Bay and the head of Harvey Estuary. Three smaller reserves for recreation and conservation adjoin the development site. Reserves also cover parts of Lakes Mealup and McLarty. Lot 1154, adjacent to Lake Mealup, is privately owned by the Lake Mealup Preservation Society, for the purpose of preserving the existing environment (Hurford, pers. comm.). These areas comprise a conservation resource of regional significance (DCE, 1983). They flank the Point Grey area and occupy much of the Shire of Murray's frontage to the Peel-Harvey Estuary system.

Major towns in the region are Harvey, Pinjarra, Dwellingup and Mandurah (Figure 1). Recent growth has focussed on Mandurah, around the water based resources of the ocean and the Estuary. Other developments focus on the western and northern shores of the Estuary. The growth of Pinjarra, in the Shire of Murray, has been limited, despite its proximity to the major employment opportunities in the region. People have shown an overwhelming preference for living closer to either the ocean or Estuary, despite the need to travel longer distances to work.

Point Grey represents the only substantial area of elevated land within the Shire of Murray which is suitable for residential development, which overlooks the Estuary and which is not reserved for conservation.

The Peel Inlet Management Authority (PIMA) has indicated that further boating facilities, on the east side of the Estuary, are desirable to ease pressure on existing sites (Waterways Commission, 1982; Town Planning Department, 1984). Discussions with officers of the Department of Conservation and Land Management (CALM) have also indicated that re-direction of increasing user pressure into properly prepared and managed sites is desirable, to ensure the future amenity of recreation areas and proper conservation of wildlife stocks.

5.2 POINT GREY

The Point Grey study area (Figure 1) forms a peninsula separating the Harvey Estuary to the west from the eastward sweep of Robert Bay within Peel Inlet. This site is dominated by an elevated north-west to south-east trending ridge up to 37m high (Figure 9), with sweeping views over Harvey Estuary to the west, across Peel Inlet towards Mandurah in the north and towards the Murray River delta and the Darling Scarp to the northeast.

The site comprises 1083ha and is 20km west of Pinjarra. Mandurah is 10km away to the north, across Peel Inlet. Perth is about 85km to the north of the site and Bunbury is the same distance to the south.

5.2.1 Point Grey Physical Environment

5.2.1.1 Landform, Soils and Drainage

Most of the Point Grey site consists of a ridge of Tamala Limestone, with a capping of secondary calcite, overlain by siliceous sand (Figure 10). This ridge is the eastern most component of the Spearwood Dune System (McArthur and Bartle, 1980). The ridge coincides largely with the peninsula and falls away to the shores of the Estuary and to flats inland. The soil types on the project area are all represented in reserves surrounding the Peel-Harvey Estuary. Table 9 lists the landform units present at Point Grey and their representation elsewhere.

The predominant soil type is the yellow phase of the Karrakatta sand (Ky) unit, which is typical of higher topographic positions between 5 and 35m elevation. Grey-brown sand at the surface changes to bright yellow-brown sand beneath. Limestone usually occurs within 1m of the surface.

Redistribution of sand by wind action has resulted in bare limestone exposures (KIs) to the west, coinciding with local high points, and low sandy hills where the sand has been redeposited to the east (Kgb), usually at less than 5m elevation (Figure 10). Small seasonal swamps (Ksw), with peaty or diatomaceous soils, occupy depressions in the Spearwood Dunes. Parallel sand ridges (Pr), formed by wind action, fringe the shoreline to the west and northeast. Minor occurrences of sands of the Bassendean Dunes occur in the northeast of the site. Gavin sand, (Gas(d)) forms highly leached low dunes in the northeast. Joel sand (Js), which has a peaty surface horizon, occurs in swales in this area.

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TABLE 9

LANDFORM UNITS PRESENT AT POINT GREY AND THEIR REPRESENTATION ELSEWHERE

LANDFORM CODI UNIT		CHARACTERISTICS	REPRESENTATION IN RESERVES	
SPEARWOOD DUNE	ES			
Karrakatta sand (Yellow phase)	Ку	Low hilly landscape; grey brown surface passing into bright yellow sand, often with limestone within 1m	Extensive representation in Yalgorup National Park, south west of Point Grey.	
Karrakatta sand (Grey phase)	КдЬ	Gently undulating landscape; grey sandy surface, very light grey sub surface passing into pale yellow sand within a metre. Probably no limestone below	Significant representation in C51 surrounding Harvey Estuary	
Karrakatta (Limestone outcrop)	Kls	Hilly and irregular terrain; bare limestone or shallow brown sand with much outcrop	Localised representation in Mealup Point Nature Reserve and Yalgorup National Park	
Swamps	Ksw	Seasonal swamps in Karrakatta landform often with a surface crust of diatomaceous earth	Represented around Lake McLarty and Lake Mealup reserves and Nature Reserve 24739	
Parallel Ridges	Pr	Benches fringing Peel Inlet and Harvey Estuary. Includes saline flats, sandy terraces and sandy beach ridges	Represented in Stony Point and Mealup Reserves and in C51, east side of Harvey Estuary	
Mixed Estuarine Alluvium	MEA	Beach and estuarine deposits of humic sandy clays, silts and clayey sands. Black and brown muds and clays, often salty	Extensively represented in C50 reserves over Austin Bay and east side of Peel Inlet	
BASSENDEAN DUN	ES			
Gavin sand	Gas(d)	Light grey sand overlying an organic or iron-organic pan to 5m	Represented in C51 east of Harvey Estuary	
Joel Sand	Js	Low lying areas; grey sand or sandy loam surface with an accumulation of organic matter	Represented in C51 east of Harvey Estuary	

Sources: McArthur et al. 1959 McArthur and Bartle, 1980 Fine textured, salty, mixed estuarine alluvium (MEA) occupies the northeastern corner of the site (where the sewage treatment plant is to be sited), along the shore of Robert Bay (McArthur et al. 1959). This area is low lying, poorly drained and often flooded. Robert Bay Drain crosses this unit and flows along the boundary of the site before entering Peel Inlet. All soil types, with the exception of the small area of alluvium, are very freely drained and water retention is low.

Shire of Murray planning controls state that no dwelling may be constructed below the 2.5m AHD contour (Shire of Murray, pers. comm.). Land below the 3.0m contour is highlighted on Figure 7. There is no surface drainage on-site, with all water passing through the soil profile to the water table. Eastward drainage from the site is towards the mixed estuarine alluvium soil unit and Robert Bay Drain. A chain of swamps, including Lake Mealup, drain the southeastern portion of the site, while elsewhere, drainage is to the Estuary and Inlet. Mealup Main Drain enters the Estuary south of the site (Figure 11).

The waters surrounding the site are shallow, with depths less than 0.5m extending between 200 and 1000m offshore. Some sections of Robert Bay are frequently exposed. The offshore substrate comprises organic muds and alluvium in Robert Bay with evidence of shell grit and sand on the western shore. There are limestone outcrops in a number of locations, notably in the vicinity of Point Grey itself, Stony Point and Mealup Point.

In summary then, little or no run-off is expected as the landform is conducive to deep drainage of applied water and nutrients. The sandy soils are ideally suited to construction, although detailed site investigations may be necessary where limestone is present.

The Estuary shore is generally resilient under foot traffic due to the predominance of limestone, shell and sand deposits. Significant shoreline erosion is not evident. The fine alluvium bordering Robert Bay is likely to be more sensitive.

5.2.1.2 Geology

The regional geology of the project area is shown in Figure 11.

The site is underlain by Tamala Limestone, grading eastwards into the sands of the Bassendean Sands, Guildford Formation and then into clays of the Guildford Formation. The older Jandakot beds are a permeable sandy formation underlying the Guildford sands and clays. These sands and limestone overlie clays of the Osborne Formation beneath and to the west of the site, and the interbedded sandstones and claystones of the Leederville Formation east of the site.

The Cretaceous Leederville Formation consists of thinly bedded, westerly dipping $(0.5^{\circ} \text{ to } 1.0^{\circ})$ beds of silt, sand, sandstone and carbonaceous shale. The sands and sandstones are lenticular, fine to medium grained and well sorted. The Leederville Formation contains two lithostratigraphic, and more importantly, hydro-stratigraphic marker horizons which effectively divide the Formation into upper, middle and lower units.

The most important marker horizon in relation to the present study is the 'green clay', which occurs at a depth of 200 to 250m beneath the project area. The green clay is 4 to 6m thick and has been intersected in all the deep exploratory and groundwater production bores drilled in the Mandurah region. The base of the Leederville Formation occurs between 100 and 150m below the 'green clay' marker horizon.

5.2.1.3 Climate

DCE undertook a comprehensive meteorological survey between October 1976 and October 1979 at Robert Bay to supplement the historical data collected from the Bureau of Meteorology station at Mandurah Post Office. Data were collected by DCE on rainfall, temperature, humidity, evaporation, barometric pressure, wind speed and direction. These data have been used in this assessment wherever applicable and are supplemented by the long term records from Mandurah.

The Point Grey area is characterised by a temperate, mediterranean climate experiencing warm, dry summers and mild, wet winters.

The Bureau of Meteorology has been recording climatic data at Mandurah since 1889. Mandurah's annual average rainfall is 884mm, with approximately 92% of the rainfall falling between April and October. Only 71mm of rain falls during the summer season from November to March. The growing season extends from early April to mid November (Department of Agriculture, 1975). June is the wettest month with 195mm of rainfall, occurring over 18 days and July has an average of 20 raindays with 176mm of rainfall. January has the least rainfall with an 8mm monthly mean, occurring over 2 days on average.

Rainfall recorded by DCE at Robert Bay for 1977 and 1978 was well below the Mandurah average. Records of 746 and 611mm respectively, represent 84% and 69% of the long term average rainfall recorded at Mandurah Post Office (DCE, 1980).

Temperatures recorded at the Robert Bay Climatological Station (1977-1979) show that conditions at Point Grey are moderate throughout the year, with the highest mean monthly maximum recorded in February (30° C) and the lowest mean monthly minimum recorded in August (9° C).

The mean monthly relative humidity may be interpreted from 0900 and 1500 hour data from Mandurah Post Office. The highest mean relative humidity occurs in June (72.5%) and the lowest in January (48%). Means of 84% relative humidity in July 1978 and 58% relative humidity in February 1978 were recorded at the DCE station at Robert Bay.

Pan evaporation data were collected on a monthly basis at Robert Bay during the period January 1977 to February 1978. Four empirical formulae were applied to the data for comparison with the pan converted results. Reasonably good agreement was achieved between pan derived lake evaporation and two of the four formulae. These data show that mean daily evaporation is highest during the summer months, with a peak of approximately 9.3mm in January. Evaporation decreases until mid winter, with the lowest mean daily rate of approximately 1.8mm recorded during June (DCE, 1980).

Estimates of annual evaporation from the Peel-Harvey Estuary, based on the records above, varied from 1421.2mm (1977/78) to 1330.0mm (1978/79). Information from the Bureau of Meteorology indicates that the annual average evaporation in the Peel-Harvey Estuary area is approximately 1400mm (Bureau of Meteorology, in prep.), which shows good agreement with the data collected from Robert Bay. Wind data are given as a series of wind roses developed from data recorded at Mandurah Post Office (Figure 12). These data show that there is a strong southwesterly component at Mandurah during spring and summer, and a strong southeasterly component during autumn. During the winter months the winds are predominantly from the northern and western quadrants.

Data collected by the DCE during 1977/78 confirm that the 21 years of wind data collected at Mandurah reflect the local wind conditions at Robert Bay. Table 10 shows the dominant wind direction for the four seasons as recorded at Robert Bay.

	DOMINANT W	IND DIRECTION
SEASON	ROBERT BAY (1977 - 1979)	MANDURAH (1965 - 1986)
SUMMER	SW/SE	SW/SE
AUTUMN	SE/SW/NW	SE
WINTER	SW/NW/SE	W/NW/NE
SPRING	SW	SW

TABLE 10

DOMINANT SEASONAL WIND DIRECTION, ROBERT BAY AND MANDURAH

Sources: DCE, 1980 Bureau of Meteorology (in prep.).

5.2.1.4 Hydrology

The hydrology of the site is controlled by the dominant northwest/southeast trending ridge which divides the site into easterly or westerly flowing watersheds. To the south of the proposed development is Lake Mealup, whose catchment is bounded to the south by the Mealup Main Drain. To the east of the development the Robert Bay Drain flows into Robert Bay from the agricultural lots to the southeast. There are no constructed drains on the development site, and neither surface nor groundwater flows generated on the development site feed the Lake Mealup catchment. Figure 7 shows the surface drainage divides on the development site as interpreted from 5m contours, including the Lake Mealup drainage to the southeast of the site.

The highly permeable nature of the surface sands and limestone underlying most of the site indicate that surface runoff would be rare under normal conditions and limited in area. On the low lying eastern part of the site, adjoining Robert Bay, the alluvial and lagoonal deposits of silts, clays and organic materials are expected to be of much lower permeability, and without constructed drains, may be subjected to seasonal surface water flooding because of reduced rainfall infiltration. This seasonal flooding would have been reduced since the construction of the Robert Bay Drain.

In summary, the dominant mechanism for flow of water from the site is vertically downwards through the sands to the limestone aquifer, then horizontally in a northeastly or southwestly direction to the Peel Inlet and Harvey Estuary.

5.2.1.5 Hydrogeology

The hydrogeology of the project area may be considered in terms of the shallow groundwater in the surficial deposits and the deeper groundwater in the pre-Quaternary sediments. A schematic hydrogeological cross-section is shown in Figure 13.

o Surficial Aquifer - Point Grey

A detailed study of the shallow groundwater hydrology of the site was carried out by:

- o undertaking a drilling, and observation bore construction and testing programme,
- describing the geological and hydrogeological conditions of the shallow aquifer, and
- analyses of groundwater samples to determine water quality in terms of salinity and phosphorus and nitrogen nutrients.

This study is described in detail in Dames & Moore, 1986, and summarised in Appendix G. The following discussion presents an outline of the important issues.

The Tamala Limestone contains a relatively thin, lens-shaped fresh water aquifer which increases in thickness from the Estuary to under the ridge, where it has been measured at 6m (Figure 13). Total storage of freshwater in this aquifer is estimated to be about 3.3 million cubic metres $(10^6 m^3)$ with an average recharge of about 2700 cubic metres per day (m^3/d) .

The freshwater lens overlies a saline body of water, with salinities ranging from 20,000 to 30,000 milligrams per litre (mg/L). The shallow nature of the freshwater lens and proximity to highly saline water render the resource unsuitable as a potable water supply. Hence, the major study objective was seen to be the assessment of the surficial aquifer as a vehicle for nutrient transport to the Estuary.

Studies in many parts of the Swan Coastal Plain have indicated that the Tamala Limestone is very permeable, with permeabilities probably in the order of 100 to 150m/day or higher. In general, there appears to be a groundwater divide under the highest portion of the peninsula and groundwater therefore flows to the northeast and southwest of this divide. Hydraulic gradients are generally low reflecting the high permeability of the Tamala Limestone.

The analyses of shallow groundwater samples taken during the drilling programme show that the level of nitrates in the upper zone of saturation is generally high and can be above the allowable limit of 45mg/L for potable groundwater. In addition, it is only the freshwater lens which contains high nitrate levels and this suggests that the source is related to the agricultural and grazing activites practised in the area during the past 140 years. Average nitrogen levels were estimated at 5mg/L.

Phosphate levels in the shallow groundwater are generally quite low despite the recent application of fertilisers. Only one exploration bore (PG5) intersected groundwater with a phosphate content greater than 0.2 mg/L (P-P₂O₅) (Dames & Moore, 1986). Unlike the nitrate, the higher concentrations of the phosphate occur both in the freshwater lens and the more saline water, and this suggests that the source of the phosphate could be from both the ground surface and the waters of Peel Inlet.

o Surficial Aquifer - Lake Mealup

Lake Mealup is a surface expression of a surficial aquifer. In the area, the groundwater has low salinity of less than 500mg/L of Total Dissolved Solids (TDS). The water quality in Lake Mealup varies seasonally and was measured to have a salinity of about 3000mg/L TDS in January 1987.

The deeper part of this shallow aquifer contains connate salts which are not yet flushed from the system into the Harvey Estuary. Salinities at the base of the water table aquifers at Lake Mealup are predicted to be 5000mg/L TDS or greater.

o Surficial Aquifer - Waroona Mound

Recent surveys performed by the Geological Survey of Western Australia have identified a second surficial aquifer 12 to 15km southeast of the project site. This resource is referred to as the Waroona Mound and is known to contain potable water over an area of 120km^2 . The aquifer occurs within the Guildford Formation which consists of mainly sandy clay. Overlying the Guildford Formation is the Bassendean Sands, which is a thin stratum (1 to 2m) of poorly sorted, fine to medium grained quartz.

The Waroona Mound has an average thickness of 10m, and in places, represents the recharge area to the deeper Leederville Formation (Figure 13).

o Leederville Formation

The Leederville Formation is a confined aquifer, comprised of a sequence of claystone, siltstone and sandstone of marine or near-shore origin. The aquifer is high yielding and generally exceeds 100m thickness. Recharge is mostly by downward percolation of rain near the Darling Scarp but may also be from the underlying South Perth Shale, or from overlying surficial aquifers where they are in direct contact.

Groundwater flow directions in the lower portions of the Leederville Formation are west to northwest and the aquifers are confined and may be artesian. The potentiometric surface of the middle unit of the Leederville Formation is higher than the water table in the surficial aquifer and can rise to between 5 and 10m above sea level. Bores tapping the middle unit of the Leederville Formation aquifers may therefore flow at the surface, depending on the depth of the bore and the elevation of the natural surface at the boresite.

The distribution of groundwater salinity within the Leederville Formation in the Mandurah area is complex. The main freshwater aquifer occurs above the green clay marker horizon and exceeds 50m in thickness (Figure 13). The upper portion of the Leederville Formation has variable groundwater quality consisting of isolated zones of freshwater within more saline water.

Towards the east, away from Peel Inlet, groundwater quality in the upper portion of the Formation improves significantly. Towards the west, in the Dawesville area, a large thickness of freshwater inexplicably occurs in the upper portion of the Leederville Formation.

5.2.1.6 Land Use

The principal land use in the Point Grey project area is parkland grazing on improved pastures. Indeed, all of the privately owned land is presently zoned 'rural'. Productivity is low, as is typical for sandy soils of the Spearwood Dunes. McArthur and Bartle (1980) consider the sandy ridges of the Spearwood Dunes to be "marginal or poor agricultural land". The use of fertiliser is obligatory on these sandy soils when the land is converted to agricultural activities, mainly due to the heavy leaching of sulphur and to a lesser extent, phosphorus. Agriculture has been practiced in the area since the 1840s and it is probable that some dryland cropping occurred on the alluvial soils surrounding the Old Farm House in the area, located near the main entrance to the project site. There is no evidence of cropping there today, although lupins for sheep feed have regularly been grown at Point Grey in recent years. Available records suggest that superphosphate was applied to the property from 1980 to the end of 1983 at an average dressing of 18 kilograms phosphorus per hectare per year (kg P/ha/yr). Further details of fertiliser practices are contained in Section 6.2 and in Dames & Moore (1986). Approximately 720ha (or 66%) of the property has been cleared. The status of clearing is shown on the Frontispiece.

Limestone and sand have been extracted for construction purposes from small quarries on the site. Timber for short poles and fence posts has also been cut on-site.

The Old Farm House on Lot 75, located near the entrance to the project site, dates from 1848 and may be of some interest from an historical land use point of view, however, it is not listed on the register of The National Trust or the National Estate.

In summary, the present rural zoning leads to parkland grazing being the predominant land use at Point Grey. Regular applications of fertiliser (sulphur or gypsum) are required to maintain moderate productivity on the sandy soils. It is also highly likely that a percentage of the applied nutrients are leached to the groundwater and/or ultimately to the Estuary (Dames & Moore, 1986).

Present day land uses surrounding the site principally comprise grazing, conservation and recreation. There are three small reserves for recreation and conservation within and adjacent to the site (Figure 14). Foreshore reserves are currently present at intervals around Point Grey. Recreational activities occur presently in the form of crabbing and fishing at Robert Bay and Herron Point, 6 to 7km from the project area, limited boating on the waterbodies, and bird watching (especially at Lake Mealup, on the foreshores and in the conservation reserves). These recreational activities are not presently controlled in any way and there is evidence of degradation of heavily used sites such as Robert Bay. These trends are likely to occur regardless of developments at Point Grey.

5.2.1.7 Phosphorus Import for Agriculture

The farmed area of the 1083ha site is approximately 720ha, the remainder being native vegetation of varying condition.

The annual fertiliser requirement will depend largely on farm management practices. Farmers in the Peel-Harvey Estuary catchment have recently been introduced to a low solubility phosphate fertiliser called Coastal Superphosphate, specifically designed for the highly leached soils of the Swan Coastal Plain. This fertiliser initially results in less phosphorus reaching the groundwater, however, its popularity with the region's farming community is decreasing, usage having dropped from 15.7% of all phosphorus fertiliser applied in the Estuary catchment in 1985, to 5.7% in 1986 (Bott and Humphries, 1986).

The phosphorus load applied to the Point Grey site would increase if any of the uncleared regions were cleared and incorporated within the farming programme. This additional clearing of farmland would most likely take place if the property retained its rural zoning, and was managed as a commercially viable agricultural practice.

Phosphorus contribution to the Estuary from the existing agricultural land use can be estimated by the arithmetic product of annual groundwater throughflow and groundwater phosphorus concentration (Appendix F). Throughflow is estimated at 10% of rainfall (88mm/yr) giving a volume of 0.63 million cubic metres per year $(10^6 m^3/yr)$ over the farmed area. In the uncleared areas, the input of phosphorus from farming to the shallow groundwater can be assumed to be very low, almost zero, whereas the average phosphorus concentration of the groundwater in the farmed areas is about 0.07mg/L (Dames & Moore, 1986). Hence, the phosphorus output is calculated to be 0.04t/yr. This represents about 0.4% of the estimated applied phosphorus. The values are somewhat lower than those likely to apply for the Bassendean Sands, however, they may be applicable to the Karrakatta soils.

5.2.2 Point Grey Biological Environment

Point Grey retains an attractive mixture of vegetation types which, together with the fragmented and variable density of clearing, makes for a very desirable living environment. The presence of fauna in its native setting, especially large numbers of waterbirds, adds further interest to the locality and the region.

Retention of this mixture of habitats and associated fauna is central to the attraction of the area for settlement. It is a primary aim of the proposed development, therefore, to ensure that the project is managed in such a way that it does not have significant deleterious effects on the biological environment.

Appendix A presents a full discussion of the terrestrial biological environment at Point Grey. A summary is given below.

5.2.2.1 Vegetation and Flora

Vegetation Units

Vegetation types and condition are shown on Figure 15. Vegetation units are closely associated with soil units and a general description of the relationship between the two is contained in Table 11. Clearing and pasture development have resulted in the intentional and unintentional establishment of exotic species on disturbed areas throughout the site.

Eight native vegetation units were recognised on the Point Grey site by Brown (1980). **Tuart woodland** (Eucalyptus gomphocephala) dominated the areas of yellow Karrakatta sand over limestone, with an understorey of <u>Banksia</u> grandis and <u>B. attenuata</u>. Proteaceous species, <u>Acacia</u> spp. and blackboy (<u>Xanthorrhoea</u> spp.) are common shrubs. Much of this unit has now been cleared for grazing. **Banksia/Eucalypt woodland** occurs on the grey and yellow phase of Karrakatta sand. This unit comprises tuart, jarrah (<u>E. marginata</u>) and marri (<u>E. calophylla</u>) in the overstorey with <u>B. grandis</u> and <u>B. attenuata</u> and Proteaceous species common in the understorey. This unit has also been subject to clearing but large, good quality stands exist on the southern half of the site. Flooded Gum woodland (<u>E. rudis</u>) occurs on low lying areas of grey sand and the parallel ridges. <u>Banksia littoralis</u> and swamp paperbark (<u>Melaleuca rhaphiophylla</u>) are characteristic of the understorey and occur separately, often with sedge species prevalent as groundcover. This unit often intergrades with swamp vegetation. -49-

TABLE 11

VEGETATION UNITS PRESENT AT POINT GREY AND THEIR RELATIONSHIP TO LANDFORM UNITS

LANDFORM UNIT CODE		VEGETATION UNIT	CHARACTERISTIC VEGE	ATION SHRUB AND		COMMENTS	
	2.046		DVERSTOREY	UNDERSTOREY	GROUND COVER		
Karrakatta sand (yellow phase)	Ку	Tuart woodland	Eucalyptus gomphocephala E. marginata, E. calophylla	Banksia attenuata B. grandis Allocasuarina fraseriana Agonis flexuosa	Hibbertia spp. Hakea spp. Acacia pulchella Xanthorrhoea spp.	Largely cleared + for agriculture on site	
		Banksia/Eucalypt woodland	E. gomphocephala, E. marginata, E. calophylla	B. attenuata B. grandis Xylomelium occidentale Allocasuarina fraseriana	Hakea lissocarpha Jacksonia sternbergiana Acacia pulchella Hibbertia polystachya	Largely uncleared + on southern part of site	
Karrakatta sand (grey phase)	Kgb	Banksia/Eucalypt woodland	as above	as above	as above	Minor occurrence	
		Flooded gum woodland	E. rudis, B. littoralis B. attenuata Melaleuca raphiophylla		Sedges	Water discharge areas fringing eastern side limestone ridge	
		Dune vegetation	see below	see below	see below	see below	
Karrakatta (limestone outcrop)	K1s	Banksia over limestone	B. attenuata B. grandis Occassionally E. gomphocephala Allocasuarina fraseriana	Dryandra sessilis	Acacia pulchella Templetonia retusa Melaleuca spp. Leucopogon spp.	Over broken limestone	
		Heath		Dryandra sessilis Occassionally E. leptophylla	Jacksonia hakeoides Petrophile spp. Templetonia retusa	Over bare limestone	
Swamps	Ksw	Swamp vegetation	E. rudis, B. littoralis M. preissii		Sedges, Rushes	In swamps	
Parallel Ridges	Pr	Flooded Gum woodland	E. rudis	Melaleuca spp. Acacia saligna Jacksonia signorum Oxylobium spp.		Low lying areas adjacent to point	
		Thickets	Occassionally B. littoralis B. grandis and Allocasuarina fraseriana	Kunzea ericifolia Acacia rostellifera		Parallel to western shoreline, inland from dunes Over limestone on point	
		Dune Vegetation		Melaleuca cuneata Acacia saligna	Brachyloma preissii Acanthorcorpus preissii Olearia axillaris Jacksonia horrida Pittosporum sp.	Generally on western shoreline and around point. Minor occurrence to east of site occurs on Kgb	
		Beach vegetation	Casuarina obesa	Melaleuca cuticularis	Scirpus sp. Juncus krausii Schoenus sp. Sarcornia sp. Halosarcia sp.	On beaches, fringing shore	
Mixed Estuarine Alluvium	MEA	Melaleuca Thicket		Melaleuca sp.		Almost all bare ground or cleared.	

It is probable that these two units are the same, or at least form a continuum, since they occur on the same landform unit. The main difference between them, now, seems to be the degree of clearing

Source: Vegetation descriptions based on Brown, 1980 in Muirhead, 1980

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Banksia over limestone occurs where limestone outcrops, and <u>B. attenuata</u> and <u>B. grandis</u> are dominant with <u>Dryandra</u> <u>sessilis</u>, <u>Acacia pulchella</u>, blackboy and <u>Templetonia</u> <u>retusa</u> in the understorey. This unit grades into **Heath** where the overstorey is absent. <u>Dryandra</u> <u>sessilis</u> and <u>Templetonia</u> <u>retusa</u> are characteristic, with occasional E. leptophylla occurring in mallee form.

Swamp vegetation comprises a further distinct unit in the area. The Beach Unit, a narrow band of herbaceous plants along the shore, was aggregated with the swamp unit by Brown (1980). It is marked by flooded gum, swamp paperbark and <u>B. littoralis</u>, with sedges and rushes as groundcover. The last five units above are all largely uncleared on the site. Thickets comprise dense stands of predominantly <u>Kunzea ericifolia</u> on the sandy parallel ridges or <u>Acacia rostellifera</u> shrubs over limestone on Point Grey. Occasional <u>Banksia</u> spp. are present in both cases. Thickets of dwarf swamp paperbarks occur on the mixed estuarine alluvium but much of this unit has been cleared.

Dune vegetation is distinguished by small paperbark trees (<u>Melaleuca cuneata</u>) and <u>Acacia saligna</u> with a mixture of groundcover species. The beach supports she-oak (<u>Casuarina obesa</u>) and saltwater paperbark (<u>Melaleuca cuticularis</u>) with salt tolerant samphires (<u>Sarcocornia sp. and Halosarcia sp.</u>) characteristic of salty flats. The rush, <u>Juncus kraussii</u> often fringes the water's edge and plays an important role in stabilising the shore.

Sensitive Flora

Surveys of plant collections held in the Western Australian Herbarium, from the development area and sites within 20km of it, identified two species currently gazetted as rare flora under the Wildlife Conservation Act, 1950-1980. Four other species recorded within 20km of the development area are, though not gazetted, regarded as probably rare or geographically restricted. These six species are listed in Table 12 and, because of their restricted distributions or limited numbers, may be considered to be sensitive.

Likely habitats for two of the species, <u>Drakea jeanensis</u> and <u>Jacksonia gracilis</u> do occur within the development area, although neither of these have yet been recorded there. The habitats occupied by these species are well represented in reserves around the Harvey Estuary (Table 12) and the development is not expected to affect their status.

TABLE 12

RARE, GEOGRAPHICALLY RESTRICTED AND POORLY COLLECTED SPECIES OF VASCULAR PLANTS RECORDED WITHIN 20KM OF THE POINT GREY DEVELOPMENT

SCIENTIFIC NAME	FAMILY	HABITAT	LANDFORM UNIT	HABITAT PRESENT ON POINT GREY SITE	HABITAT PRESENT IN REGIONAL RESERVES
Boronia crenulata	RUTACEAE	Heath and sedge vegetation in peaty swamps and on sand to clay flats	Swamp, Ksw	No	Lakes Mealup and McLarty
* <u>Conostylis</u> pauciflora	HAEMODORACEAE	Coastal stabilised dunes	Quindalup Dunes, Ql	No	Yalgorup National Park
* <u>Diuris</u> purdei	ORCHIDACEAE	Paperbark swamps	Swamps, Ksw	No	
Drakea jeanensis	ORCHIDACEAE	On white sand in <u>Kunzea</u> <u>ericifolia</u> heath	Parallel Ridges, Pr	Yes	C51, North of Herron Point -
<u>Jacksonia</u> gracilis	PAPILIONACEAE	<u>Banksia attenuata</u> and <u>B. ilicifolia</u> woodlands on deep grey sand	Karrakatta Kgb (Grey phase)	Yes	C51
<u>Parsonsia</u> <u>diaphanophleba</u>	APOCYNACEAE	Climber on river bank vegetation	River Terraces, RT	No	C51, Harvey River

* Gazetted Rare Species

<u>Brachyloma preissii</u>, a species recorded by Brown (1980), has been referred to as a rare species (DCE, 1983). However, collections in the Western Australian Herbarium indicate that it is neither rare nor restricted, and in the project area it occurs on parallel beach ridges and is prevalent in foreshore areas. Foreshore areas will be retained in the existing conservation reserves (A2738 and A24739) as well as within 50m of high water mark all around the site.

Dieback

Jarrah dieback disease, <u>Phytophthora cinnamomi</u>, has recently been noted by officers of CALM in reserves in the Point Grey region but no detailed mapping has been carried out (Towers, pers. comm.). The available information is noted in Table 13. A number of susceptible plant species are present in the Point Grey area, notably members of the Proteaceae such as <u>Banksia</u> spp., suggesting that precautions to prevent the spread of the disease will be appropriate during development.

Weed Species

Clearing and pasture development have resulted in the establishment of exotic species, both intentionally and unintentionally, on disturbed areas throughout the site. Extensive weed invasion of the surrounding conservation reserves does not appear to have occurred.

Vegetation Synthesis

Most of the Point Grey project area has been cleared of native vegetation and now supports grazing pastures (Frontispiece). Significant portions of the site still carry native vegetation, in good condition, which has conservation and amenity value. The vegetation units present on the project area are closely allied to the landform units, which are all represented in reserves in the local region, as outlined in Table 11.
5.2.2.2 Terrestrial Fauna

A detailed literature search of available data on terrestrial fauna was undertaken for the area and for nearby areas known to contain similar habitats to those occurring on the Point Grey peninsula. Discussions were also held with local naturalists, the Lake Mealup Preservation Society, Western Australian Museum and specialist botanists.

A reconnaissance trip was undertaken to assess the Point Grey habitats and predict the presence or absence of fauna, in particular, those species which are gazetted as rare or otherwise in need of special protection.

The Point Grey development area is expected to contain favourable habitats for a total of 28 species of mammals, including five introduced mammals. Eight species of frogs, 24 species of lizards and 11 species of snakes are likely to occur in the project area, based on available habitats and known distribution ranges. A total of 80 species of land birds may be expected to utilise the semi-cleared parkland and bushland areas that form the largest habitats on Point Grey.

Appendix A contains comprehensive species lists of fauna possibly occurring at Point Grey.

Four animals which could be found in the project area on the basis of available habitats, but were not observed during field investigations, are gazetted as being 'rare or otherwise in need of special protection' (Fisheries and Wildlife, 1983). These are:

- Western Quoll (<u>Dasyurus geoffroii</u>), which is a marsupial predator, known as the Western Native Cat,
- o Peregrine Falcon (Falco peregrinus), a fast flying predatory bird,
- o Carpet Python (Morelia spilotes), a non-poisonous snake, and
- o Lerista lineata, a small skink, which has not been recorded south of Mandurah.

The first three species mentioned above all range widely across south western Western Australia and even if present at Point Grey, none is likely to be adversely affected by the development because of either their mobility or preference for wetland habitats which will be reserved under the concept plan. The skink's known distribution is limited to the Swan Coastal Plain between the Swan and Murray Rivers (Carati et al. unpublished). The species is represented in secure 'A' class reserves south of Perth. Nichols (pers. comm.) has found that the species is common on suitable sites between the Swan and Murray Rivers but has not been found outside this range despite searches on suitable sites. If it does occur at Point Grey, it would not be expected to be particularly vulnerable to the proposed development as it is well adapted to disturbed areas.

5.2.2.3 Wetland Habitats

There are two types of wetland habitats associated with the Point Grey project. The first and most obvious is the Estuary itself (Section 5.3.2). The second, less conspicuous form of wetland habitat comprise the seasonal and permanent swamps that lie east of the project site. The significance of these features is that they fall within the Waroona Mound which has been nominated as the water supply for the project.

It is likely that the Waroona Mound was once extensively covered by wetlands, however, the area has been extensively cleared and drained for agriculture, and now only remnant wetlands remain (Figure 16).

The environmental significance of these wetlands is that they are important breeding areas for waterbirds. They also serve as important dry season refuge areas for waterbirds that move to the coast as inland lakes dry up at the commencement of summer.

Most of the wetlands within the Waroona Mound are freehold, and many have been extensively altered as a consequence of drainage and grazing. The only gazetted reserve is Nine Mile Lake (C16907), which is one of a series of wetlands that define the western edge of the Mound. The Nine Mile Lake complex is known to support a variety of waterbird breeding colonies including:

- Little Bittern (Ixobrychus minutus)
- o White-faced Heron (Ardea novaehollandiae)
- Hardhead (Aythya australis)
- o Black-fronted Plover (Charadrius melanops)
- o Musk Duck (Biziura lobata)
- o Black Swan (Cygnus atratus)

- Black Duck (Anas superciliosa)
 - o Marsh Harrier (Circus aeruginosus)
 - o Darter (Anhinga melanogaster)
 - o Great Egret (Egretta alba)
 - o Rufus Night Heron (Nycticorax novaehollandiae), and
 - o Little Egret (Egretta garzetta) (R.A.O.U. pers. comm.).

The proposed groundwater abstraction programme recognizes the importance of these wetlands, and will be located several kilometres to the east so that the drawdown effects will not effect the water levels in these wetlands (Section 6.3.2).

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5.2.2.4 Conservation Reserves

Point Grey adjoins five 'C' class reserves, namely:

- o C33039 (Recreation),
- o C2707 (Conservation of Flora and Fauna),
- o C27528 (Recreation),
- o C11718 (Recreation), and
- o C7502 (Water).

Although only one of these is designated for conservation, the others are uncleared and retain conservation values.

At Mealup Point, in the southwestern corner of the Point Grey development area, there is an 'A' class reserve also designated for Conservation of Flora and Fauna. Two additional 'A' class reserves, A6627 and A24739, occur to the southeast of the Point Grey development area. To the east of the project site lies Nine Mile Lake (C16907), a wetland that is reserved for the Conservation of Flora and Fauna, and gazetted in the National Parks and Nature Conservation Authority.

All reserves are shown on Figure 14. Other reserves occurring in the district are discussed in Section 5.4.

Table 13 outlines the current status and vesting authority for these reserves, together with the System 6 and PIMA recommendations for all eight reserves (DCE, 1983). Foreshore reserves also occur intermittently around the Peninsula. In their uncleared state, they too retain conservation values and help protect the shore from erosion.

FIRST CURRENT STATUS SYSTEM 6 RECOMMENDATIONS PIMA MANAGEMENT DIEBACK AND NAME GAZETTED EPA PROGRAMME RECOMMENDATIONS RECORDED* (ha) Purpose Vesting Authority Locality No. Purpose Vesting Authority Purpose Vesting Authority A24739 48.1 21.06.1957 Conservation NPNCA Part C52 Conservation NPNCA NPNCA Conservation McLarty of Flora of Flora of Flora Nature Reserve and Fauna and Fauna and Fauna A2738 29.5 22.10.1897 Conservation NPNCA Conservation NPNCA No, may Mealup Point of Flora of Flora be present Nature Reserve and Fauna and Fauna C2707 104.8 20.06.1958 Conservation NPNCA Part C50* NPNCA Conservation Conservation NPNCA No, may Carrabungup of Flora of Flora of Flora be present Nature Reserve and Fauna and Fauna and Fauna A6627 17.6 21.04.1899 Conservation NPNCA Part C52# Conservation NPNCA of Flora of Flora Fauna and Fauna C7502 139.2 02.11.1900 Water Not Vested Part C50* Conservation NPNCA Water of Flora and Fauna C11718 4.05 30.07.1909 Recreation Not Vested Environmental and Recreation (Water) C27528 34.2 07.05.1965 Recreation Not Vested Part C510 Parkland Shire of Environmental Shire of Stony Point Murray and Recreation Murray C33039 1.9 20.12.1974 Recreation Shire of Murray NPNCA National Parks and Nature Conservation Authority PIMA Peel Inlet Management Authority Recommendation C50.4: Reserves C2707 and C7502 to be cancelled and their respective areas added to Reserve B4990 Recommendation C51.5 : Purpose of Reserve 27528 be amended to Parkland, vested in the Shire of Murray 0 # Recommendation C52.3 : Reserve C6627 be cancelled and its area added to Reserve A24739 + Based on examination by CALM, November 1986

Land that is 'Not Vested' is administered by The Department of Lands Administration

Sources: DCE, 1983 Waterways Commission, 1982 Dept. Conservation and Land Management Dept. Land Administration

RESERVE NO.

AREA

CURRENT STATUS AND RECOMMENDATIONS FOR CONSERVATION RESERVES IN THE VICINITY OF THE PROPOSED DEVELOPMENT

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5.2.3 Point Grey Sociological Environment

5.2.3.1 Aboriginal Archaeology

Background to Survey

An archaeological survey of the Point Grey development area was conducted for this project. A full report on this survey appears as Appendix B.

The objectives of the archaeological survey were to:

- integrate data from previous work in the region to form a predictive strategy, if possible, and to place the results of the survey in context,
- o carry out a systematic sample survey of the designated survey area, and
- locate and record Aboriginal archaeological sites within the survey area.

This survey was designed to identify the potential for physical disturbance of the environment to affect archaeological sites.

Obligations Under the Aboriginal Heritage Act, 1972 - 1980

If any newly recorded Aboriginal sites are found during the survey or project development, the Proponent is obliged to submit site documentation, on appropriate forms, for registration with the Department of Aboriginal Sites, Western Australian Museum.

Previous Archaeological Research

Previous archaeological work in the vicinity of the survey area has not resulted in any sites being recorded on or near the designated survey area which encompasses the project area. Site density in the nearby North Dandalup area was 1.25 per square kilometre (Anderson, 1981 and 1982). Other surveys at Coolup and on the Mandurah-Pinjarra Road failed to locate any archaeological sites (O'Connor and Quartermaine, 1986; Quartermaine, 1986).

Another survey of a large area between Mandurah and Bunbury, revealed that most artefacts were found in areas that had been cleared of surface vegetation, either by natural or human means. Most sites recorded during that survey were to the west of the Peel-Harvey Estuary, with only two sites recorded to the east of the study area. Those closest to the Point Grey site are small artefact scatters, mostly of quartz flakes and chips, one of which also contains some chert artefacts (Novak, 1975). There are no known records from the study area (Novak, pers. comm.).

Survey Methodology

Access was along a series of tracks and fencelines, which allowed all parts of the survey area to be reached. Firebreaks and small cleared sandy areas, plus the foreshore of the Harvey Estuary, provided the best surface visibility. The sandy nature of the soil made artefact location potentially easy, as the only lithic material occurring naturally, was the limestone which outcropped in various parts.

The designated survey area was systematically sampled from north to south using eastwest transects, concentrating on areas with good surface visibility or high site discovery potential. The shoreline was surveyed, where vegetation cover permitted, in traverses parallel with the shore.

For the purposes of this survey, a site is defined as three or more artefacts in close association, in respect of open sites. Solitary artefacts, named isolated finds, are also recorded but are not registered as archaeological sites.

Survey Results

No archaeological sites were located in the designated survey area. One isolated find, a quartz flake, was recorded on an eroding slope of yellow sand, 50m east of the shoreline of the Harvey Estuary, at a point approximately 1km south of Stony Point.

An underground cave, named Avalon Cave and mapped in 1974 by the Western Australia Speleology Society, was located. It is in a limestone ridge and appears as a sink-hole at surface level with a shaft, of about 1m maximum diameter, going down for 4 to 5m and then becoming horizontal. The entrance and surrounding surface area were examined but no archaeological material was found. No information of archaeological significance had been recorded when the cave was mapped previously (Chalmers pers. comm.).

Conclusions

Since no archaeological sites were recorded as a result of the present survey, no recommendations for protection of sites are necessary.

Should the developer uncover any archaeological material as a result of the development, such discovery must however, be reported to the Western Australian Museum under the terms of the Aboriginal Heritage Act, 1972-1980.

Human interference to Aboriginal sites is an offence as outlined in Section 17 of the Western Australian Aboriginal Heritage Act, 1972-1980, unless authorised under the Act. Therefore, the Proponent will take appropriate measures to inform any personnel working on the project, of this requirement.

5.2.3.2 Aboriginal Ethnography

An ethnographic field survey in the vicinity of Point Grey was carried out in January 1987. The specific aim was to locate the traditional Aboriginal custodians of the area, or their successors, and consult with them to ensure that the proposed development did not pose a threat to Aboriginal sites, as defined by the Western Australian Aboriginal Heritage Act, 1972-1980. The location of the survey area and a detailed account of the study are presented in Appendix C.

The single most important event in the history of Aboriginal-European contact in the survey region, is undoubtedly the so-called Battle of Pinjarra which took place in 1834 on the banks of the Murray River. Friction between settlers and Aborigines in the Murray River region led to a one-sided battle between an expedition commanded by Lieutenant Stirling, and the local Aborigines. This resulted in heavy Aboriginal casualties. The site of the battle has since become a symbol of resistance among Nyungars, thereby locating the Murray River as an area of potential conflicts.

Despite the near extinction of the Murray River Aborigines, continuity with the traditional past was maintained. The primary contributors were George Windjan, of Mandurah, and Kitty, of Pinjarra; both were survivors of the Battle. Parents of the present senior generation (all of mixed ethnic descent), were young adults when Windjan and Kitty were still alive.

One elderly man, who now lives in Pinjarra, was born in that period and retains an impressive amount of traditional knowledge. Widely respected, he also speaks an amount of the traditional language, an accomplishment shared by few of his fellow Nyungars.

In the early years of this century, an Aboriginal fringe developed around the main townships of the southwest; a fringe that lasted until the 1950s, when Nyungars began to move into Homeswest and privately rented houses. The main regional fringe camp developed into the Pinjarra Reserve. Other smaller camps were located at Halls Head, Barragup, Ravenswood, Adam Road and Robert Bay.

The mythological framework of the region concerns mainly the Waugal. Waugal (also Wagal, Wagyl, or Uocol) is the Dreaming ancestor, usually manifested as a water serpent, who created the Murray and Serpentine River systems, and still retains a presence in some deep pools in the area. Waugal beliefs are certainly not a latter-day phenomenon; they were noted and recorded by early settlers as reported by Salvado (1977). So far as could be ascertained, there are no Waugal beliefs associated with the survey area.

To the south of Point Grey, the small island located between Herron Point and the west bank of Harvey Estuary, some 800m off the eastern shore, is a site of religious significance. According to Aboriginal tradition, this island was the site of a ceremonial ground, the focal point of which was a white egg-shaped stone a little larger than an emu egg.

There are no previously recorded ethnographic sites of significance in the survey area. Nearest sites are the Waugal areas and Egg Island described above. However, there is the possibility that a native burial ground may be situated in Carrabungup Nature Reserve (C2707) near Point Birch. However, since this Reserve is outside the study area, the matter was not pursued further.

Independent evidence suggests that Point Grey had been used as an Aboriginal camping ground in traditional times and that a degree of sentimental attachment is still associated with it among living people (O'Connor et al. 1985). Evidence collected in this survey has shown that Aborigines from Pinjarra and Mandurah have continued to camp, until quite recent times, in discreet and private nooks on the shores of Austin and Robert Bays. Contact with Point Grey peninsula, however, has not been not lost, despite the fact that this area is fenced private property. The existence and approximate location of the cave mentioned in the archaeological survey is known to local Aborigines. The area identified as a traditional camping ground is delineated in Appendix C.

5.2.3.3 Existing Social Value

The Point Grey site has continued in private ownership since the initial release of the land last century and has not been accessible to the public. Under these circumstances the key social issues related to the site have been recreation and landscape values. Recreation Reserves C11718 and C27528, both near Stony Point, are surrounded by private property and are only readily accessible from the Estuary. There is, therefore, a low level of public use of the reserves and the land in private ownership. Consequently, the site does not constitute a significant recreation resource for the public at present. The site has been included, by implication, in generalised statements referring to the benefits of retaining vegetation on the eastern shore of Harvey Estuary as a natural backdrop to the views across the waterbody from the populated centres of Miami, Novara, Mandurah, etc (National Trust, 1973; Town Planning Department, 1976). The vegetated foreshore margins of the Point Grey peninsula therefore possesses regional landscape value.

As noted in Section 5.3.2.2 there are waterbird roosting areas along the shores of the site which potentially have social value as birdwatching locations.

As discussed, the existing social value of the site is limited, due to restrictions on access. There is, however, considerable latent social value in the site. This would be enhanced by development of carefully controlled access and appropriate management. The Mandurah and Districts Planning Study (Town Planning Department, 1984) in fact recognised that the Point Grey site was one of the few sites in the Shire of Murray, within sight of the Peel-Harvey Estuary, which was suitable for development. The Study supports the concept of specialised settlements with emphasis on conservation, leading to a potential population of 12,000 to 15,000. The proposed development is consistent with the findings of the Mandurah and Districts Planning Study. Although much of the site is already cleared, it is the Proponent's intention to retain foreshore vegetation and existing trees as an integral part of this development. This strategy would be consistent with the desire to retain the aesthetic integrity of the eastern shore of Harvey Estuary.

There is considerable existing use of the Peel Inlet and Harvey Estuary waterways (Town Planning Department, 1976; Town Planning Department, 1984) as discussed in Section 5.3.3. As such, the adjacent Estuary is socially valuable, perhaps more so than the land area of Point Grey itself.

Only 35% of the waterway is over 1m deep, however, (Town Planning Department, 1984) and there is a concentration of boat ramps on the west side of the area, which often leads to overcrowding (Town Planning Department, 1976). Both these factors limit the opportunities for boating. Shallow areas, on the other hand, are important for crabbing and prawning which are important pastimes in the district. Once again, the Point Grey area presently has little social value due to restricted access.

The site is, however, one of the few on the east side of the waterways which is not reserved for conservation and which is resilient enough to support properly controlled boating access. Provision of boat ramps in this area is consistent with the need to alleviate pressure on existing facilities and provide public access to an area which is currently held in private ownership.

Duck shooting has been prevalent in the southern region of the site, particularly around Lakes Mealup and McLarty. In the past, problems with fires and vandalism have resulted from this activity. Due to the recently conferred conservation status of the Lakes and safety issues connected with shooting around the Estuary shores, duck shooting has now been banned from the Point Grey area.

5.3 PEEL-HARVEY ESTUARINE ENVIRONMENT

5.3.1 Estuarine Physical Features

5.3.1.1 Morphology and Bathymetry

The Peel-Harvey Estuary comprises the Peel Inlet and Harvey Estuary; the tidal reaches of the Serpentine, Murray and Harvey Rivers; and an inlet channel at Mandurah that connects the system with the Indian Ocean.

Peel Inlet exists today as a circular waterbody approximately 70km² in area, with a central basin that never exceeds 2.5m below AHD (approximately mean sea level) in depth.

The Inlet comprises a broad, intertidal and shallow sub-tidal marginal shelf (less than 0.5m AHD) that constitutes 37% of the area of Peel Inlet (Hodgkin and Birch, 1986). The Harvey Estuary is an elongated waterbody, aligned north-northwest/south-southeast. It is approximately 20km long and 3 to 4km wide. It has an area of 60km². Water depth rarely exceeds 2.5m AHD, and marginal shallows of less than 0.5m below AHD constitute approximately 14% of the Estuary's area (Figure 17).

The Peel-Harvey Estuary is linked to the Indian Ocean by a narrow, 5km long channel, located in the northwest of the system.

5.3.1.2 Hydrology

Three rivers discharge into the Peel-Harvey Estuary: the Serpentine, Murray and Harvey.

The Serpentine River has a catchment area of 1800km^2 that comprises forested land east of the Darling Scarp and agricultural land on the Swan Coastal Plain. The Serpentine is relatively fresh and is dammed at the western edge of the Plateau. Most of this river's input to the Peel Inlet is derived from rainfall on the Coastal Plain.

The Murray River has a catchment area of approximately 8300km² which comprises a mixture of agricultural and forested land. This river is not dammed, and since it derives water from the lower rainfall agricultural areas east of the escarpment, where soil salt storage levels are high, water salinities are generally high (Collins, 1974).

The Harvey River discharges into the southern end of the Estuary and has a catchment area of approximately 700km². The catchment on the Coastal Plain is intensively developed for irrigated agriculture. The River and its tributaries are dammed by the Logue Brook Dam, the Harvey Weir, the Samson Brook Dam, the Drakesbrook Reservoir and the Stirling Dam. Consequently, much of the flow to the Estuary is derived from rainfall on the agricultural land, west of the escarpment. Nutrient loads are high and this water is generally fresh.

Flow for all three rivers is strongly seasonal, with nearly 90% occurring in the four months from June to September. Despite this general trend, there is great variation from year to year depending upon volume, timing and periodicity of rainfall (Hodgkin and Birch, 1986).

5.3.1.3 Salinity

The salinity of the Peel-Harvey Estuary is essentially governed by three variables: exchange of water with the sea, river inflow and high evaporation rates during the summer. As a result, salinity levels fluctuate from relatively fresh (5 to 10 parts per thousand - ppt) in the winter to hypersaline in the summer (45 to 50ppt) or 1.5 times the salinity of seawater.

The salinity range tends to be greater in the Harvey Estuary than the Peel Inlet. This is due to the long residence times for water in the Harvey Estuary that occur as a result of restricted exchange with the ocean. During the winter months, the restricted exchange has the effect of minimizing dilution of the freshwater with water from the marine-influenced Peel Inlet. During summer, the high evaporation rates result in hypersaline conditions in the shallow, southern extremity of the Harvey Estuary, and restricted exchange with oceanic water through tidal exchange, ensures that high salinities (34ppt) persist until the onset of winter rains.

5.3.1.4 Tidal Regime

The astronomic daily tidal range in the ocean near Mandurah is small (0.2 to 0.9m) and seldom exceeds 0.1m in the Peel-Harvey Estuary because of the restriction of flow imposed by the Mandurah inlet channel.

Local meteorological forcing also affects water levels along the coastline and in the Estuary. Southward propagating distubances, known as continental shelf waves (Hamon, 1966) are generally thought to be generated by surface winds associated with mesoscale weather systems that regularly pass over the continental shelf. These waves have periods of approximately seven days and a maximum range of 0.3m (Harrison, 1983; Webster, 1983). Because of the longer periodicity of these disturbances, they are generally unattenuated by the restrictions imposed by the inlet channel.

Tidal variations are also affected by barometric pressure, with sea level varying inversely with barometric pressure by approximately 0.01m per millibar. In the Mandurah region, this could lead to variations of up to 0.2m (D'Adamo and Lukatelich, 1985).

Other meteorological forces such as onshore and offshore winds, can influence water levels. Strong sea breezes are known to raise water levels on the eastern shores of the Peel Inlet by several centimeters with the reverse being true for strong easterly winds. The cumulative effect of meteorological influences can approximate 0.5m.

In summary, the short term astronomic tidal variations that occur along the coastline are attenuated by approximately 90% in the Peel-Harvey Estuary by the restrictions imposed by the inlet channel and therefore generally never exceed 0.1m. The longer period tidal variations generated by continental shelf waves are not attenuated by the inlet channel, but even when combined with meteorological effects, generally do not exceed 0.5m.

5.3.2 Estuarine Biological Environment

5.3.2.1 Flora

Phytoplankton

The phytoplankton community is dominated for most of the year by diatoms, with a characteristically high species diversity in summer, which falls away in winter. The summer diatom community largely consists of three species of <u>Pleurosigma</u>, whilst during winter, Rhizoselenia alata and Chaetoceros species are most common.

<u>Nodularia spumigena</u> dominates the planktonic blue-green algal flora, particularly in the Harvey Estuary. <u>Nostoc</u> and <u>Oscillatoria</u> are the next most prominent genera. The generally higher phytoplankton population in the Harvey Estuary is thought to be due to the higher phosphorus input, coupled with a lower flushing rate (Hodgkin et al. 1980).

Benthic macro-algae

Benthic algal populations were dominated by <u>Cladophora</u> aff. <u>albida</u>, a green alga which grew as small ball-like clumps of densely branched, radiating filaments. These clumps were often unattached on the Estuary floor, where they decomposed to form an anaerobic ooze. A detailed summary of the biology of <u>Cladophora</u> is given by Hodgkin et al.(1980). Cladophora is now rarely seen in the Peel-Harvey Estuary. Since 1981, <u>Cladophora</u> has been replaced by <u>Chaetomorpha</u>, <u>Enteromorpha</u>, <u>Ulva</u>, <u>Gracilaria</u> and <u>Chondria</u> (Lukatelich and McComb, 1986). It is these algae which contribute to summer algal accumulations on the shores of the Estuary, and cause widespread problems for local residents and managing authorities. The problems experienced during these algal accumulations include:

- o need for algal harvesting,
- o alienation of beaches,
- o odours, and
- o public complaints.

These problems result in recurrent high expenditure of about \$200,000 per year.

Aquatic angiosperms

The two major species of aquatic angiosperms are <u>Ruppia migacarpa</u> and <u>Halophila</u> <u>ovalis</u>; less common species are <u>Zostera mucronata</u> and <u>Lepilaena cylindricarpa</u>. <u>Ruppia</u> grows in very shallow (<0.3m) water, whilst <u>Halophila</u> can tolerate the lower light levels found in slightly deeper water.

Both <u>Ruppia</u> and <u>Halophila</u> grow mostly in spring and summer, <u>Halophila</u> regenerating mainly from rhizomes and <u>Ruppia</u> from seed in very shallow water and rhizomes in deeper water. Detachment of leaves and shoots occurs in autumn, but drift from degenerating plants has never caused offensive beach accumulations as have rotting piles of algae (Hodgkin et al. 1980).

5.3.2.2 Fauna

Invertebrate Fauna

The invertebrate fauna can be broadly grouped into zooplankton and benthic invertebrates.

In most Estuaries, including the Peel-Harvey Estuary, benthic invertebrates constitute by far the greatest proportion of invertebrate fauna (Hillman, 1985). They also represent a major link between estuarine primary production by plants and larger consumers such as fish and birds.

Zooplankton

During the winter river flow period, zooplankton populations are dominated by a single species of estuarine copepod, <u>Gladioferens</u> <u>imparipes</u>. As water salinity increases during the summer, the abundance of copepods declines and is replaced by other crustacea that are normally regarded as benthic invertebrates, i.e. amphipods, mysids and harpacticoid copepods (Hodgkin, et al. 1980).

The Harvey Estuary generally supports a larger zooplankton population than Peel Inlet, probably because of the lower flushing losses to the sea, the higher phytoplankton population and the greater quantity of suspended detrital material (Hodgkin, et al. 1980).

Benthic Invertebrates

This group of fauna applies to bottom-dwelling animals, animals that live on plants, and those which sometimes swim freely in the water column, such as shrimps.

The Peel-Harvey Estuary benthic invertebrate population is reasonably small, probably as a result of the large salinity range. Approximately 90% of the biomass is made up of four species of molluscs, three species of worms and three species of amphipods (Hillman, 1985). Appendix D provides detailed species lists of benthic invertebrates in the Peel-Harvey Estuary.

Fish and Large Crustaceans

The fish fauna have been comprehensively documented by Potter et al. (1983) and Lenanton et al. (1984). These studies identified 29 families and 55 species of fish, which is comparable to the fish fauna of the Swan River Estuary.

Nine of the fifteen most abundant species of fish found in the Estuary are marine and spend variable periods of their life cycle in the Estuary. These species, including the mullets and whitings, form the basis of the amateur and professional fishing industry.

The Estuary also supports populations of crabs and prawns which represent important commercial and recreation resources.

The blue manna crab (Portunus pelagicus) occurs throughout the Peel-Harvey Estuary system and the saline regions of tributary rivers during summer and autumn. The blue manna crab is known to be highly seasonal in abundance and distribution. Following the onset of winter rains, when salinity levels in the Peel-Harvey Estuary decrease, the range of <u>P</u>. pelagicus contracts to the mouth of the Estuary where salinities remain favourably high.

Two species of prawn are important within the Estuary. The larger of the two is the western king prawn (<u>Penaeus latisulcatus</u>) which spawns offshore between November and April, with peak activity occuring in January. New post-larval recruits move into the Estuary during this period and mature prawns evidently commence migration out of the Estuary in February, and continue to do so through to May.

The second species of prawn that inhabits the Estuary is the western school prawn (<u>Metapenaeus dalli</u>) which completes its life cycle within the Estuary and therefore does not enter the sea for spawning. The school prawn passes up the rivers during spring, and breeds in the upstream areas of reduced salinity. Spawning generally occurs in January to March (Potter and Manning, 1986).

Waterbirds

Sixty waterbird species have been recorded on the Peel-Harvey Estuary. Nineteen of these are summer migrants from breeding areas in the northern hemisphere. Eighteen are listed in the Japan-Australia Treaty on Migratory and Endangered Birds.

Surveys undertaken in 1976-77 by the Department of Fisheries and Wildlife concluded that the most valuable areas to waterbirds in the Peel-Harvey Estuary were Sticks Channel, the south-eastern area of Peel Inlet and the southern portion of the Harvey Estuary. There are also important waterbird roosting sites on some of the rocky points around the peninsula and in some bays (Figure 18; Lane, pers. comm.).

Mosquitoes

An inter-departmental committee, consisting of representatives from the Waterways Commission and Departments of Health, Conservation and Environment, Agriculture and Fisheries and Wildlife, was formed to assess the extent of the mosquito problem in the greater Mandurah and Bunbury region (Health Department, 1986).

The aim of the study was to:

- assess the mosquito breeding problem (identifying where and when breeding occurs, which species are involved, and environmental factors facilitating breeding),
- o adult mosquito activity (where and when activity occurs, dispersion distance)
- o nuisance effects (both breeding and adult mosquito activity), and
- assess importance of local mosquitoes as vectors of Ross River Virus, an arbovirus which is transmitted by several species of vector mosquitoes, including <u>Aedes</u> vigilax, which occurs throughout the Mandurah region.

Results for the Bunbury region were published in 1986, and results of the Mandurah survey are expected in September 1987. Preliminary indications from the Mandurah study indicate that the species are the same as those identified at Bunbury, i.e. <u>Aedes</u> camptorhynchus and <u>Aedes vigilax</u>.

The study was able to conclude that the extensive occurence of tidal flats in Mandurah offered greater potential breeding habitats than in Bunbury, and hence the extent of the problem was probably proportionately greater (Wright, pers. comm.).

These views are supported by an attitudinal survey conducted in the Mandurah region in 1985 (Kinhill Stearns, 1985). This survey concluded that mosquitoes were a significant seasonal problem that was generally regarded as being worse than odours generated by decomposing algae.

5.3.2.3 Existing Nutrient and Biological Status

The Peel-Harvey Estuary is a highly stressed eutrophic ecosystem, mainly as a result of the agricultural activities carried out in the Murray, Serpentine and Harvey River catchment areas. The undeveloped soils in these catchments are inherently deficient in nutrients, leading to the heavy use of fertilisers. This in turn has resulted in elevated nutrient levels (principally phosphorus and nitrogen) in the soils and in the rivers discharging into the Estuary.

Point-source discharges of effluent have also been recognised as an important contribution of nutrient to the Estuary. For example, it has been estimated that in 1985, 34% of the total Serpentine River phosphorus load was derived from a piggery. In 1986, this figure was estimated at 24%, or 9.4 tonnes (Bott and Humphries, 1986).

The eutrophic condition in the Peel Inlet is manifested by an excessive growth of benthic macro-algae (formerly <u>Cladophora</u>, now <u>Chaetomorpha</u>, <u>Enteromorpha</u> and <u>Ulva</u>) and in the Harvey Estuary by regular 'blooms' of phytoplankton (Nodularia).

The earliest report of an algal nuisance was in 1960 when fishermen complained of a slimy red alga (<u>Monosporus australis</u>) clogging their nets. First recorded complaints of weed fouling the foreshore date was from 1969, although aerial photographs suggest the presence of accumulations of weed near Coodanup in 1965 and 1967 (Hodgkin et al. 1985).

During the early 1970s, the dominant nuisance macro-alga was <u>Cladophora</u>, a filamentous species that grew as small cottonwool - like balls, and formed a carpet over the bottom. Since then, the blue-green micro-alga <u>Nodularia</u>, has become a problem species in the Harvey Estuary and <u>Chaetomorpha</u>, <u>Ulva</u> and <u>Enteromorpha</u> in the Peel Inlet. In June 1987, a large crop of <u>Ulva</u> was observed in the southern region of the Harvey Estuary for the first time.

<u>Nodularia</u> blooms are normally confined to spring and early summer, and have been worse and more prolonged in the Harvey Estuary. There were occasional blooms before 1980, but since then they have been annual events. Since 1983, the area covered by the <u>Nodularia</u> bloom has remained relatively constant. During the period 1970-1979 when levels of macro-algae growth became socially unacceptable, the total scale fishery in the Estuary actually increased (Lenanton et al. 1985a). In recent years, the total fish catch has decreased partly as a result of fishermen converting to gill netting rather than the more productive haul netting technique that can only be practised in algae-free waters. This has also meant that fishermen who normally operate in the Harvey Estuary, where the blooms are most intense, have been required to divert their activities to the Peel Inlet where conditions for fishing are more favourable during the bloom periods (Lenanton et al. 1985a).

The effect of increased macro-algal and blue-green algal growths since 1970 on crustacean populations, is more difficult to assess for two reasons. The first is that very little research has been performed on the three crustacean species that form the basis of the fishery and secondly a significant proportion of the crab and prawn catch is taken by amateurs, and therefore, catch statistics are incomplete. However, EPA officers have noted that <u>Nodularia</u> growth seems to exclude prawns from the area (EPA, pers. comm.).

5.3.2.4 Estuarine Condition at Point Grey

The Point Grey foreshore comprises three geomorphological zones:

- o The western foreshore, which represents the northeastern region of the Harvey Estuary, and consists of a relatively narrow marginal platform approximately 400m wide.
- o The Point Grey Sill, which has formed as a result of northward littoral drift of sediment derived from the marginal shelf. The sill extends northwards about 1km from the high water mark at Point Grey. At its broadest point, it is approximately 1.5km wide.
- o The Peel Inlet marginal shelf which is approximately 400m wide in the north, and broadens to 2km as it swings south into Robert Bay.

The geomorphology of the intertidal and shallow sub-tidal margins of Point Grey has a significant affect on the local estuarine condition because it effects fundamental habitat variables such as water circulation, substrate type, water depth and turbidity. Algal accumulations cause most concern when they occur near or upwind from urbanised areas, such as those at Coodanup and Novara (Figure 19).

Accumulations that occur in more remote areas, are of less concern because odours generated from decomposing algae are too distant from existing population areas to be offensive. As a result, the foreshore at Point Grey has not been regularly monitored for algal accumulations to date, so the magnitude of the algal problem at this location is largely unknown.

The algae that are responsible for the offensive odours are generally the free-floating species that grow rapidly in late spring when favourable light, temperature, nutrient and salinity conditions prevail, however, <u>Enteromorpha</u>, an attached macro-algae, is also responsible for the generation of offensive odours. The growing season proceeds throughout the summer and generally begins to decline in autumn.

Because the algae detach and float, areas of accumulation are largely determined by growth areas, the direction of the wind, wave action and currents (both tidal and wind generated). During spring and summer, the prevailing winds are from the southeast in the morning and southwest in the afternoon (Figure 12). The strength and duration of these winds are sufficient to establish a wave set that reinforces the effect of wind on floating algae, resulting in large accumulations on the northern foreshores of Peel Inlet. The likelihood of excessive accumulations of algae occuring on either the eastern or western foreshore of Point Grey is therefore lower than could be expected for foreshore areas affected by summer wind and wave patterns. Waterways Commission officers have noted accumulations of macro-algae in these areas in recent years, however, these have not been quantitatively measured (Waterways Commission, pers. comm.). These accumulations are likely to be the cause of potential public comment.

This situation is largely confirmed by an algal monitoring programme, funded by the Waterways Commission, and designed to record biomass levels at selected sites throughout the Estuary. This programme has been performed on a quarterly basis since January 1984 by the Centre for Water Research at the University of Western Australia.

The data indicate that, for sampling stations located on the eastern foreshore of Point Grey, algal biomass levels are consistently lower than those occurring offshore from points of accumulation near Coodanup, the Inlet Channel and Falcon (Figure 19). The only exception to this generalisation is the second last sampling period, where the station in Robert Bay showed high levels of biomass (Waterways Commission, unpubl. data).

The sampling programme did not include a station near the western foreshore at Point Grey. In the deeper water at this location, <u>Chaetomorpha</u> is known to grow in large amounts (EPA pers. comm.). However, during the time when weed accumulation causes the most problems, strong sea breezes can be expected to result in a northerly flow of water along this section of the foreshore and therefore, heavy accumulations are less likely to occur along this section of the Estuary than would be expected in locations less favoured by the prevailing wind pattern (e.g. Coodanup).

5.3.3 Estuarine Sociological Environment

5.3.3.1 Existing Uses

The Peel-Harvey Estuary is highly valued for its natural resources. The Estuary supports a large and diverse population of water birds, with at least 70 species known to occur in the region. Nineteen of these are summer migrants from northern hemisphere breeding areas (see Appendix D).

The Estuary also supports the most important estuarine commercial fishery in temperate Australia (Lenanton et al. 1985b) and a rapidly increasing amateur/recreation fishing resource. A five day boating survey conducted over the 1978 Australia Day long weekend estimated approximately 5000 launchings (Schwinghammer, 1978). A recent study concluded that the Estuary is the most popular boating area outside the Perth Metropolitan region (PA Australia, 1981).

The overall popularity of the Estuary is demonstrated by the results of a survey conducted for the Mandurah Tourism Development Plan. This survey indicated that the largest single tourist activity in Mandurah was fishing and crabbing with 29% of responses. The second most popular attraction was beaches (17.4%) followed by Inlet/Estuary/boats (16.4%) (Skitmore and Bunbury, 1985).

5.3.3.2 Development Trends on the Estuary

The Peel-Harvey Estuary is located within a region of rapidly growing population (Section 5.5.1), reflecting the influence of the large workforce associated with Alcoa's Pinjarra and Wagerup operations, the promotion of Mandurah as a retirement centre and the establishment of tourist developments in the region. The proximity of the area to the Perth Metropolitan region also allows a significant day visitor population to travel to Mandurah and the nearby Estuary.

A Western Australian Tourism Commission study estimated that, in 1986, 1.6 million people made a day trip from Perth to Mandurah, and it is expected that a large percentage of this number would be attracted by the natural features of the Estuary and the associated developing infrastructure.

This has resulted in numerous water-based residential development projects designed for the tourist, the first and second home markets, and the retirement market. These projects are summarised in Table 14.

TABLE 14

WATERWAY DEVELOPMENT PROJECTS, <u>PEEL-HARVEY ESTUARY</u>

DEVELOPMENT PROJECT	APPROVED LOTS
John Holland's Waterside Mandurah Canals Development	300
Murray Lakes	370
Winslea, Murray River	60
Yunderup Canals	325
TOTAL	1055

Source: Feilman Planning Consultants, 1987

The John Holland project also proposes a second stage 600 lot development, and there is a proposal for an additional 200 lots at Yunderup Canals. The Western Australian Development Corporation is managing a site located at the mouth of the Mandurah Inlet Channel. It is understood that this site may also be developed with water based housing and associated marine facilities. In addition, the 1000 unit Port Mandurah Canal Project is proposed by the Parry Corporation as part of its Halls Head project. A 600 unit tourist/holiday project is also proposed by Parry Corporation for the area fringing Peel Inlet known as 'The Sticks'.

The trend of water based developments is likely to continue in order to meet the demand of existing and projected population growth for the Mandurah, Murray and Waroona Shires (Section 5.5.1). The predicted increase in boat registrations for the Mandurah Shire and improved access to the Estuary through the provision of additional boat launching facilities, will increase the popularity of the waterway to recreation users.

If the proposed Dawesville Channel is approved by Government, further development can be expected to focus around the Channel.

5.3.4 Existing Management Policies

5.3.4.1 Current Estuarine Management Alternatives

A comprehensive research programme aimed at understanding the nature and causes of the algal problem has clearly shown that the excessive input of nutrients to the Estuary from agricultural land is primarily responsible for the eutrophic condition of the Peel-Harvey Estuary system.

A range of management options with the potential to reduce the input of nutrients to the Estuary, and thus ameliorate the algae problem, have been identified. These options were reviewed by DCE (DCE, 1984) and are outlined below:

- o harvesting of weed accumulations from foreshores located near populated regions,
- reducing the input of phosphorus to the Estuary by modifying agricultural fertiliser practices on the coastal plain,
- o increasing the loss of nutrients to the sea by improving tidal flushing,
- o application of algicides,
- o amendment of leaching soils with bauxite residue,
- o treatment of rural point sources of nutrients,
- o changes in land use within the catchment, and
- o controls on clearing and drainage construction within the catchment.

The first three options have been identified as the preferred management strategy, and they are discussed further in the next section. The remaining five have been identified as supplementary options requiring further evaluation. Other management alternatives that have been considered and subsequently rejected for practical, lack of potential effectiveness or commercial reasons, include:

- enlarging the Mandurah Channel,
- o diversion of the Harvey River Main Drain, and
- o dredging of the Estuary's sediments.

The preferred management strategy devised by DCE has three parts:

- continuation and possible expansion of the present programme of harvesting and removal of weed accumulations,
- o modifying fertiliser practices presently carried out on the Swan Coastal Plain to reduce phosphorus levels in rivers and drains discharging to the Estuary, and
- o construction of a channel at Dawesville to allow for the improved exchange of water between the Harvey Estuary and the Indian Ocean (DCE, 1984).

The aim of the weed harvesting programme is to keep the beaches which are located near populated centres, free of weed and thus alleviate the offensive odours that occur when the weed decomposes. The programme is not seen as a long term management solution, but rather a method of control. It is recognised as being an expensive programme, and one that causes considerable damage to the foreshore. Destruction of the marginal vegetation has resulted in erosion of some sections of the foreshore (Hodgkin et al. 1985).

The fertiliser modification programme has the objective of reducing the amount of phosphorus entering the Estuary whilst maintaining existing agricultural land uses and levels of productivity.

The programme was implemented in 1984 and consisted of four measures:

- o soil testing of all paddocks on the coastal plain catchment,
- introduction of Coastal Superphosphate to replace superphosphate for use on sandy soils,
- evaluation of fertiliser requirements for maintenance of an economic level of production, and
- advice to farmers on the appropriate type and rate of fertiliser to be applied to their paddocks (Hodgkin et al. 1985).

The construction of the Dawesville Channel would promote the exchange of water between the Estuary and the ocean and lead to a reduction in the quantity of nutrients retained in the Peel-Harvey Estuary system. The Channel would result in higher salinities within the Estuary and this would inhibit the growth of <u>Nodularia</u>, and probably favour the growth of selected species of macroalgae. Further, the Channel would raise the maximum permissible phosphorus loadings to the Estuary required for a non-eutrophic (i.e. mesotrophic) system from 73t/yr to an average of 139t/yr (DCE, 1985).

It is recognized that the Channel would greatly alter the ecology of the Peel-Harvey Estuary, and would involve considerable capital investment. The cost-benefit of this management option is still being evaluated by Government.

5.4 REGIONAL CONSERVATION

5.4.1 Reserves

Reserves adjacent to the project area are shown on Figure 14. Three of these reserves have conservation of flora and fauna as their present purpose (Table 13). Within a 5km radius of the Point Grey development area there are approximately 380ha of reserved land, of which 200ha (53%) is currently vested in the National Parks and Nature Conservation Authority (NPNCA) for the purpose of Conservation of Flora and Fauna.

In the wider context, the Point Grey area falls within System Six of the Environmental Protection Authority's strategy recommending further conservation reserves as described in the 'Red Book' (DCE, 1983). Two areas subject to conservation recommendations in the Red Book (C50-Peel Inlet and C51-Harvey Estuary) have boundaries adjacent to the proposed development. In addition, part of the area subject to recommendation C52, Lake Mealup, lies to the southeast of the proposed development. Other reserves to the south of Mealup Main Drain are outside the catchment area of the development.

The areas designated in the Red Book as C50-Peel Inlet and C51-Harvey Estuary, are noted as comprising probably the most important Estuary in southwestern Australia as a conservation area for water birds. The most important water bird habitats are the extensive shallows. The Estuary system also provides an important nursery area for commercial and recreational species of fish and crustaceans. The designated areas contribute to open space of regional significance because of their conservation and recreation values and their proximity to Perth and Bunbury. Lake Mealup is part of the area designated C52 in the Red Book. Together with Lake McLarty to the south, it provides freshwater in summer for the birds of the saline Estuary and supports a resident bird population. A species of heath, <u>Brachyloma preissii</u> which occurs on reserve A24739 in this area, is described as rare, although this designation is subject to some uncertainty (see Section 5.2.2.1).

Recommendations for reserves are also contained in the Peel Inlet Management Plan (Waterways Commission, 1979). The current vestings and purposes of the reserves, together with the DCE and PIMA recommendations, are listed in Table 13.

Two of the reserves adjacent to the development have recreation as their designated purpose, although neither has been developed and both support native vegetation.

Crown foreshore reserves partially surround the development area. The present development concept proposes that they extend all the way around the peninsula. Other large areas of conservation reserve or proposed reserve extend around the eastern side of Peel Inlet, along the eastern and southern edges of Harvey Estuary, and around Lakes Mealup and McLarty. Yalgorup National Park occupies a large part of the strip of land to the west of Harvey Estuary.

The habitats, soil types and hence vegetation types represented on the Point Grey site and in the conservation reserves adjacent to the project area are represented in much larger conservation areas (Table 11). Karrakatta yellow phase and limestone units are notably present in Yalgorup National Park. The area designated C51, to the east of Harvey Estuary (Figure 14), contains a well developed and well vegetated representation of the parallel sand ridges soil unit and associated vegetation. The combination of soil types and a steep limestone slope dropping to the shoreline, present in Stony Point recreation reserve, is also represented along the foreshore reserves and at Point Grey itself and will thus be protected by the proposed foreshore reserve system that forms an integral part of the project.

Overall, 213ha or just under 20% of the Point Grey project area is to be reserved in public ownership. All landscape units present on the development site are represented in reserved areas elsewhere.

5.4.2 EPA Recommendations

As Table 13 shows, the EPA has made recommendations for three of the 'C' class reserves: C27528, C2707 and C7502. It was recommended that the designation of Reserve C27528 (Stony Point) be changed from recreation to parkland and vested in the Shire of Murray. Cancellation of Reserves C2707 and C7502 was recommended following incorporation of their respective areas into Reserve B4990, on the eastern shore of Peel Inlet. The EPA recommended that the purpose of C7502 be changed from its current purpose of 'water' to 'conservation of flora and fauna'.

The two 'A' class reserves to the southeast of the development area are both vested in the National Parks and Nature Conservation Authority for conservation of flora and fauna. It is important to note that since 1983 when the System Six Red Book was released, Reserve 6627 has been upgraded from a 'C' to an 'A' class reserve and its purpose amended from 'watering place for stock' to 'conservation of flora and fauna'.

5.4.3 PIMA Recommendations

The Peel Inlet Management Authority (PIMA) has made recommendations on six of the eight reserves in the vicinity of the proposed development. The same status (i.e. purpose and vesting authority) as currently applies was recommended for five of them.

The only exception is Reserve C27528. PIMA have recommended that it be vested in the Shire of Murray for recreational purposes, instead of being administered by the Department of Lands Administration.

5.5 REGIONAL SOCIOLOGICAL ENVIRONMENT

5.5.1 Population

5.5.1.1 Growth Trends

Population statistics for the Shires of Mandurah, Murray and Waroona since 1971 are detailed in Amendment No. 58 to the West Murray Town Planning Scheme (see Feilman Planning Consultants, 1987). Populations within the three Shires from 1971 to 1981 increased significantly from 11,995 to 21,460, with the Shire of Mandurah realising a doubling in population (Australian Bureau of Statistics 1986).

Mandurah recorded a population of 12,720 at the 1981 Census and its population has been estimated by the Australian Bureau of Statistics to be 17,100 in 1985 (ABS, 1986). This, however, is a midwinter estimate, and the population in summer is estimated to exceed 40,000 persons. Primary reasons for this seasonal increase are tourist and holiday traffic and second home owners.

The Australian Bureau of Statistics (ABS) has estimated the resident populations in the Shires of Murray and Waroona to have increased from 6306 and 2434 in 1981 to 7170 and 2700 in 1985 respectively (ABS, 1986). The extremely strong population growth within this hinterland is highlighted in the average annual growth rates (1976-81) for Mandurah, Murray and Waroona of 8.92%, 4.60% and 5.13% respectively (Department of Industrial Development, 1983). These are significantly higher than the Statewide average of 2.1%.

The high growth rates in the hinterland reflect, amongst other things, the influence of Alcoa's operations at Pinjarra and Wagerup, coupled with major tourist developments, and the promotion of Mandurah as a retirement centre.

5.5.1.2 Age Distribution

The Shire of Mandurah has a higher proportion of aged persons (19% over 65) than other areas in the hinterland, and the Perth Statistical Division (9% over 65). This is indicative of its attractiveness as a retirement community. However, there appears to be a trend towards a more balanced population with a significant increase in the proportion of young adult family groups since 1971.

Overall age distributions in the Shires of Murray and Waroona were very similar to the State average in 1981.

5.5.1.3 Population Estimates

Conservative population projections by the State Planning Commission indicate that the population of the hinterland will increase to 42,934 by the year 2001. This assumes current trends continue. The introduction of major developments in the area would inflate this estimate considerably. The range of growth options for the hinterland results in an anticipated population of between 45,000 and 55,000 people. Detailed population estimates are presented in the Planning document (Feilman Planning Consultants, 1987).

5.5.2 Employment

5.5.2.1 Base Industry

In order of priority, bauxite/alumina, agriculture, tourism and forestry are the prime base employment industries in the district. Feilman Planning Consultants (1987) details the breakdown by industry.

The Alcoa bauxite mines and Pinjarra alumina refinery play a significant employment role, with a total of approximately 1900 employees, which is 73% of the resident manufacturing workforce in the hinterland (Alcoa, pers. comm.). Approximately half of these employees live in Mandurah, one third in the Pinjarra area and the rest elsewhere. It is anticipated that the bauxite/alumina industry will maintain its high employment profile.

Agricultural industries, particularly dairying, are also major employers in the Shires of Murray and Waroona. Agriculture is expected to continue strongly as a base industry, although minor declines are forecast.

The Worsley gold mining project, located 12km northwest of Boddington, has resulted in a construction workforce of 400. By the end of 1987, an operational workforce of 200 will be required (Shire of Boddington, pers. comm.).

Due to the small size of Boddington, the proximity of Mandurah and Mandurah's social infrastructure, it is likely that a proportion of the base and service workforce from the Worsley project will live in the Murray/Mandurah region.

Three new industries proposed for the Shire of Murray (to produce rare earths, gallium and charcoal) will provide a total of 200 direct jobs. Using Department of Resources Development (1982) multipliers, the total population likely to be generated could be in excess of 1350. Based on the Alcoa experience, 80% of these will live in the Murray/Mandurah region.

Employment in both service industries and tourism have realized strong growth in recent years and this is expected to continue.

5.5.2.2 Manufacturing Establishments and Associated Employment

The number of manufacturing establishments in the Shires of Mandurah, Murray and Waroona increased from 22 in 1969/70 to 52 in 1983/84. Although the majority of the establishments were in Mandurah, the majority of the corresponding increase in employment occurred in the Shire of Murray, as a result of the Alcoa developments.

In addition to employment generated from within the region, it is expected that the Murray/Mandurah region will increase its function as a dormitory locality for a Perth Metropolitan based workforce. Proposed improvements in road access (e.g. Perth-Bunbury Highway) would improve this employment option for the Shires of Murray and Mandurah.

5.5.2.3 Development of Industrial Centres within the Study Area

As detailed in the Planning document (Feilman Planning Consultants, 1987), there is ample spare capacity within the zoned industrial areas of the hinterland to meet strong demand over the next 5 to 10 years.

5.5.3 Tourism - Overview

Details of tourism in the hinterland are presented in the Planning document (Feilman Planning Consultants, 1987).

The Mandurah Region continues to be one of the State's major tourist/holiday destinations. It is currently the third most popular tourist attraction in Western Australia. Mandurah attracts high numbers of both holiday makers and day trippers from Perth. A study in 1985/86 indicated that 1.6 million people made day trips from Perth to the Mandurah/Pinjarra area, being by far the most important destination (WA Tourism Commission, 1986).

In recent years the region has experienced strong growth in tourism, exceeding many other major State tourist destinations. Although the tourist traffic is primarily domestic, there has been a significant increase in interstate holiday visits since 1983, particularly visits originating from Perth. With the development of new quality tourist holiday accommodation centres in the region (e.g. The Atrium, Silver Sands Holiday Village, Murray River Resort, The Lakes and the Reef Hotel), scope exists for growth in the largely untapped international and interstate tourist markets. In addition to tourism, the Mandurah region continues to be the most popular centre for the establishment of holiday homes by people living in the Perth Metropolitan region.

5.5.4 Housing

5.5.4.1 Housing Commencements

Since 1981, housing commencements within the hinterland have remained strong and relatively constant. In 1985/86, 538 dwellings were commenced, of which 477 were new houses. Continued growth in the Perth population is likely to result in the continued strong growth in the numbers of holiday homes in the Mandurah region, and in demand for first homes for workers commuting to Perth.

5.5.4.2 Residential Growth Areas - Mandurah

The South West Development Authority has documented the likely future major residential development areas within Mandurah, as follows:

- o Halls Head/Port Mandurah,
- o East Mandurah Estate,
- o Dudley Park Estate,
- o Waterside Mandurah,
- o Mandurah Park, and
- Consolidation of Existing Centres.

When developed, these residential areas are expected to cater for the urban growth in Mandurah for the next decade.

5.5.4.3 Residential Growth Areas - Shire of Murray

Although planned and proposed major residential projects within the Shire of Mandurah have the ability to provide an on-going supply of residential land, there is a lack of comparable quality land within the Shire of Murray. There is a foreseeable demand for Special Rural lots as the Shire's existing designated areas are almost fully developed. A high percentage of the growth in the Murray area has taken place in the Special Rural Areas adjacent to the Mandurah Shire.

5.5.5 Education

A Senior High School and three primary schools cater for existing educational requirements within the Murray Shire. Spare capacity exists in all of the schools in the locality. Future student numbers are anticipated to remain at existing levels with a slight decline expected in high school student enrolments after 1988. Additional spare capacity is therefore expected at the high school over the next few years. The High School is currently undergoing a \$1.5 million upgrading programme.

5.5.6 Proposed Major Developments

5.5.6.1 Mandurah

The following proposed major developments for the Shire of Mandurah are potential sources of employment. Details of each are provided in the Planning document (Feilman Planning Consultants, 1987).

- o Mandurah Hospital,
- o Canal Development,
- Court House and Police Station,
- o Radio Station,
- o Ambulance Depot,
- Dredging Mandurah Channel (Mandurah Estuary),
- Dawesville Channel,
- o Mandurah Ocean Marina,
- o Mandurah/Murray Airstrip,
- o Sticks Development Project,
- Mandurah Broadwater Development,
- Smoked Fish Industry, and
- Maritime Training School.

5.5.6.2 Murray

A number of industrial projects including a chemical processing works and a pelletising plant have been mooted by local entrepreneurs and are likely to be located within the existing Pinjarra Road Industrial Area, in the near future. These would provide additional employment sources for the area, as would the following:

- Relocation of Midland Saleyards,
- o The Agnew-Clough Charcoal Plant,
- o The Rhône-Poulenc Gallium Plant, and
- o The Rhône-Poulenc Rare Earths Plant.

5.5.7 Retail Structure

Mandurah has an extensive range of large retail establishments with excess capacity, many of which are patronised by residents of the hinterland. The Shires of Murray and Waroona have a number of rural traders, small grocery stores and other premises which cater for local demand. Further details of retail structure are presented in the Planning document (Feilman Planning Consultants, 1987).

5.5.8 Community Facilities

The Shire of Mandurah has by far the most extensive range of community services in the three Shires. It provides a full range of facilities including 37 commerical facilities, 32 community groups, 41 voluntary groups and 15 service and government agencies. More detail on these groups is presented in the Planning document (Feilman Planning Consultants, 1987).

The majority of these facilities are able to extend their services if required, or are currently under capacity.

Although the Shire of Murray has a less extensive range of community services than Mandurah, it is provided with all the basic community requirements. Many facilities within the Shire of Murray service localities throughout and beyond the Shire.

The Shire of Waroona has a limited number of community facilities, primarily servicing the Waroona township and surrounding districts.

The existing Pinjarra hospital has excess capacity, some of which is presently being taken up by beds allocated to care of the aged.

A hospital is under construction in Mandurah and this will provide additional capacity.

5.5.9 Current Population, Livelihoods and Social Attitudes

One caretaker/farm manager presently resides on the Point Grey site. The population density on surrounding properties is very low with inhabitants limited to a few families in scattered farm houses on properties to the south and east of Point Grey. These residents are generally engaged in farming pursuits, principally low density grazing. Much of the surrounding area is low lying or swampy with conservation being the primary land use.

The principal population centre in the Shire of Murray is the township of Pinjarra. At the 1981 census the population of Pinjarra was 1336 (ABS, 1981).

The residents of Pinjarra and surrounding districts are primarily involved in farming, forestry and service industries or are directly or indirectly employed by the nearby alumina refinery and bauxite mines of Alcoa of Australia Ltd. Many, especially the farming families, are long time residents who can be expected to have a conservative view of new developments, an expanding population and an influx of foreign students to the area.

Studies conducted in connection with the Kemerton Smelter Project, 65km south, revealed a number of generalised potential community concerns related to new developments in this region (Dames & Moore, 1985).

Local press reports and discussions within the Pinjarra community have indicated that the following particular items are potentially of concern to local residents:

- o continuation of access to traditional recreation pursuits and locations,
- o an influx of foreign students into Pinjarra,
- the potential for displacement of local students from educational places by foreign students,
- o competition for employment opportunities for school leavers,
- o the environmental sensitivity of the Estuary,
- o preservation of waterbird habitats, and
- o potential for traffic congestion.

Aspects such as those outlined above are addressed in subsequent sections of this report.

Opportunities which have been identified in discussions within the community include:

- o construction, service and staffing employment opportunities,
- o increased tourism potential and consequent income,
- o improved boating access to the eastern foreshore of the Harvey Estuary, and
- o potential alternative residential sites within the Shire of Murray close to the Estuary.

The site also represents one of the few water based locations within close proximity to the Perth Metropolitan region that is suitable for a large scale development.

Discussions with representatives of the Shire of Murray indicated that the Shire strongly supports residential development of the site and the opportunity for increased public access to it. The Shire is aware of the cost of providing services to the area.


6.0 ASSESSMENT OF ENVIRONMENTAL IMPACTS

6.1 GENERAL

The proposed development will proceed in two distinct phases. The first will involve the construction of the College complex and the associated infrastructure, and the second will involve the staged residential subdivision of Point Grey, and the gradual development of an urban settlement.

The construction of the College will result in essentially short term physical disturbances to the site (e.g. earthworks, building activity, road construction etc). Whilst the urban development phase will result in longer term environmental effects that will occur as a result of the influx of people to the site (e.g. population pressure on the nearby reserves and the adjoining Estuary, water supply development, waste water treatment and disposal, the application of garden fertilisers etc).

The objective of this section of the ERMP is to synthesise all information gathered during the environmental investigations conducted for this project and predict the potential short and long term impacts of the project on the Point Grey ecosystem (which includes the Peel-Harvey Estuary and the surrounding community). The possible effect of the Estuary and the proposed Dawesville Channel on the project, has also been considered as part of the assessment process.

The approach has been to evaluate the potential impacts on important components of the environment (such as nutrients, water supply, etc), before drawing together key issues and presenting an overall synthesis. This assessment process then forms the basis of an environmental management programme which is discussed in detail in Section 7.0.

6.2 NUTRIENTS

6.2.1 Overview

The main cause of the increasing algal growth in the Peel-Harvey Estuary has been attributed to the increasing amounts of phosphorus and nitrogen flowing into the Estuary. Both phosphorus and nitrogen are essential for plant growth and a shortage of either can limit the size of the algal crop. For the Peel-Harvey Estuary, phosphorus tends to be the limiting nutrient and consequently, many of the management techniques designed to improve the water quality of the Estuary are aimed at reducing the input levels of this nutrient.

The reduction of nitrogen inputs to the Estuary presently represent a less favourable management option because of the significantly larger amounts that flow into the system and because the blue-green alga, <u>Nodularia</u>, is able to fix nitrogen from the atmosphere. Its growth is therefore less dependent upon nitrogen inputs from drainage.

Thus, under the existing situation, the long term management strategy for reducing the growth of algae in the Estuary is to reduce phosphorus inputs to the system (Section 5.3.4). The major drawback from this approach is that the sediments of the Estuary basin represents a large store of nutrients (particularly phosphorus) that has built up over many years. This store is capable of being released into the water column where it is available for uptake by algae. So, even if no more phosphorus were imported into the Estuary, there may be enough nutrient to support some <u>Nodularia</u> growth in the short to medium term, although it is believed that direct phosphorus inputs are needed to supplement recycled nutrients to support "bloom" conditions. It is for this reason that the Government is considering the Dawesville Channel option, as this represents a more immediate solution to the existing algal problem.

The construction of the Dawesville Channel will not necessarily represent a complete solution to the algal problem, at least in the short term, because it is predicted that as the Estuary becomes more marine, the growth of macro-algal species will be favoured (Hillman, 1986). Unlike blue-green alga, these species cannot fix atmospheric nitrogen and hence their growth will be influenced by nitrogen inputs to the system. It is for this reason that the potential nitrogen loads generated from the proposed development at Point Grey are evaluated in this ERMP.

There are a number of nutrient inputs to the Estuary that contribute to periodic algal blooms. They are: river and drain flow, groundwater flow, surface runoff, seawater and urban sewage. Of the total, it has been estimated that approximately 90% is derived from river and drainage input (Hodgkin and Birch, 1986).

The principal sources of phosphorus to the rivers and drains that enter the Estuary are superphosphate fertiliser and soil-bound phosphorus. The phosphorus contained within the superphosphate is rapidly leached from the sandy farm soils, and following transmission to the Estuary, is trapped by diatoms where it is retained in the decaying organic detritus of the surface sediments of the Estuary. This phosphorus is then available for uptake by <u>Nodularia</u> and a variety of green algae such as <u>Chaetomorpha</u> and <u>Enteromorpha</u>.

The principal source of nitrogen to the rivers and drains feeding into the Estuary are the leguminous crops grown in the Estuary catchment.

6.2.2 Nutrient Impacts of the Development

To successfully evaluate the potential impact of the development on the nutrient levels in the Point Grey environment, it is necessary to establish a baseline against which a comparison can be made. There are several possible approaches, and these are detailed below.

The maximum quantity of phosphorus (as superphosphate) that could theoretically be applied to the Point Grey site is 19t/yr. This would occur if:

- o the full 1083ha of the site were commercially developed for agriculture, as opposed to the semi-commercial farming practice that presently operates on 720ha, and
- a phosphorus application rate of 16 to 18kg/ha/yr (the average rate traditionally used by farmers on the Swan Coastal Plain; Bettenay et al. 1985, Yeates et al. 1985) were used on the property.

In reality, this quantity would be slightly less because some areas of the 1083ha site would not be fertilised, for example, naturally vegetated areas, rock outcrops, etc.

In order to more realistically determine the nutrient requirements of the site, a soil testing programme was undertaken by the Western Australian Department of Agriculture, Catchment Extension, Fertiliser Advisory Service. Sixteen paddocks/areas were sampled and eleven analyses were reported. Two of these soil samples were taken on uncleared areas (Figure 20). Table 15 lists the results of the survey in terms of the Department's recommendations for fertiliser application for optimum farm production.

Fertiliser was seen to be required for each paddock sampled. In terms of phosphorus required, the paddocks varied from 4.5kg/ha to 20.7kg/ha with the uncleared bush blocks requiring 11.7kg/ha and 15.3kg/ha (Table 15).

Due to the high variation observed, and the expected high variability within paddocks and soil types, it is not pertinent to calculate the fertiliser requirement for the total site by area weighting each sample. The phosphorus requirement for optimum farming practices was therefore calculated using the arithmetic mean of the eleven samples over an area of 1083ha (for full agricultural development, 9.74kg/ha per year) and the arithmetic mean of the nine samples measured on the existing farmland over an area of 720ha, which is equivalent to 8.7kg/ha per year. This represents an annual application of 11.2t for full agricultural development, and 6.3t for the existing 720ha farmland (Appendix F).

TABLE 15

PADDOCK SOIL NO.** TYPE		OPTIMUM SUPERPHOSPHATE APPLICATION RATE (kg/ha)	APPLICATION RATE AS PHOSPHORUS (P) (kg/ha)	
2	Coloured Sand	80	7.2	
3	Joel/Deep Coolup	230	20.7	
4	Coloured Sand	120	10.8	
6	Coloured Sand	80	7.2	
7 *	Coloured Sand	170	15.3	
8 *	Coloured Sand	130	11.7	
12	Good Transitional	50	4.5	
13	Coloured Sand	90	8.1	
14	Coloured Sand	80	7.2	
15	Good Transitional	60	5.4	
16	Joel/Deep Coolup	100	9.0	

SOIL SAMPLE ANALYSES

* Forested paddocks

** For paddock number, see Figure 20

Nitrogen loading to the site by plant fixing of atmospheric nitrogen has been estimated to be about 140t/yr for the existing farmland (Department of Agriculture, pers. comm.).

Thus, for the purposes of the present investigation, the baseline conditions chosen to assess the potential impact of the proposed development on the nutrient levels of the surrounding environment are 6.3t/yr phosphorus and 140t/yr nitrogen.

The proposed development has the potential to produce nutrients (mainly phosphorus) from the following specific sources:

- o fertiliser application to private lawns and gardens,
 - o disposal of sewage treatment plant effluent as a fertiliser and water source on the golf course,
 - o disposal of septic tank effluent on the leisure allotments,
 - o imported fertiliser application to the golf course, and
 - o fertiliser application to the public parks and gardens and College area.

The combined potential phosphorus load generated at full development (year 50) and following the implementation of a detailed nutrient management plan (Section 7.3), is estimated at 4.5t/yr. Details of the calculations used to derive this figure are given in Appendix F, whilst a summary of the amount of phosphorus generated from each of the sources identified above, is provided in Table 16. Figures 21, 22 and 23 show a breakdown of phosphorus application from all sources following full development.

The estimate of 4.5t/yr at full development is approximately 30% less than the recommended application rates for the existing farming practices at Point Grey, as defined by the Department of Agriculture.

The potential nitrogen loading to the site has been estimated as 24.5t/yr at full development, and this represents an 82% reduction from the existing loading. This dramatic reduction is largely due to the replacement of nitrogen fixing pasture crops that have been traditionally grown on-site for pasture.

Although the loadings of phosphorus are seen to be reduced to 'acceptable' levels (in terms of agricultural application), it was necessary to assess the outflows of nutrient from the site given that the development will cause changes to the site's hydrogeological processes. Again, detailed calculations are given in Appendix F.

A shallow groundwater exploration programme was conducted on-site to determine the total phosphorus and nitrogen storage in the groundwater and potential rates of nutrient mass transport from the site to the Estuary (Dames & Moore, 1986).

The shallow freshwater aquifer (<2000mg/L TDS) storage beneath the site was estimated to be about 3.3 x $10^6 m^3$, with an average phosphorus concentration of 0.07mg/L (as P) and nitrogen of 5.9mg/L (as N).

TABLE 16

PROPOSED NUTRIENT MANAGEMENT PROGRAMMES, PHOSPHORUS LOADING TO DEVELOPMENT FROM ALL SOURCES

YEAR	RESIDENTIAL LAWNS (t/yr)	LEISURE LAWNS (t/yr)	GOLF COURSE (t/yr)	CAMPUS (t/yr)	PARKS, GARDENS (t/yr)	SEPTIC TANKS (t/yr)	STP EFFLUENT* (t/yr)	TOTAL
1	0.05	0.04	2.16	0.09	0.12	0.06	0.0	2.52
5	0.2	0.13	1.52	0.09	0.12	0.41	0.0	2.47
10	0.6	0.13	0.53	0.09	0.24	0.74	0.0	2.33
15	1.0	0.13	0.53	0.09	0.24	0.9	0.0	2.89
20	1.4	0.13	0.53	0.09	0.36	0.9	0.0	3.41
30	1.9	0.13	0.53	0.09	0.48	0.9	0.18	4.21
40	1.9	0.13	0.53	0.09	0.48	0.9	0.33	4.36
50	1.9	0.13	0.53	0.09	0.48	0.9	0.48	4.52

* Quantity to be disposed of in excess of golf course requirements

Storage of nutrients in the shallow groundwater are estimated at 0.23t of phosphorus and about 19.5t of nitrogen. If the aquifer is in steady state on an annual basis (i.e. inputs of water and nutrients are balanced by outputs of water and nutrients) then nutrient outflow can be estimated by the product of concentration and annual throughflow.

Assuming that the throughflow is equal to about 10% of average rainfall (88mm/yr), nutrient outflows through the shallow groundwater system are estimated at 0.04t/yr phosphorus (as P) and about 3.7t/yr nitrogen (as N).

Following the development of the site, it is expected that the throughflow will increase from $0.95 \times 10^6 \text{m}^3/\text{yr}$ to about $1.2 \times 10^6 \text{m}^3/\text{yr}$ from the 1083ha, but that the steady phosphorus concentration of the groundwater will reduce to about 0.03 mg/L (as P). This is because the reduced application rate following development is applied to a greater surface area (1083ha) or larger volume of aquifer. As such, the predicted outflow following full development is estimated to be 0.033t/yr (Appendix F).

In summary, the nutrient impacts of the development are expected to be immeasurable in terms of total Estuary nutrient status (i.e. less than 0.lt/yr phosphorus inputs from the development compared to an average annual phosphorus loading (1977 - 1984) to the Estuary of about 150t/yr; Birch et al. 1985). These estimates are based on the implementation of a detailed nutrient management programme. In terms of localised nutrient status at the development site, any impacts, if detectable, are expected to be beneficial since they will lead to a reduction in nutrients both in comparison to existing phosphorus and nitrogen loadings, and in possible loadings should the Point Grey site be further developed for more intense agricultural production.

6.3 WATER SUPPLY

6.3.1 General

The impacts of water supply development have been identified for each of the water supply alternatives (Section 4.8.1).

Obtaining all or part of the supply requirements from the surficial aquifer within the Quaternary sands (i.e. the Waroona Mound) may be achieved by pumping from shallow production bores located 12 to 15km southeast of the development (Figure 24).

Potential environmental impacts are as follows:

- lowering of shallow groundwater levels and the resultant effect on lakes and swamps,
- o localised drawdown effects on pasture productivity,
- o changes to land use practices within the proposed bore field, and
- o competition with existing and potential groundwater users.

The shallow surficial aquifer at Point Grey, is limited in its pumping capacity, although some small abstraction may be beneficial in terms of irrigation water supply supplementation and the recycling of nutrients that are stored within this 'mobile' groundwater system.

Impacts that relate to the use of this aquifer are listed as:

- o overpumping, leading to saline inflow or upconing from the deeper more saline groundwater, and
- o increased drawdowns and its related effects on local vegetation.

In addition, urbanisation on Point Grey will lead to a transient modification to the rates of recharge by rainwater infiltration and to discharge by evapotranspiration as well as modification to net volumes of annual groundwater outflow from below the development.

Abstraction of groundwater from the Leederville Formation has the potential to:

- lead to saline intrusion or leakage of more saline water into the freshwater Leederville aquifer,
- induce leakage from overlying aquifers with the consequent effect on wetland areas, and
- o lower water levels within the aquifer, with local and regional implications.

6.3.2 Impacts of Pumping from the Waroona Mound, to the southeast of Point Grey

Water for the development will be extracted from the Quaternary sands aquifer from an area southeast of Point Grey. The total area of low salinity groundwater (less than 1000mg/L TDS) in this locality is about 120km² (Figure 24).

Impacts associated with this resource are related to the localised lowering of groundwater levels and the seasonal dewatering effects on lakes, swamps, pasture and the limited areas of natural woodland areas. As a consequence, the location of the borefield, and the bore layout, together with the expected pumping and recharge/ discharge rates were examined using numerical modelling methods. These methods enabled the prediction of the localised and regional effects of pumping (Appendix G).

An L-shaped borefield layout (assumed to be placed along road reserves) was simulated over a twelve month pumping period using recharge estimates for the lowest rainfall year recorded for Perth (1877-1986) which occurred in 1940. A distribution pumping throughout the year was estimated from seasonal demand requirements.

The drawdowns at the end the summer and winter periods were predicted using a blockcentred flow simulation procedure (Figure 25, Appendix G). The aquifer area was discretized into 500m x 500m cells, with eight pumping cells having a one kilometre separation. Figure 26 shows predicted drawdowns from the borefield west towards the approximate location of the Harvey Estuary. These drawdowns are conservative, as recharge calculated from the lowest recorded rainfall was used.

These results are presented in Table 17 and show that the radius of influence away from the borefield will be at a maximum at the end of the summer period and would occur about 1.5km away from the borefield (the radius of influence is defined here by groundwater levels being predicted to drawdown no more than 0.05m).

TABLE 17

TRANSIENT RESPONSE OF SHALLOW BOREFIELD AQUIFER WITH SEASONAL RECHARGE

	SIMULATION TIME (days)	AVERAGE DRAWDOWN IN BOREFIELD (m)	RADIAL INFLUENCE (km)
End of Summer	146	1.3	1.5
End of Winter	365	0.4	0.6

The steady state effects of borefield performance can be assessed by comparing the abstraction rates with throughflow rates and rates of recharge under the pumping scenario.

Assuming that recharge rates during winter are generally about twenty percent of annual rainfall (900mm) or 180mm/yr, the potential yield of water would be no more than 180ML/km² per year. The total annual domestic water requirement of 1518ML/yr (Table 4) will be satisfied by harvesting recharge from about 10km².

Appendix G describes in detail the water balance and modelling studies undertaken to assess the above impacts of groundwater abstraction.

6.3.2.1 Potential Impacts on Lakes and Swamps

The area of low salinity groundwater that comprises the Waroona Mound, approximates 120km². This area has been extensively cleared, drained and developed for beef and dairy cattle production. As a result of this activity, only small areas of remnant wetland remain (Figure 16). The most significant of these is the Nine Mile Lake complex, located on the western edge of the Waroona Mound. This wetland habitat serves as a breeding area for at least twelve species of waterbird, and a summer refuge for many other species (Section 5.2.2.3).

The local and regional significance of these wetlands is recognised, and the results from the groundwater drawdown simulations presented in Table 17, will be used to locate the borefield to ensure that there are no adverse impacts on nearby lakes and swamps.

6.3.2.2 Localised Drawdown Effects on Pasture Productivity

Pasture productivity is greatest during the winter, and gradually diminishes with the onset of summer. Dewatering may reduce the growing period of pasture, however, this effect would be confined to a small area immediately surrounding each bore.

6.3.2.3 Land Use within the Borefield

It is proposed to locate production bores and associated pipeline easements along road verges, thus avoiding the need to alienate private land. It will, however, be necessary to ensure that land use activities practised within the groundwater catchment area do not lead to unacceptable changes in groundwater quality. The predominant land use activity in the region is presently low intensity agriculture, and this is regarded as being compatible with the maintenance of potable quality groundwater. Future land management policy will need to control the introduction of intensive agricultural activities in the region, such as piggeries and abbatoirs, which could result in unacceptable effluent discharges (Section 7.4).

6.3.2.4 Competition with Existing and Potential Groundwater Users

The Waroona Mound forms part of the Murray Groundwater Region. With the notable exception of Alcoa, located north of Pinjarra, this resource is mainly utilized for low intensity agricultural and horticultural practices. Water Authority records show that there are very few licenced bores in the Waroona Mound area, thus indicating that the existing competition for this resource is low. The likelihood of more intensive users establishing in the area is also low.

6.3.3 Impacts of Pumping from the Point Grey Surficial Aquifer

The surficial aquifer has been recognised as a limited groundwater supply source. It may be used to irrigate the golf course which would also provide the opportunity to recycle groundwater nutrients, thus minimising the nutrient outflow of the Estuary and fertiliser import to the golf course (and hence project site).

Groundwater levels will be maintained to ensure that an acceptable balance is maintained between abstraction rates and probable increases in recharge due to urbanization. The effect of potential groundwater changes on vegetation communities is discussed in Section 6.4.6.1.

6.3.4 Impacts of Pumping from the Leederville Formation

6.3.4.1 Saline Intrusion into the Leederville Aquifer

Within the vicinity of the Point Grey site, the Leederville Formation is expected to contain higher levels of salt to the northwest, and to be overlain by the more saline Osborne Formation.

Pumping at rates which may reverse the regional flow gradient to the southeast is expected to result in saline intrusion of the water supply. As a consequence it will be necessary to carefully monitor, model and manage the adopted supply scheme to ensure that the short and long term water quality is maintained.

6.3.4.2 Leakage from Overlying Aquifers

The overlying Quaternary sands in the vicinity of Point Grey are separated from the aquifer production zone by as much as 50m of interbedded claystones and sandstones of the Upper Leederville Formation. Consequently, abstraction of groundwater from the Leederville aquifer is not expected to have any impact on Lake Mealup or the associated water table.

6.3.4.3 Drawdown from Recharge Zone

The Upper Leederville aquifer subcrops southeast of the project site, and although the recharge zone co-incides with a chain of environmentally important wetlands, the regional drawdown effects of a groundwater abstraction programme at Point Grey are expected to have an insignificant effect on their water levels.

6.4 CONSERVATION RESERVES

Protection of the native flora and fauna is of prime importance on conservation reserves. These reserves are not designed to accommodate human activities, and such activities are generally excluded. Reserves designated for recreation or other purposes, may also have conservation value, and in these areas, management should encourage the retention of native vegetation and protection of fauna. It is for these reasons that the proposal seeks to designate the entire foreshore of Point Grey a reserve, to be managed in a manner to reflect ethnographic, conservation and recreation values. The proposed development has the potential to affect the flora, fauna and conservation values of reserves in the following manner:

- o fire,
- o introduced animals,
- o weed invasion,
- o vehicular or pedestrian traffic,
- o dieback disease,
- o groundwater drawdown,
- o excessive nutrient inputs, and
- illegal waste dumping.

Each of these impacts is examined in turn below, together with the potential impact on foreshore reserves that may result from the construction of the Dawesville Channel.

6.4.1 Fire

Fire is perhaps the most likely agent to affect the conservation value of reserves. At present, there is a risk that fires originating on agricultural land as a result of farming activities or campers, will spread to the surrounding reserves. This risk is enhanced during the summer by the presence of dry pasture on agricultural land, the need to operate equipment which may initiate fires over this land, and the sparse population of the site which makes detection and suppression of fires difficult. Campers, shooters and amateur fishermen may also leave camp fires burning and these have often been the source of wild fires (Letchford, pers. comm.).

Existing fire breaks appear to have been generally well maintained by both the land holder and/or the reserve vesting authority. The existing farm manager is acutely aware of the risks of fire and maintains a fully operational fire fighting unit on standby. These measures can reduce the risk of fire, however, they cannot eliminate it.

Although there is evidence of fires and their deleterious after-effects in the area (Brown, 1980), the native vegetation remaining in the Point Grey area appears to be in good condition. Fires are of course a natural component of the natural ecosystems of the Swan Coastal Plain (Seddon, 1972) and the native biota will recover successfully from fire provided it is not excessively frequent. This is recognised by CALM who presently burn reserves in the area and the foreshore margins on about a 3 to 10 year rotation (Lowe, pers. comm.).

The introduction of 9000 residents into the project area over 50 years, as well as an annual influx of tourists and day trippers, can be expected to increase the fire risk. Alternatively, introduction of extra firebreaks and the presence of more people to detect and suppress fires, will tend to reduce the spread of fire, as will the replacement of pasture with roads, houses and gardens and provision of reticulated water supplies. Provision of more formalised holiday accommodation in caravan parks and camping grounds will also tend to diminish the opportunity for camp fires to escape. Fires may also be started within reserves and spread to adjoining properties. This will eventually require management.

Overall, the frequency of fires is unlikely to increase as a result of the development. Appropriate control measures will, however, be required, and these are described in Section 7.2.1.

6.4.2 Introduced Plants

Exotic pasture species and weeds common to pastures are already widely distributed in the Point Grey area. Areas that are disturbed as a result of the development will be prone to weed invasion, e.g. couch grass (<u>Cynodon dactylon</u>). This may increase the fire risk along road verges and areas prone to continual disturbance. Weeds may also be introduced into conservation reserves where frequent or permanent disturbance to the native vegetation occurs.

The overall impact of introduced plants on conservation reserves is unlikely to be significant since the reserves at Mealup Point and Carrabungup are adjoined by large leisure living lots where only building envelopes may be cleared. Firebreak clearing around these reserves has already occurred.

6.4.3 Introduced Animals

Animals introduced as pets have the potential to affect the native fauna. Cats and dogs are of principal concern as they may kill birds and other small animals, or disturb birds that are roosting or nesting. The increase in population has the potential to markedly increase the number of domestic dogs and cats kept as pets. The small conservation reserves immediately adjacent to populated areas are most likely to be at risk. The largest and most important conservation reserves located near to the development site (west of Peel Inlet and south of Harvey Estuary) are not likely to be markedly affected by domestic animals because of their size and remoteness from the high population areas.

There is the potential for some increase in the number of feral animals, as a result of escapes or releases from domestic control. However, only about 5% of abandoned cats are believed to succeed as feral animals (Muir, pers. comm.).

Birds feeding on the waterways or far out on the flats are not likely to suffer significant disruption by dogs. Birds roosting along the shore could be more vulnerable and may require protection.

Town planning control (Section 13.0) will be used to prohibit residents keeping stock (including horses) on Point Grey because of the potential damage that could occur on conservation reserves if the stock escaped.

6.4.4 Dieback

Dieback disease (<u>Phytophthora</u> cinnamomi) has not been positively identified on reserves immediately adjacent to the development, but it is present in the district (Towers, pers comm.).

Dieback symptoms have also been noted on the site. Vegetation units with susceptible species, such as those from the family Proteaceae, are vulnerable to the introduction or spread of the disease by soil disturbance, new introductions from earthmoving equipment or by increases in the extent and duration of soil saturation. Fortunately, the free draining soils on the site are not prone to overland flow or prolonged saturation. Attention to the operation of earthmoving equipment and adequate consideration of the need for drainage will be required to control dieback disease.

6.4.5 Traffic

The increased population has the potential to increase vehicular and pedestrian traffic in conservation reserves. Vehicular traffic can disturb native vegetation either directly by physical impact or indirectly by the introduction of dieback or fire. Such disturbance may also initiate erosion, leading to further disturbance. Intensive foot traffic may lead to trampling. Suitable control of pedestrian access will be required to restrict entry to sensitive areas and direct traffic to designated, resilient access points.

No formalised access for either vehicular or pedestrian traffic will be provided to conservation reserves. The Proponent will liaise and co-operate with CALM in regard to management plans designed to close off existing informal access. In recognition of the need to limit access to the Mealup Point reserve, the southern-most access road spur has been relocated eastwards, away from the reserve boundary.

Although the project will result in an increased population in the area, the development has been designed to prevent formal access to conservation reserves so that direct impact from the development is unlikely.

6.4.6 Groundwater Changes

Groundwater levels fluctuate naturally under the influence of the annual rainfall and evaporation cycle. Native flora and fauna are adapted to this cycle and the consequent fluctuations. Longer term droughts and floods also occur naturally. Prolonged changes to groundwater levels may, however, lead to shifts in the suite of plant and animal species occupying a site.

6.4.6.1 Surficial Aquifer - Point Grey

Proposals to develop a groundwater supply for domestic use and irrigation purposes at Point Grey could influence these natural fluctuations, however, it is unlikely that vegetation communities within the foreshore reserves or in the elevated areas of the project site will be adversely affected. The reasons for this are as follows:

- o the surficial aquifer reaches its greatest thickness under the central north northwest/south south-east trending ridge that bisects the project area (Figure 4). Any reduction in water level due to groundwater abstraction or increase due to urbanization, will be greatest at this point and least near the foreshore reserves,
- o the surficial aquifer is highly transmissive Tamala limestone. Any rainfall recharge flows quickly through the sub-surface and outwards to the Estuary. This has the effect of creating a groundwater level that does not fluctuate widely and whose surface remains essentially horizontal, and

it is proposed to utilize the surficial aquifer as a source of water for the golf course. This will also provide a means of recycling groundwater nutrients (Sections 7.3 and 7.4). As part of this programme, water levels will be regularly monitored, thus providing an additional means of ensuring that any increases in groundwater recharge that may result from urbanization can be balanced by groundwater abstraction programmes (Section 7.4).

The Point Grey development site is almost entirely outside the catchment of Lake Mealup and therefore, no effects on the hydrology of this wetland system are expected.

Reserves at Carrabungup, Stony Point and Mealup Point are likely to be independent of groundwater accumulating elsewhere on the Point Grey site. Carrabungup Reserve does not receive flow from the site and the other two reserves are local high points over limestone. Vegetation growing over limestone is generally independent of the water table (Mattiske, 1986). It is possible that flows emerging near the shoreline help to sustain the thicket vegetation in the reserves but these are not expected to be affected by the development.

6.4.6.2 Surficial Aquifer - Waroona Mound

The major water source for the project will be the Waroona Mound, south east of Point Grey. The only reserve that lies within this area is Nine Mile Lake. Detailed groundwater drawdown simulations have been performed to ensure that the water levels in this reserve will be unaffected by the project (Section 6.3.2).

6.4.6.3 Leederville Formation

Abstraction of groundwater from the deep artesian Leederville Formation will not affect either the Point Grey or Waroona Mound surficial aquifers and hence, shallow wetlands or dependent vegetation will be unaffected.

6.4.7 Nutrient Inputs

Nutrients derived from garden fertilisers or septic tank disposal systems can affect the water quality of nearby swamps and lakes. In the case of the Point Grey development, it is not expected that Lake Mealup will be affected.

A number of measures have been incorporated into the design of the project to ensure that any nutrients originating from the development site do not pass through to the lake. For example, the road in the southern region of the property has been realigned outside the Lake Mealup catchment, thus eliminating the possibility of stormwater flow reaching the lake.

In addition, the dwelling density in the southern portion of the development will be restricted to less than one lot per hectare, and any nutrients generated from septic tank systems or garden fertilisers will flow away from Lake Mealup because of the configuration of the catchment boundary.

It is also noted that Lake Mealup is over 500m from the nearest boundary of the development site, and that existing agricultural activities located immediately north of Lake Mealup and outside the Proponent's property boundary, are more likely to influence long term nutrient levels in Lake Mealup.

6.4.8 Rubbish Dumping

Illegal rubbish dumping is sometimes a problem on reserves. A regular, formalised collection service with provision for removal of garden refuse, will eliminate the need for illegal dumping, and adverse impacts from this source are not likely.

6.4.9 Dawesville Channel

Hodgkin et al. (1985) have estimated that the Dawesville Channel would result in an increase in tidal height of about 0.2m. In low-lying foreshore margins, this increase in tidal height will result in greater areas of land being periodically inundated.

At Point Grey, this would probably only be noticeable along the eastern foreshore near Robert Bay. The remaining sections of the foreshore are generally too steep for a 0.2m rise in water level to adversely affect the foreshore reserves, either through inundation or erosion. In most cases, the width of foreshore reserve at Point Grey exceeds 50m, and therefore any loss of land that may result from the increased tidal range will still leave a foreshore margin greater than that recommended by PIMA.

6.4.10 Summary of Impacts on Reserves

There are already a number of problems relating to fire, rubbish and weed introductions on conservation reserves, due to their present use by duck shooters, campers and fishermen. The proposed development will create new opportunities for formalised access to Point Grey. This will provide the opportunity to reduce the existing population pressure on conservation reserves which are not designed for human use, and this will allow greater protection of flora and fauna. The management of these impacts is discussed in Section 7.

6.5 ESTUARINE FISH RESOURCES

6.5.1 Amateur Fishing

The proposed development at Point Grey has made provision for four boat launching sites: three on the western foreshore, to provide access to the Harvey Estuary, and one on the eastern foreshore, providing access to Robert Bay (Figure 2).

These sites will enable the construction of boat ramps and associated car parks that will facilitate access to the Peel-Harvey Estuary for people living on Point Grey, as well as provide an important alternative for people living in areas east of the Estuary, for example, Pinjarra, Ravenswood and Waroona. At present, there are no boat launching facilities along the foreshore extending south from Yunderup Canals, along the southern shores of Peel Inlet, the eastern foreshore of Harvey Estuary, and northwards along the western foreshore to Dawesville.

During the summer holiday period, congestion at the existing launching facilities concentrated near Mandurah, can be considerable (Schwinghammer, 1978). This congestion has been recognised by PIMA in their Peel Inlet Management Programme, which advocates additional boat ramps for vessels up to 5m in length. New boat launching facilities at Point Grey conforming with this policy would help relieve the pressure on the existing ramps, as well as help spread the amateur fishing load more evenly throughout the Estuary. Thus the proposed project will provide a positive benefit to the amateur fishing industry. The improved access to the southern regions of Peel Inlet and the northern waters of Harvey Estuary, will probably mean that amateurs will fish areas normally worked by the professionals. This may represent an area of potential conflict, however, the significance of this competition is likely to be minimal because amateurs will generally fish for table species such as cobbler, whiting and herring, whereas the professional fishermen concentrate on netting bait fish such as yellow eye mullet. Competition between amateurs and professionals for crustaceans such as crabs and prawns may represent a greater potential problem, but this is likely to be a regional problem associated with the general urban development of the Mandurah/Pinjarra region, and not a problem that is specifically associated with the project. In the long term, it is likely that professional fishing within the Estuary will be phased out to accommodate the increased demand from amateur fishing.

6.5.2 Professional Fishing

Professional fishermen operating within the Estuary have traditionally worked either within the Harvey Estuary or within Peel Inlet. The percentage of fishermen working both water bodies, was small. This is no longer the case because the Harvey Estuary fishermen have had to re-direct their effort into the Peel Inlet to avoid the excessive blooms of <u>Nodularia</u> that clog their nets and reputedly reduce fish numbers. This trend is seasonal and generally occurs during spring and summer. Improved access to the Peel Inlet from Point Grey may assist those professionals who live on the eastern side of the Estuary by providing them with additional flexibility in fishing waters less affected by algae.

6.6 BOATING FACILITIES

The establishment of boating facilities at Point Grey would result in three forms of environmental impact; the first relates to foreshores, the second relates to dredging impacts, and the third relates to the social effects that will result from increased access to the eastern shores of the Estuary. Each potential impact is discussed below.

6.6.1 Foreshores

The provision of car parks and boat ramps will require some earthworks and the removal of small areas of undergrowth. The removal of large trees should be avoided where possible. The car park design should ensure that direct rainfall runoff to the Estuary will be minimised. Post and rail fencing is recommended to prevent vehicle movement beyond the car park area, except at boat ramp sites. Litter bins will be provided and a collection service carried out as part of the Shire's normal duties. Foreshore vegetation (particularly sedges) will be maintained to protect the foreshore against any erosion that may result from wash arising from boating activities.

6.6.2 Dredging

Dredging would be required at each site and potential impacts will relate to excavation operations and the disposal of spoil. The following discussion considers the impacts under two scenarios: one without the Dawesville Channel and the other with the Channel.

6.6.2.1 Without the Dawesville Channel

Dredging operations with the present tidal regime will require excavations to a depth of -1.0m chart datum. Preliminary geotechnical investigations have indicated that at Sites 1, 2, and 3, the depth to limestone exceeds 2.0m below the mudline (Figure 2). Surface sediments comprise loose sand and soft clays. At Site 4, outcrops of limestone do occur, however, hand probing suggests that a suitable channel route could be established.

The unconsolidated sediments present at most sites will allow the use of a cutter suction dredge mounted on a pontoon. At Site 4, however, excavation may require the use of blasting or heavier excavation equipment.

The width of the channels is expected to be approximately 25m. The channel lengths will vary as will the volumes of spoil excavated from each site (Table 18). Dredge spoil will be deposited at sites selected in consultation with PIMA and the Department of Marine and Harbours. Dredge spoil could be used to form islands and spits in order to protect facilities from the prevailing winds and to provide additional roosting sites for waterbirds.

Alternatively, spoil could also be used onshore as fill for car parking areas and roadways.

The channels that would be required to provide access to deeper water will disturb small areas of shallow water benthos and may inadvertantly pass through fish nursery grounds. The impact on these habitats is insignificant when viewed in the context of the overall Peel-Harvey Estuary system, because of the small areas involved. The total area likely to be disturbed is 5ha, which represents about 0.006% of the Estuary's total intertidal and shallow sub-tidal (<1.0m) area. This estimate assumes that the surface area of the Peel-Harvey Estuary is 130km² (Hodgkin and Birch, 1986) and that approximately two thirds, or 86km², is less than 1m deep.

TABLE 18

PROPOSED BOAT LAUNCHING SITES			
SITE	VOLUME	LENGTH	
	$(10^{3}m^{3})$	(m)	
1	14	550	
2	15	600	
3	12	400	
4	16	600	

DREDGING VOLUMES AND CHANNEL LENGTHS -PROPOSED BOAT LAUNCHING SITES

6.6.2.2 With Dawesville Channel

The results of modelling studies designed to predict the effects of a channel at Dawesville on water levels in the Estuary have been summarized by Hodgkin et al. (1985). They indicate that the range of astronomic tides within the Channel will increase from 0.11m to a maximum of about 0.35m (Table 19). The actual change in water level experienced in any one day will occasionally be greater than this because of the combined effects of daily tides, long period changes and meteorological influences.

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TABLE 19

	RANGE AT DA	WESVILLE (m)
OCEAN RANGE (m)	WITHOUT DAWESVILLE CHANNEL	WITH DAWESVILLE CHANNEL
0,85	0.11	0.35
0.7	0.08	0.30
0.3	0.06	0.15

EXAMPLES OF PRESENT AND PREDICTED DAILY TIDAL RANGES

Source: Hodgkin et al. 1985

The increase in daily tidal range will have the effect of increasing the height to which water will normally rise and lowering the level to which it would normally fall, by approximately 0.2m (Hodgkin et al. 1985). The low lying areas of Point Grey near Robert Bay may, therefore, be subject to slightly greater periods of flooding. Elsewhere along the Point Grey foreshore, the margins are too steep for there to be much effect.

The predicted hydrological changes may affect the construction and operation of the boating facilities. Present proposals allow for excavation of channels to a depth of -1.0m chart datum. The increased tidal range may restrict access during low tide, and this may require the channels to be excavated an additional 0.5m. This will result in greater quantities of spoil which will be disposed of in the manner previously described.

The use of dredging spoil for bird roosting sites will be of particular importance if the Dawesville Channel is constructed because areas presently used by water birds will be flooded more frequently as a result of the predicted increases in tidal range.

6.6.3 Boating Pressure

Boating access to the Peel-Harvey Estuary will be greatly improved, especially for people living on the eastern side of the water body, or those living elsewhere that want access to the Harvey Estuary or the southern regions of Peel Inlet. The facilities will also ease the pressure on other boat launching ramps located near the more populated regions such as Mandurah. If the Dawesville Channel is constructed, the facilities will allow residents and nonresidents of Point Grey easy access to the Indian Ocean. Similarly, if the Channel is constructed, the boating activity near Dawesville will undoubtedly increase, and Point Grey will represent an easily accessible launching and recreation alternative. It will also represent a convenient visiting location for people travelling through the Dawesville Channel and onwards to the Murray and Serpentine Rivers.

The existing use of the Estuary by boat users has been described in Section 5.3.3. The proposed development will naturally attract people eager to own land near a large, protected expanse of water such as the Peel-Harvey Estuary, so an increase in the number of boats can be expected.

The increased boating population expected to utilize the Estuary is likely to occur as a natural function of the normal population growth of the Perth and Mandurah-Pinjarra region. The proposed Point Grey development will help to decentralize this growth and minimize the congestion which presently occurs at existing boat launching facilities during peak holiday periods, as described above. This aspect of the project therefore represents a positive benefit to the community.

In summary, the provision of boating sites and the development of associated car parking facilities will cause minimum environmental disturbance to foreshore regions and the shallow water benthic environment. Positive benefits that will result include improved access to the Estuary, a means of relieving boat launching pressure that periodically occurs at facilities located near Mandurah and the Murray River, and additional waterbird roosting sites.

6.7 SOLID WASTE DISPOSAL

Waste disposal will be controlled by the Shire of Murray, using an existing site located well away from the Peel-Harvey Estuary. The proposed Point Grey development will have the effect of shortening the life of this facility to about 7 to 10years. Under an agreement between the Proponent and the Shire of Murray, the Proponent will provide funds to enable the Shire to select and purchase an alternative waste disposal site well before the capacity of the existing site is reached.

Any new site would comply with the requirements of the Health Department, the Water Authority and the Shire. Any new site is likely to be located on relatively impermeable soils, towards the Darling Scarp, and thus far enough away to have no environmental effect on the immediately surrounding community, the Point Grey site or the Estuary.

6.8 FORESHORE AREAS

A continuous belt of foreshore reserve, at least 50m wide, will be established around the Point Grey peninsula. This will link up existing foreshore reserves, conservation reserves and recreation reserves. No commercial developments are proposed on the foreshore reserve, and recreation facilities such as boat ramps would be for the benefit of the general public. Any recreation amenities proposed for land associated with the traditional Aboriginal camping place, would be required to be developed in accordance with the requirements of the Western Australian Aboriginal Heritage Act, 1972 - 1980.

Usage of the foreshore reserves can be categorised under the headings of boating, fishing and recreation, and each is discussed below.

6.8.1 Boating

Potential environmental impacts on foreshore reserves are likely to arise as a result of the physical disturbance to the foreshore caused by the development of boating facilities (e.g. ramps, car parks), by increased human acitivity (e.g. vegetation trampling, litter, fire, etc), or by wash resulting from the boats themselves. These issues have been discussed in Section 6.6, where it was stated that the potential impacts would be minimised by carefully selecting sites to avoid the unnecessary disturbances to vegetation, and by incorporating car park design measures that would minimise erosion and direct runoff to the Estuary.

Facilities will be preferentially located away from important waterbird sites. A minimum separation of 50m will be maintained from important waterbird roosting sites.

6.8.2 Fishing

The main usage of foreshores is likely to be for crabbing and prawning. These are traditional recreational activities in the Peel-Harvey Estuary. Formalised access to the foreshore and car parking will be provided at boat launching sites. Access beyond these areas will be discouraged by locating service roads away from the foreshore. The other main impacts anticipated from fishing activities are likely to be from litter and cooking fires. Rubbish bins will be provided and serviced at formal access points by the relevant authorities. Barbeque/crab cooking sites may also be provided. The Proponent will liaise with the necessary authorities regarding the proper control of fishing activities and provision of facilities (e.g. PIMA, CALM, Shire of Murray). Provided access points are correctly located, adequate litter collection services are provided, and fires are lit in the designated places, no unacceptable impacts on foreshore areas due to fishing are anticipated. Current problems with informal access by crabbing parties and initiation of uncontrolled fires will probably diminish as a result of the development.

6.8.3 Recreation Areas

Other recreational activities such as walking, wading, picnicking and windsurfing will also revolve around formal access points. None of these activities is likely to have significant impact, other than those already identified on foreshore areas. Hence the control measures mentioned above should be adequate.

6.9 IMPACTS OF THE ESTUARY ON THE DEVELOPMENT

The eutrophic condition of the Estuary has manifested itself in a variety of ways, with perhaps the most socially important being the accumulation and subsequent decomposition of algae and the generation of offensive odours. These odours occur after the collapse of seasonal algal blooms, and are most offensive during late summer and early autumn. The effect is most pronounced in areas down wind from the major points of accumulation which are largely influenced by prevailing winds. These locations generally occur along the northwestern, northern and northeastern margins of the Peel Inlet in response to the southeasterly/southwesterly wind regime which typically exists during late summer. These areas are immediately adjacent to the most populated region of the Peel-Harvey Estuary and this accounts for the high level of social concern associated with the algal "problem".

The relative remoteness of Point Grey has meant that the extent to which large masses of algae accumulate in the shallow water margins along this section of the foreshore, is not well documented. The only quantitative data routinely collected in the vicinity of this area is performed by the Centre for Water Research at the University of Western Australia. These data indicate that biomass accumulations near Point Grey are consistently lower than at sampling sites located in the north of Peel Inlet, thereby tending to confirm the effects of wind outlined above and described in detail in Section 5.2.1.3. The State Government is committed to resolving the weed "problem" and improving the overall water quality in the Estuary (Section 5.3.4). It is recognised that it may be five to ten years before the effects of any management strategy result in a significant improvement, during which time, the "social cost" of previous land use activities in the Peel-Harvey Estuary catchment will have to be borne by existing or potential residents of the region.

Under existing conditions, Point Grey is probably located in one of the most favourable positions on the Estuary foreshore. There are two reasons for this, and both are related to wind. The first is that the wind regime does not favour the build-up of large quantities of algae on the foreshore at Point Grey (Section 5.3.2.4). The second is that the prevailing morning wind direction during the late summer is from the southeast (Section 5.2.1.3), and is therefore a land breeze that will not bear offensive odours. During the afternoons, winds will generally pass over the Harvey Estuary before reaching the proposed development site. These winds may be unpleasant in terms of odour, but the effect will be minimal compared with, say Mandurah, because of the relatively narrow expanse of water west of Point Grey over which the wind travels.

During periods of algal blooms, recreation activities in the vicinity of Point Grey will be affected, despite the locational advantages described above; these occurrences will be seasonal, and should be regarded a regional issue as opposed to one resulting directly from the proposed project.

One of the possible management strategies for the Estuary involves the construction of the Dawesville Channel, connecting the Estuary and the Indian Ocean to the west of the Point Grey Peninsula.

If the Channel is constructed, it is predicted that there will be a short term increase in macro-algal biomass in the Peel Inlet and possibly further south in the Harvey Estuary (Hillman, 1986). Therefore, in the short term, macro-algae may replace blue-green species such as <u>Nodularia</u>, as the major nuisance species responsibile for disrupting fishing activities and generating offensive odours. If this occurs, the Point Grey site will become an even more desirable location compared with alternative sites situated along the Estuary foreshore for two reasons.

Firstly, the site will continue to be favoured because of the prevailing wind direction and the influence of this pattern on weed accumulation zones. Secondly, the Dawesville Channel will considerably increase the rate of exchange of water between the Ocean and the Peel-Harvey Estuary, especially near Point Grey which is almost directly opposite the proposed channel location.

Water exchange between the Ocean and the Estuary is presently greatest near the entrance to the "Sticks Channel". Summer maximum water residence times at this site has been estimated at 5.6 weeks, with the winter minimum being 1.4 weeks (Hodgkin et al. 1980). Equivalent estimates for the Harvey Estuary (opposite Mealup Point) are 12.5 and 2.4 weeks, for the southern Harvey Estuary 6.3 and 2.3 weeks and for Robert Bay 7.1 and 2.0 weeks. A channel at Dawesville will greatly reduce these residence periods, especially at the three locations described above, which all occur near Point Grey.

Thus the overall water quality in the vicinity of Point Grey will be as good as, and probably substantially better than, other locations throughout the Estuary. In the longer term, it is expected that the nutrient stores presently bound by the sediments will decline and the entire system will become more marine. If this happens, the problems caused by the offensive odours will presumably diminish, as will the relative advantage of the Point Grey site compared with alternative population centres sited along the foreshore.

Another factor that is partially related to the Estuary and has the potential to impact on the future residents at Point Grey is the presence of mosquitoes. As with algae, mosquitoes are a regional problem that is best documented in populated areas. Thus the extent of the problem at Point Grey is largely unknown, although some circumstantial evidence is available which suggests that the close proximity of extensive areas of suitable breeding habitats may require the implementation of mosquito control techniques. Various management options are discussed in Section 7.8.

In summary, the potential impact of the Estuary on the development relates mainly to offensive smells generated by decaying algae. These impacts will cause temporary loss of amenity and a restriction in some water-based recreation activities. These problems are likely to be significantly less at Point Grey than elsewhere along the Estuary foreshore because the prevailing winds that occur during summer and early autumn do not appear to favour the accumulation of large quantities of algae on the Point Grey foreshore. Furthermore, Point Grey is not downwind from areas prone to large accumulations of weed, as are the settlements at Falcon, Coodanup and Mandurah. If the Dawesville Channel is constructed, water exchange rates will be greater near Point Grey than locations further away from the Channel site, thereby further favouring the proposed development site.

6.10 SOCIOLOGICAL IMPACTS

6.10.1 General

The population growth for the Shires of Mandurah, Waroona and Murray are 4.2, 2.4 and 2.2 times greater respectively, than the statewide average, creating demand for residential land (Section 5.5). These population trends are supported by the number of housing commencements for the Mandurah, Murray and Waroona Shires, which, in the case of Mandurah, is 50% higher than the City of Bunbury, despite Bunbury's higher population (Feilman Planning Consultants, 1987).

In addition to these natural growth trends, at least three industrial development projects are envisaged for the Shire of Murray; these are the Rhône-Poulenc gallium and rare earth plants, and the Agnew-Clough charcoal producing plant (see Section 5.5.2).

Residential growth options within the Shire of Murray are limited, particularly the provision of quality, elevated residential land, adjoining the shores of the Peel Inlet and Harvey Estuary.

Growth pressures on other parts of the Shire where land is less suited to residential development (i.e. along the Murray River, where the flood plain constrains existing developments, or along the shores of the Peel Inlet, where major conservation reserves have been nominated) will be eased with the development of Point Grey. The introduction of elevated, residential land into the market place may attract additional growth into the Shire of Murray.

The project will introduce a viable regional alternative to Mandurah as a place to live, and thus it will compete in the regional market place for land sales. The proposed staging of the project has, however, been geared at a low rate, taking into account projected population growth rates. It is proposed to create yearly stages of 100 lots with the anticipated dwelling development rate being 40% to 45%. In the short term, the bulk of shopping needs for the community at Point Grey are likely to be satisfied in Mandurah and to a lesser degree Pinjarra. As the project develops however, and the proposed District Shopping Centre at Point Grey is established, reliance on those other centres will reduce.

As previously outlined, Thomas Peel College is to be established as a privately funded, self contained education establishment, independent of State or Commonwealth resources. It is currently proposed that the College will accommodate primarily overseas students from Asia and Europe. Selected students will be admitted to enter Australia on Study Visas which will be valid only while they are attending courses at the College. Courses are designed to be extremely intensive and from 10 to 40 weeks in duration.

In making the financial commitment to fund the training of the students overseas, parent concern has been expressed at the need for discipline and the creation of an environment conducive to learning - preferably divorced from the distractions of city living. These aspects reflected upon the decision to select and develop a site within the Point Grey area.

Guidelines for setting up the College have taken into account the question of discipline. Students will be regulated to ensure acceptable discipline levels are achieved. Unruly or disruptive students will be confronted with the options of conforming or being expelled from the College and thus having their visa cancelled. If needed, this behavioural discipline measure provides the College with a significant control mechansim - the threat of being sent home is a significant deterrent to overseas students.

Knowledge, experience and ability to handle and work with overseas students will be primary considerations when selecting staff for the College.

It is planned that specially selected counselling, welfare and medical staff will complement the normal teaching staff at the College to assist students in assimilating into the student life for the duration of their stay.

The live-in nature of the College, with supporting counselling staff, will assist in minimising the normal problems experienced by overseas students, such as loneliness, cultural change, adaption to living independently, managing a budget and generally looking after themselves in a different environment.

The College students will be both male and female. Although participating in intensive studies, they will naturally not be restricted to the College for the total duration of the courses. Working excursions and visits, utilisation of limited weekend free time, and interaction with the local community will be encouraged. It is envisaged that specific programmes involving cultural, sporting and artistic exchange will be developed, with local community groups being invited and encouraged to participate.

Transport facilities will be arranged by the College to cater for students without private transport. Visits to the region's attractions and Perth will be arranged during the students' limited free time.

It is anticipated that Perth will be the primary destination for students during their major free time periods, such as weekends. Mandurah and to a lesser degree Pinjarra, in the early years of the Point Grey development, will also attract students during free time, because of their close proximity.

Contact between students and the local community is likely to take place more through controlled formal arrangements organised by the College rather than through informal contact. The intensive nature of courses at the College, combined with the limited free time available and likely low level of private transport, will considerably reduce informal contact opportunities.

All student accommodation will be provided as part of the Thomas Peel College complex and pressure on rental accommodation in the region will not occur. Sporting and recreational facilities will be provided as part of the College complex, thus existing and proposed community sporting and recreation facilities will not be placed under pressure.

The administrative and counselling services provided at the College will constantly monitor community attitude and student/community contact. This will assist in ensuring that the impact of students on adjoining communities will be positive and welcomed.

It is felt that many benefits will be derived by the local community through cultural, sport and artistic exchange programmes with College students.

The College and its students will not have any impact upon existing Government and non-Government schools in the region. Although projected at students from the Asian and European region, the College will be open to all fee-paying students. Consideration is currently being given to awarding a limited number of scholarships to members of disadvantaged groups in the State.

Considerable benefits will accrue to the community within the region by the creation of additional employment in the service sector. Many of these jobs will be suitable for school leavers and married women. The project will not result in additional competition for jobs in the region; it will actually create new jobs.

Because the level of car ownership is expected to be low, traffic generation from the College is expected to be low and consequently, traffic congestion problems are not anticipated.

6.10.2 Economic Benefits

6.10.2.1 Employment and Expenditure

Thomas Peel College

The Thomas Peel College will cost in excess of \$50 million in capital expenditure, resulting in considerable economic benefit for Western Australia. It is currently estimated that the project will generate a construction workforce peaking at about 430.

Preliminary investigations indicate that it is likely that approximately 40% of the construction workforce will be drawn from the Pinjarra/Mandurah/Rockingham region, 10% from Bunbury and the South-West, with the remainder coming from the Perth Metropolitan area.

Once completed, the College will generate employment opportunities for approximately 80 full time teaching and administration staff, and service employees, including: cleaning, maintenance, landscaping/gardening, security and kitchen staff.

In addition to the employment opportunities listed above, a considerable multiplier effect will be created by the demand for servicing facilities. These include:

- o food and beverage supplies the College, which will incorporate kitchen and canteen facilities on-site, will generate demand for in excess of 3000 meals daily,
- school consumables stationery supplies, printing, supply of newspapers and magazines,
- building and ground maintenance supplies equipment servicing (air conditioning, heaters, computers, etc.),
- o laundry services for 1000 beds plus associated towel and other linen supplies, and
- o fuel supplies.

The employment opportunities generated by the demand for services listed above will, in many cases, be adequately served by businesses located within the Pinjarra/Mandurah region.

The College will also generate considerable demand for convenience shopping, thus creating a catalyst for development of a small shopping centre on-site. This facility will also service the proposed adjoining residential area and holiday/tourist sites. In addition, expenditure on convenience goods and entertainment could be expected to flow into Pinjarra and Mandurah.

It is expected that a high percentage of the College staff will build and live at Point Grey, thus creating additional job opportunities in the housing construction area.

Subdivision Construction Phase

Development of the subdivisions will take place in stages over a projected period of 30 years at an estimated cost of \$37 million. Work opportunities in many construction and associated fields will be created including:

- o earthworks,
- o road construction,
 - sewer and water installation,
 - o material supplies,
 - o surveying, and
- o landscaping.

Contractors in the region will be afforded the opportunity to submit tenders to carry out these works. Opportunities to expand the permanent workforce within the region will therefore result. The Point Grey project currently provides for up to four boat launching sites with associated parking and back-up facilities. The sites for these facilities will be provided at no cost to the community.

Provision of Foreshore and other Reserves

Approximately 70ha of reserved land is to be ceded free of cost to the Crown for the benefit of the general public.

The new reserves will compliment existing reserves, forming a continuous band of publicly owned land around the Point Grey peninsula. Continuation of existing farm operations would deny the general public access to these foreshore areas unless land was resumed at public cost.

6.10.2.2 Foreign Exchange and Tourism

The College will make a valuable contribution to the country's foreign exchange earnings. Market research indicates that there is significant demand for education in Australia from people who live in Asia and Europe. Preliminary feasibility studies indicate that foreign exchange earnings in excess of \$15 million can be expected to be generated from fees and accommodation. This figure will be inflated by additional spending by students on day-to-day needs such as clothing and entertainment etc. Provision has been made for lodge accommodation for visiting parents, so this group can also be expected to provide foreign exchange. Other international tourists, while difficult to quantify, will be a target market for the tourism facilities at Point Grey, and they will also contribute to foreign exchange earnings.

6.10.3 Access

Road access to the site will be via Greenlands, Carrabungup and Edges Roads. Traffic flow along these roads will increase as a result of the project, both during the construction period for the College and the development of the residential and tourist components of the project. The existing road access will be upgraded to accommodate the anticipated traffic growth, ultimately providing access to the proposed Perth - Bunbury Highway (see Section 4.8.2).

As part of the development of Point Grey, project roadworks will be provided. The new roadworks will not only be of benefit to new residents within the Point Grey project area, but will also provide an improved facility for existing rural residents in the area. All of the new subdivision roads, plus the initial upgrading of the access road to Point Grey from Pinjarra, will be provided at no cost to the community.

6.10,4 Landscape Aesthetics

Retention of the natural environment is an integral component of the Point Grey concept (Dames & Moore, 1986) and wherever possible existing vegetation will be retained.

Comparison of the existing distribution of vegetation (Frontispiece) with the proposed development (Figure 2) shows that most vegetation will indeed be retained, especially around the foreshores. Detailed site plans will be developed and selected areas of individual trees and vegetation within each development zone, will be marked for retention by the contractors. Point Grey will remain as an aesthetic backdrop to views across the Harvey Estuary and the Peel Inlet. This is consistent with the objective expressed in the Mandurah and Districts Planning Study (Town Planning Department, 1984). Substantial areas of landscaping and tree planting will occur, especially within the largely cleared northern portion of the property. Planting of native species to blend with the local landscape and to conserve water resources, will occur around the Thomas Peel College, and this theme will be encouraged throughout the development. The College itself will be designed consistent with this philosophy.

Significant deleterious impacts on the aesthetic environment are not anticipated as a consequence of the Point Grey development.

6.10.5 Summary

A Summary of Potential Environmental Impacts is presented in Table 20.

TABLE 20

SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS

POTENTIAL IMPACTS	LIKELY DURATION	SIGNIFICANCE	MANAGEMENT POLICY
Nutrients	Ongoing	High	 phase out agricultural practices minimise net fertiliser impact to the site by utilising tertiary sewage effluent, varying fertiliser application rates to conform with soil requirements and encouraging the use of nature plant species containing storm water runoff restricting the number of septic tank units.
Water Supply	Ongoing	High	 Prohibit the private use of the Point Grey surficial aquifer locate bore field and define abstraction rates to ensure that natural habitats are not influenced by local drawdown effects initiate an exploration programme to prove up the Leederville Formation resource.
Conservation Reserves	Ongoing	Medium	 Initiate the creation of a continuous foreshore reserve; retain vegetation and protect fauna initiate first order management measures define access and tourist sites, foreshore reserve widths and locate launching sites in accordance with the conservation value of reserves construct and maintain fire breaks prevent the introduction of dieback control groundwater abstraction rates to minimize effects on local vegetation communities.
Boating Facilities	Medium Term	Low	 Confine sites to resilient, suitably fortified locations, close to relatively deep water to minimize potential disturbance caused by dredging provide controlled access, including car parks, rubbish disposal facilities, etc.
Local Algal Accumulations	Medium Term	High	 Monitor accumulations and liaise with PIMA, EPA and Marine and Harbours to determine most effective means of minimizing the problem.
Sociological			
(i) Ethnography	Short Term	Low	 Maintain contact with relevant aboriginal groups and the relevant authority with whom the aboriginal site is vested.
(ii) Thomas Peel College	Ongoing	Low	 Provide social counciling, Welfare and medical facilities within the College.
Dieback	Ongoing	Medium	o Adopt standard hygiene practices.
Fire	Medium	Medium	 Construct and maintain fire breaks, provide a fully – equipped fire fighting unit and provide educational literature highlighting risks of fires.
Mosquitoes	Ongoing	High	o Monitor the extent of the prblem during the College construction phase of the project and liaise with relevant local authorities, PIMA and the Department of Health to determine the most appropriate control measures for the region.
7.0 ENVIRONMENTAL MANAGEMENT

7.1 MANAGEMENT PHILOSOPHY

The proposed development has been conceived and designed in terms of the environmental setting of Point Grey and the capacity of the site's ecosystem (which includes the surrounding Estuary) to accommodate urban settlement. The development concept is to include an environmental management programme as an integral part of the development plan. This programme will be prepared on approval of the project.

The objective of the following sections is to describe the environmental management programme on the basis of the potential environmental impacts described in Section 6. Emphasis is given to describing measures that will firstly avoid environmental impacts, and where this is not possible, minimising and ameliorating their effects.

The first section describes a range of management issues that are common to the development as a whole (e.g. fire, the introduction and spread of dieback disease, rubbish disposal, etc). Subsequent sections describe management procedures that will be adopted in relation to specific issues including:

- o nutrients,
- o water supply,
- o surficial aquifers,
- o conservation areas,
- o foreshores,
- o algae accumulations, and
- o social issues.

The Proponent's management programmes and commitments, made as a condition of environmental approval, are presented in bold type for easier reference.

7.2 GENERAL MANAGEMENT ISSUES

7.2.1 Fire Management

Fire management has two major functions:

- o protection of life and property, and
- protection of vulnerable elements of the natural environment, especially in conservation and other reserves.

Fire control will be most important in the areas zoned for large leisure living lots due to the relatively high fuel loads present within the uncleared regions, and the importance of retaining native vegetation in these areas to maintain their aesthetic appeal. Fire control will also be required in residential areas but the need will diminish as development proceeds. Reserved areas will require on-going management by the responsible authorities but residents and visitors can contribute to fire prevention, primarily by understanding the need for, and simple means of, fire prevention.

The proposed development will be reticulated, and a fire hydrant system will be installed according to standard residential development practice. The installation of these outlets will proceed progressively, ultimately reaching a spacing of 100 to 200m in the residential sections of the development. In the leisure living lots, the spacing of hydrants will be located according to the standard 20 minute turn-around loading period generally applied by the Bush Fires Board to rural subdivisions. The Proponent will comply with the provisions of the Bush Fires Act, 1954 and will afford every co-operation to the Shire of Murray, CALM and the local volunteer fire brigade in the effort to prevent and suppress fires. The Proponent will liaise with the Shire of Murray, CALM and the local fire brigade to produce an on-site, volunteer fire fighting capability. The Proponent will purchase and equip a dedicated fire fighting vehicle, which will form the basis of a local volunteer's Fire Brigade, once the population of Point Grey becomes established.

All reasonable precautions will be undertaken during construction operations over the summer months. Contractors will be required to ensure that all mobile equipment is fitted with a fire extinguisher and an efficient exhaust system to minimise the risk of fire from sparks. Total fire ban days will be observed. Operations such as welding will be conducted over bare mineral earth or with adequate protective matting in place.

Fires for rubbish disposal will be lit in accordance with all relevant regulations and they will be adequately supervised.

Suitable fire suppression equipment such as rakes, knapsack sprays and earthmoving equipment will be on hand. All contractors will be required to instruct construction staff in the need for basic fire prevention and safety.

Under existing legislation all property owners will be required to install firebreaks at least 2m wide on all boundaries, to conform with Shire of Murray by-laws. The Proponent will retain responsibility for providing fire breaks around undivided or unsold portions of property that remains in its ownership.

The Proponent will liaise with the responsible authorities regarding the preparation of suitable breaks. Where warranted, fuel reduction zones will be created, especially where the development area adjoins public lands such as conservation reserves. All of the Proponent's fire breaks will be maintained substantially free of flammable material but with full consideration of the aesthetic value of the land. The principles laid down in the National Parks Association of NSW Fire Policy provide useful guidelines in this regard (National Parks Association of New South Wales, 1980).

The current programme of hazard reduction burning will continue under the control of the responsible authorities on public land. Where a large area of the Proponent's land is to remain undeveloped for a number of years, the Proponent will arrange for either hazard reduction burning or grazing by stock to limit ground fuel levels. Reticulated water supplies, provided to all developed lots on the site, will be available to assist with fire suppression. Emergency water supplies could also be drawn from the Estuary, via the boat ramps, if required.

In the event of a fire, public safety and access for firefighters will be facilitated by the ring road system proposed for the development. As well as acting as firebreaks themselves, these ring roads will provide alternative escape/access routes. The planned staged road network (Figure 2) will provide alternative routes to either leave the site or reach safety at the waters' edge. These routes will be progressively constructed as the development proceeds.

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Public education will be an important aspect of both fire prevention and suppression. All land purchasers will be advised of the fire risks associated with the area. An education programme will provide information on the installation and maintenance of fire breaks, house designs that provide maximum protection from bush fires, safe garden design, safety precautions and routines to be observed in the case of a fire.

7.2.2 Dieback

Prevention of dieback introduction and spread will be an important consideration on the development site and in surrounding reserves.

- All earthmoving contractors working on-site under the Proponent's instructions, will be required to ensure that any mobile equipment which has been working in areas known to be infected with jarrah dieback disease, is adequately washed down to remove infected soil.
- Spoil, debris or equipment under the control of the Proponent, will not be moved onto any conservation reserve.
- Equipment operators will be required to be briefed on disease control by the contractors working for the Proponent.

7.2.3 Surficial Aquifer

Management of the surficial aquifer at Point Grey will have the principal objective of maintaining the water table of an environmentally acceptable level. Drawdown will be limited by the following management actions:

- Reticulated water will be supplied to each residential and large leisure living lot. It is recommended that the use of private household bores to abstract water from the shallow aquifer, should be prohibited by having the area declared a "Groundwater Control Area" in accordance with the Country Areas Water Supply Act, 1947-1979. Suitably treated liquid sewage effluent water will be available for irrigating landscaped and open space areas such as the golf course. Re-use of this water is seen as a means of protecting the shallow groundwater supply from overuse, and minimizing the potential through flow of nutrients to the Estuary.
- o The small catchment areas which may contribute to Lake Mealup will be protected from deleterious inputs by locating stormwater recharge basins outside the catchment. No withdrawal of groundwater from the surficial aquifer is planned within the catchment area of Lake Mealup.

7.2.4 Rubbish Disposal

Rubbish dumping and littering have the potential to adversely affect all parts of the development, as well as surrounding reserved areas. Management of such activity will be conducted as part of the Shire of Murray's general services, and will include the following measures:

- Combustible material will be collected and burnt on a regular basis by controlled burning, which will observe all normal precautions and burning regulations.
- Rubble and building material will be regularly collected and diposed of by dumping on-site in a suitably located pit, and covered with soil.
- The Shire will provide a daily rubbish collection service for wet refuse and a weekly collection service for dry refuse. Disposal will take place at the existing Shire tip.
- The Proponent will provide funds to enable the Shire of Murray to select and purchase a suitable waste disposal site for the Point Grey development.

It is envisaged that recycling receptacles for items such as glass, aluminium and paper will eventually be provided at the district shopping centre, to further discourage illegal dumping.

7.3 NUTRIENT MANAGEMENT

7.3.1 Lawn and Garden Fertiliser Application on Private Lots

The detailed assessment carried out on nutrient inputs to the development (Appendix F) has identified lawn fertiliser as the largest contributor of phosphorus (52% of total phosphorus inputs; Figure 21). Reduction in the amount of fertiliser applied to private lawns and gardens therefore represents one of the principal goals of the proposed nutrient management programme.

The Proponent proposes to implement a number of public education measures that have the potential to substantially reduce the amount of phosphorus applied to private gardens. These measures will include:

- landscape demonstration homes with native gardens and ground covers with minimum lawn area,
- establish a nursery at Point Grey that will supply low phosphorus fertilisers and a variety of native plant species suitable for local conditions,
- supply informative literature to purchasers of residential lots setting out the advantages of using native plants rather than conventional lawns and gardens in terms of maintenance, fertiliser and water costs, and
- o offer an incentive to prospective residents that would further encourage the use of native plants.

Additionally, as it is recommended that private householders be prohibited from using shallow groundwater bores for irrigation water supplies (Section 7.2.3), it is expected that there will be less incentive for developing lawns, thereby reducing the requirement for fertilisers.

Under this management programme, a total reduction in fertilised area of 25% or more may be achieved throughout the development (residential lots plus road verges). It is expected that a 50% reduction in lawns and gardens can be achieved on the leisure living lots. This would lead to a reduction in phosphorus application from a maximum input of 4.2t/yr to 2.1t/yr (as P). This phosphorus input can be further reduced by application of fertiliser of lower phosphorus content than the 6% assumed for the above calculations (Figure 22; Appendix F). Discussions with CSBP & Farmers consultants indicate that a new lawn fertiliser (called Growing Power) has been released on the market which contains on average about 2% phosphorus. This 66% reduction in phosphorus application to fertilised lawns and gardens could further reduce this input to about 1.0t/yr.

The Proponent will undertake to promote the use of low phosphorus fertiliser by ensuring that distribution outlets at the development site promote and sell the product. This management of lawn fertiliser will lead to a similar reduction in the amounts of nitrogen input to site.

It is expected that the local authority will adopt a similar nutrient management policy for all open space areas requiring fertiliser and under public ownership.

7.3.2 Treated Sewage Effluent Management

It is predicted that the second largest long term input of nutrients from the development will be derived from disposal of treated sewage effluent. The environmental management programme will involve a disposal operation where by treated effluent will be used to irrigate the golf course and/or parks and gardens. This will have the two-fold benefit of reducing the water supply demand from the surficial aquifer and the Waroona Mound, as well as leading to a net reduction in the quantity of phosphorus (as fertiliser) imported on-site for use on the golf course and public parks and gardens.

The year-round irrigation of these areas would theoretically result in a fertiliser application reduction to these areas of about 1.0t/yr, however, since fertiliser boosting will be required on the irrigated areas, a net reduction in P application by imported fertilisers has been assumed to be 0.5t/yr. This estimate is based upon establishment and maintenance levels commonly used on courses within the Perth Metropolitan area. The amount of fertiliser actually applied to the golf course and parks and gardens will depend upon the results of a soil testing programme, similar to the one described in Section 6.2.2. Prior to construction of the golf course, the Proponent will undertake to have the soils tested and analysed with the view to minimising phosphorus application to a level considered acceptable for the establishment and maintenance of the grounds. It is proposed that this soil testing programme be undertaken routinely as specified by State Government Authorities.

7.3.3 Septic Tank Effluent Management

Septic tanks will only be permitted in the leisure living lot region of the development. Most of this area is elevated, well vegetated and located on Karrakatta sands. The retention and recycling of nutrients will therefore be enhanced, and leaching to the Estuary will not be significant. In the lower lying, north eastern regions of the leisure living lot zone, less favourable soil types, together with the closer proximity to the water table, will result in larger lots and therefore a lower density of septic tanks.

Council building permits will contain specific provisions relating to the installation of septic tanks.

7.3.4 Fertiliser Application to Public Parks and Gardens

Inputs of phosphorus from the fertilisation of public parks and gardens will be less than 0.5t/yr. Where possible, low concentration phosphorus fertilisers will be used on all parks and gardens. Application rates on areas controlled by the Proponent will be based upon the results of routine soil testing programmes and close liaison with the Department of Agriculture. The results of these programmes will be made available to the local Shire so that fertiliser application rates to public parks and gardens can also be revised as required.

7.3.5 Summary

In summary, nutrient management programmes to be established will significantly reduce the potential phosphorus input of the site. The phosphorus loadings to the site at full development are compared with estimated agricultural application of phosphorus as superphosphate in Table 21.

TABLE 21

PHOSPHORUS INPUTS TO THE SITE; COMPARISON BETWEEN FARM MANAGEMENT AND THE DEVELOPMENT WITH NUTRIENT MANAGEMENT PROGRAMMES

	MAXIMUM PHOSPHORUS INPUT (Ye t/yr	ear 50)
Farming Application (as recommended by Dept. of Agriculturel; 1083ha)	11.5	
Farming Application (as recommended by Dept. of Agriculturel; 720ha)	6.4	
Point Grey Development With Specified Management Programmes	4.5	

Similar percentages of reduction in nitrogen input to the development will apply using these nutrient management programmes.

Monitoring of nutrient outflows via the groundwater system is not seen by the Proponent to be a feasible undertaking. The reasons for this relate to the complexity of soil-water-plant-nutrient interactions and the high variability expected within the soil profile. There are no known studies that have identified changes in nutrient losses by groundwater outflow under differing, but similar nutrient loaded land uses, with any degree of confidence.

The Proponent will, however, undertake to monitor total phosphorus loading to the developing area, in terms of applied fertiliser, sewage treatment effluent and constructed numbers of septic tanks. The Proponent will also monitor groundwater nutrient levels in the shallow aquifer to allow comparison with predicted nutrient levels.

During the early period of the development, it is expected that a low level of maintenance farming will be undertaken on areas of the farmland which are not being developed. This will be required to maintain the condition of the site in terms of control of residual pasture for fire management etc. This short term continuation of farming will be kept to the lowest level necessary to satisfy the maintenance requirements.

It is envisaged that all farming will be phased out by year 10 of the development.

7.4 WATER SUPPLY MANAGEMENT

The proposed Point Grey development has necessitated a preliminary assessment of the potential of local groundwater sources to satisfy the project supply requirements.

Two major groundwater sources have been identified, and although only preliminary estimates have been made, it is expected that either of these sources could be used to supply a long term reticulated water supply to the project.

The Proponent proposes to initially obtain the College construction supply from the Leederville Formation aquifer by using the existing Miami 1/80 bore. The construction requirements are within the supply capacity of this bore. The bore could also be used to provide irrigation water for the Thomas Peel College, and if necessary, the supply will be monitored for changes in salinity, drawdown and pumpage.

A suitable drilling, logging and hydraulic testing programme will be undertaken to evaluate the supply potential near the site, with the objective of supplementing supply requirements from the Waroona Mound. The proposed usage and expansion or supplementation of this supply will be carried out following a detailed groundwater resource evaluation of the area. This resource evaluation will comprise:

- assessment of all monitoring data obtained from early use and testing of the supply, and
- carrying out a regional drilling, exploration and aquifer testing programme to predict aquifer performance under the expected withdrawal rates.

The Proponent undertakes to carry out programmes to develop water supply sources to supply the project. Wells installed in the Waroona Mound and/or the Leederville Formation will be constructed to Water Authority standards. Records of construction and testing will be presented to the Water Authority to obtain a licence for each well. Routine monitoring of water level data, pumpage and water quality will also be reported to the Authority.

Management and monitoring of the reticulated water to the development will be undertaken in respect of supply and quality in a manner consistent with Water Authority standards. Water levels of bores located in the Waroona Mound will also be regularly monitored to ensure that drawdown levels conform with simulation results, and that there are no adverse environmental effects.

7.5 MANAGEMENT OF CONSERVATION AREAS

Reserves gazetted for the conservation of flora and fauna and vested in the National Parks and Nature Conservation Authority (NPNCA) are managed by the Department of Conservation and Land Management (CALM). Any reserve management actions proposed by the Proponent will therefore be subordinate and ancillary to the responsibilities of CALM, or other vesting agencies in the case of reserves with purposes other than conservation.

7.5.1 General Management of Conservation Areas

Plans for the protection of nature reserves within the Shire of Murray are currently being drafted by CALM with input from a local citizens group known as the Murray Shire Reserves Fire Advisory Committee (Lowe, pers. comm.). The Shire of Murray is represented on the committee and officers of the Shire are aware of the proposed development for Point Grey. Fire management on reserves by co-operation between CALM and private land-owners is believed to be an aim of the committee.

The Proponent recognises the role of CALM, PIMA and other Government authorities in the management of reserves, especially those with conservation as their primary purpose. The Proponent will co-operate wherever practicable with any co-operative plans for reserve management which may be proposed. Such co-operative management may include collaboration on control burning and fire suppression or the use of control burnt strips inside private property as buffers around reserves.

Other management issues believed to exist on conservation reserves in the Point Grey area include unauthorised access and the setting of uncontrolled fires. The provision of suitably reinforced controlled access points to the Estuary, with suitable facilities such as fire places and interpretative signs, will reduce the deleterious impacts on reserves where the primary purpose is conservation. While reserve management and the provision of associated facilities remains within the control of the relevant authorities, the proposed development will provide the opportunity to create formal access to suitable sites. The Proponent will facilitate formal access to recreation sites, via the roads, as development progresses, following liaison with the appropriate land management agencies. Provision of access to conservation reserves will only be at the request of the relevant agency. Otherwise, the Proponent will not facilitate access to conservation reserves.

The majority of reserves under the control of CALM in the Shire of Murray are the subject of System Six recommendations. The private property included within this proposal does not include any land which is the subject of a System Six recommendation.

Parts of the land currently owned by the Proponent will be excised from private ownership and vested in the Crown. Significant areas of land allocated for ceding are located on Robert Bay, at Point Grey and around the foreshores of the Point Grey peninsula. If any area ceded to the Crown is subsequently declared a reserve for conservation, then the Proponent will undertake the same commitments in respect of these lands as have been given above for existing conservation reserves.

The Proponent recognises the important relationship between the surficial aquifers and wetland systems and vegetation communities. Groundwater abstraction rates and the location of bores will be determined to ensure that these communities will not be adversley affected.

7.5.2 Weed Control

Weed control is primarily an issue for areas, such as conservation reserves, where retention of the existing vegetation and protection from invasion by exotic species is required.

Weed control in conservation reserves will best be served by minimising disturbance to native vegetation. This goal will be facilitated by measures designed to prevent excessively frequent fires, which can lead to invasion by exotics, especially grasses. Care in the installation of firebreaks can also aid in limiting opportunities for weed invasion.

CALM or other management agencies may choose to treat isolated weed outbreaks with herbicides, however such management on reserved lands is outside the control of the Proponent. The Proponent will assist in the minimisation of disturbance by fire by the installation of fire breaks on the property, and reasonable co-operation with CALM activities designed to control weed invasion (Section 7.2.1).

7.5.3 Management of Introduced Animals

The increase in population at Point Grey can be expected to lead to an increase in the numbers of domestic pets in the area, with the potential to affect the existing vegetation and wildlife on-site.

The keeping of horses on large leisure living lots will be prohibited under the proposed Shire Town Planning Controls. This will avoid damage to vegetation on the properties due to grazing, trampling and ringbarking. Control of domestic dogs and cats will be difficult. To avoid disturbance to birds roosting on rocky points around Point Grey, protective fencing may be required around the more important sites. Such fencing would keep dogs at least 50m away from roosting birds and restrict access to people. Evidence from Pelican Point on the Swan River, suggests that this simple control can effectively prevent excessive disturbance.

No totally effective measures for the control of domestic cats are known, other than prohibition from site. Even fencing would need to be the expensive Cyclone type, with a substantial overhang, to have any effect.

The attractiveness of sites to dogs and cats can be reduced by ensuring that litter bins are regularly emptied and are constructed with self-closing lids.

The most effective tool for the management of domestic cats and dogs is ownereducation. Owners should be made aware of the impacts that these animals can have on wildlife and encouraged to keep them under supervision. Signs to this effect posted at appropriate locations will assist in this regard.

Feral animals are also a potential problem. Feral cats in particular, will eat anything from echidnas to insects and are difficult to control because unlike dogs, they will not take dead baits. Only trapping and shooting are effective, and these measures are expensive. However, only about 5% of abandoned cats appear to become successful feral (Muir, pers. comm.). Once again owners should be made aware of the damage caused by feral cats.

The Proponent will co-operate with the Shire of Murray and CALM as appropriate, to ensure that all purchasers of land on the development are aware of the importance of controlling domestic pets, and the consequences of dumping animals.

7.5.4 Management of Traffic

Excessive informal use of natural areas can lead to site damage by vehicular or foot traffic. Formalisation and control of access, as well as education, are the most effective tools for management. The provision of access and educational information on reserves remains the responsibility of the vesting authority.

The Proponent will liaise with reserve vesting authorities when providing access to the development, to assist in controlling opportunities for informal access to reserves. The Proponent will also co-operate with the vesting authorities in the provision of educational and interpretative material at formal access points, as appropriate.

7.6 FORESHORE AREAS

7.6.1 Vegetation

A foreshore reserve with a minimum width of 50m will be excised from the development area along those portions of land presently under private ownership that have a frontage at the high water mark. Management of these reserves will rest with the relevant authority. Although the details of vesting have not been finalised, it is probable that foreshore recreation areas will be vested in the Shire of Murray, conservation foreshore reserves in CALM and other foreshore areas in PIMA. It is quite possible that the various agencies may wish to rationalise or share management between themselves.

It is envisaged that the principal objective of a foreshore management policy would be to retain all vegetation, except for small areas designated for boat launching facilities and recreational access to the Estuary.

Access to the foreshore will be strongly discouraged, other than at designated, resilient sites, by providing first order management measures such as:

- closing existing tracks where necessary and allowing natural regeneration,
- erecting interpretative signs at designated stopping places to explain the need for environmental protection,
- fencing selected sensitive areas where necessary, and
- providing adequate, well-designed access points at resilient and suitably fortified sites, in order to discourage the tendency for informal access.

Where access to foreshore areas is provided, it will be located at sites which:

- minimise the potential interaction with waterbird feeding, breeding and roosting sites,
- are at points sheltered from excessive natural wave action,

- o require the minimum disturbance of existing native vegetation, particularly fringing sedges which protect the foreshore, and
- have parking areas which are provided with log barriers to prevent beach access to vehicles, except at designated boat launching sites.

The Proponent will liaise with the Shire of Murray, CALM and PIMA as necessary, to facilitate adequate foreshore management. Any specific structures to be erected by the Proponent, such as boat ramps, or management procedures to be implemented, will be subject to discussion with, and the necessary approvals of, the relevant authorities.

The locations of access points to the foreshore will be selected in consultation with the relevant authorities. These points should be selected on the following criteria:

- o foreshore conservation value,
- o accessibility to the planned road network,
- o generally sheltered from wind and wave action,
- o resilient soil types not prone to erosion,
- o proximity to deep water for boat launching,
- o avoidance of massive limestone areas offshore from boat launching sites, and
- o suitability for crabbing and prawning.

Where any foreshore access points are proposed by the Proponent, they will be discussed with the relevant authorities. Detailed plans of access, structures and landscaping will be discussed prior to construction.

7.6.2 Boat Launching Sites

The general location of sites for boat launching facilities have been selected in order to minimise the disturbance to foreshore vegetation and shallow water benthic environments (Section 6.6). It is envisaged that the specific sites selected will be:

- located according to the criteria outlined in Section 4.7, and in consultation with
 PIMA, EPA and the Department of Marine and Harbours,
- o provided at no cost to the community, and
- the subject of consultation with CALM on the preferred method for zoning roosting islets.

It is envisaged that the facilities will be installed by the Shire of Murray and that PIMA and the Department of Marine and Harbours will be responsible for the installation and management of these facilities.

A comprehensive range of suitable structures for stabilising and securing access to foreshores is detailed in the consultant's report to the Waterways Commission on the Peel Inlet Management Programme (Waterways Commission, 1979). Designs for structures such as boat ramps are understood to be generally endorsed and implemented by the Waterways Commission.

It is recommended that these designs be used for the Point Grey foreshore.

7.7 MANAGEMENT OF LOCALISED ALGAL ACCUMULATIONS

Algal biomass data collected during the period 1984-1986 by the Centre for Water Research (Section 5.3.2.4) suggests that the quantity of macro-algae occuring offshore from Point Grey is low in comparison with sections along the Mandurah foreshore. The low biomass figures, together with the prevailing wind directions in the Point Grey area during late summer, when decomposing algae causes the most concern, suggests that the need for an on-going management effort to remove local accumulations, may not be as significant as other regions of the Estuary (Sections 5.3.2.4 and 6.9).

The Proponent intends to monitor any problems associated with algal smells during the early stages of development and will liaise with PIMA on this matter.

Liaison will be maintained with PIMA regarding any discussions on proposals to harvest and remove local algal accumulations. An assessment of the potential damage that could result to foreshores and benthic habitats located in the shallow sub-tidal margins of Point Grey will be included.

7.8 MANAGEMENT OF MOSQUITOES

Management options for the control of mosquitoes include the following:

- fogging of adults using insecticides,
- fogging of larvae using insecticides,
- o biological control using predators, and
- physical control techniques (including filling or draining of breeding sites).

Wright (1986) claims that it is highly inadvisable to place reliance upon a single method of mosquito control in an area such as Mandurah. For reasons of insecticide resistance, economy, conservation and development, the use of a range of control options is preferable for treatment of each breeding site and/or residential areas.

The Proponent intends to monitor the extent of the problem during the College construction phase of the project and liaise with relevant local authorities, PIMA, EPA and the Department of Health to determine the most appropriate control measures for the region.

7.9 MANAGEMENT OF SOCIOLOGICAL FACTORS

7.9.1 Ethnography

The ethnographic study has revealed an area at Point Grey to be a traditional Aboriginal camping ground. This area has been registered as an Aboriginal site as defined by the Aboriginal Heritage Act, 1972-1980 (Appendix C).

The area of land encompassing the northern tip of Point Grey and the adjoining western foreshore region is to be ceded by the Proponent free of cost to the Crown. This area approximates 40ha and has been nominated as part of the Point Grey Concept Development Plan, and incorporated in the Town Planning Scheme Amendment No. 58.

Any alteration of the land recognised as of significance to the Aboriginal people will only take place in accordance with the provisions of the Aboriginal Heritage Act, 1972-1980.

It has been suggested that the reserve described above should be named the WINDJAN MEMORIAL RESERVE.

7.9.2 Thomas Peel College

Management issues pertinent to the College development are:

specialist counselling, welfare and medical staff will be retained by the College,

o student transport facilities will be established by the College, and

o overseas students will be required to have a study visa valid only while they are attending College. Students displaying unruly or disruptive behaviour can, at the discretion of the College Director, be expelled from the College, and that could result in their visas being cancelled.

7.9.3 Landscape Aesthetics and Conservation Value

The proposed project will be developed and managed to enhance the landscape and conservation value of the site. The foreshore reserve system will be integrated and managed as a single entity, and the removal of vegetation will be strictly controlled. The northern most portion of Point Grey will be ceded to the Crown and managed by the local authority as public open space. The area surrounding the College will be landscaped and it is anticipated that urbanization of the cleared, northern regions of the site will result in the development of public and private parks and gardens. The land use controls associated with the leisure living lots will ensure the southern vegetated areas will remain essentially uncleared.

7.10 IMPLEMENTATION OF MANAGEMENT PROGRAMME

The Proponent has recognised from the outset that the proposed development site and the surrounding Peel-Harvey Estuary is a stressed ecosystem, and that any developments proposed for the region must have due regard for a range of environmental issues.

This ERMP has demonstrated that it is theoretically possible to significantly reduce the potential environmental impact of the Point Grey project by implementing a series of management measures. It is proposed to incorporate these measures into an environmental management programme that will be carried out by an on-site manager, and would be based upon the commitments outlined above. These commitments would apply irrespective of whether the ownership of the property were to change. This will ensure continuity of management throughout the life of the development.

Precise details of the management plan will be developed once the appropriate approvals have been granted, however, the following provides an outline of the main issues that would be covered:

- o monitoring the phosphorus loading to the development site, and if higher than estimates nominated in the ERMP, review environmental management policy,
- o periodically sample the nutrient concentration of the treated sewage effluent generated by the tertiary treatment plant, record the results and make them available to relevant Government authorities,
- collect quarterly base-line nutrient samples from the Point Grey surficial aquifer during year 2 of the project, and repeat in year 5 to assess the nature of any nutrient build-up,
- monitor the performance of recharge basins, and ensure that direct runoff to the Estuary is negligible in terms of the site's water balance,
- brief new landowners on the advantages of using native plants, from the point of view of fertiliser and water requirements,
- co-ordinate routine soil testing programmes aimed at assessing the fertiliser requirements of the site, liaise with the Department of Agriculture and amend application rates as required,
- o whilst the water supply is under the control of the Proponent, monitor groundwater levels, pumping rates and water quality from production bores, and modify groundwater abstraction rates and/or spacing of production bores to ensure that long term water quality is maintained and that wetlands and vegetation communities are not adversely affected,
- o oversee the maintenance of the dedicated fire-fighting vehicle during the early stages of the project prior to the establishment of a volunteer fire brigade,
- ensure that the fire risk associated with unsold property is in accordance with the Bush Fire Act 1954,
- carry out hazard reduction burning or grazing on the Proponent's lan spacing of production bores to ensure that long term water quality is maintained and that wetlands and vegetation communities are not adversely affected,
- o oversee the maintenance of the dedicated fire-fighting vehicle during the early stages of the project prior to the establishment of a volunteer fire brigade,
- ensure that the fire risk associated with unsold property is in accordance with the Bush Fire Act 1954,
- carry out hazard reduction burning or grazing on the Proponent's land where necessary,
- o co-operate with Government authorities on reserve management,
- o monitor any algal accumulations along the foreshore, and
- liaise with PIMA and the local shire regarding any decision to remove local accumulations.

It is envisaged that many of the above functions will be gradually assumed by the Shire of Murray as part of its normal services provided to ratepayers. However, until the population of Point Grey becomes established, the Proponent recognises the need for an on-site manager.

7.11 SUMMARY OF MANAGEMENT COMMITMENTS

A summary of the management proposed for the Point Grey development are presented in Table 22. These commitments are explained more fully in the text of this document.

TABLE 22

POINT GREY DEVELOPMENT - SUMMARY OF ENVIRONMENTAL MANAGEMENT COMMITMENTS

Abbreviated descriptions of management commitments are used in the Table below. A full description is provided in the preceding section.

SUBJECT	COMMITMENT
Nutriants	r. Sectio tarke will only be utilized on large leigure living late with a dwelling density of about one per
Mutrients	hectare
	 A tertiary sewage treatment plant will treat effluent from residential lots, College and Lourist accommodation to reduce effluent nutrient concentrations to 10mg/L nitrogen and 2mg/L phosphorus Effluent from this plant will be used to irrigate open space areas such as the golf course. Surplus effluent will be discharged to ponds in winter, before being discharged on open space areas during dry
	weather ø Stormwater runoff will be directed to recharge basins
	p Demonstration houses will be landscaped with native gardens and ground covers, and areas of lawn will be kept to a minimum in an attempt to encourage prospective land purchasers to use plant species with low fertiliser and water requirements
	 Slow release phosphate fertilisers will be used on College and golf course lawns. Householders will also be encouraged to use these fertilisers, where appropriate soil types exist A nursery will be established on-site to supply low phosphorus fertilisers and native plant species
	suitable for Point Grey conditions o Informative literature will be supplied to all land owners to describe the advantages of using native
	plants a The Proponent will offer an incentive to land purchasers that would further encourage planting of native sleets
	plants o The Proponent will undertake to monitor phosphorus loading to the developed area and groundwater nutrient levels in the shallow aguifer
	o Use of shallow groundwater for irrigation of public facilities will be retained as a nutrient management option. Usage will depend upon the results of a groundwater nutrient monitoring programme
	b Liaison will be maintained with EPA and PIMA on their extensive Peel-Harvey Estuary monitoring programme by Proceeding undertakes to conduct a routine soil testing programme in co-operation with the Department.
	of Agriculture. Fertiliser application rates on areas controlled by the Proponent will be based on Department of Agriculture recommendations in order to minimise the required level of fertiliser.
Water Supply	 The Proponent undertakes to carry out programmes to develop water sources to supply the project Reticulated supplies will be provided to residential lots, College and tourist accommodation Reticulated supplies will be provided to the calf course initially, before being replaced with supplies.
	from the teratment plant
	o wells constructed will be to the standard adopted by the water Authority of Western Australia o Routine monitoring of water levels, pumping rates and water quality will be undertaken. Management
	methods will be adopted to ensure that water quality remains at levels acceptable to the Health Department
Management of the	 The majority of the northern tip of Point Grey area will remain vegetated and vested in the appropriate authority
Development	o Public access will be retained to the elevated portion of the Point o The College and residential subdivisions will be confined to the northern, cleared section of the execution of the provident of the provident of the point of the point of the point of the provident of the point of the provident of the pr
	property o Large leisure living lots will be located within the vegetated southern part of the site. Maximum vegetation will be retained in accordance with stringent building and planning controls to be enforced by
	the Shire as part of Amendment No. 58 o Commercial farming and keeping of livestock by individual owners will be expressly prohibited by planning
	o Detailed planning for the site will recognise the need to manage Foreshore access
	o Interpretive signs will be provided o Boat launching sites will be located in consultation with PIMA and the Department of Marine and Harbours printing superior and the second state of the second state of the second secon
	a Areas of new landscaping, using native species, will be established around the College a Approximately 100ha of designated private land will be ceded free of cost to the Crown.
Fire	o The Proponent will purchase and maintain a dedicated fire-fighting vehicle, which will form the basis of
	a local volunteer's Fire Brigade, once the population of Point Grey becomes established o The development will be reticulated and hydrants will be progressively installed according to standard
	o The Proponent will co-operate with the Shire of Murray, CALM and the local volunteer fire brigade to
	prevent and suppress fires o Contractors under the control of the Proponent will be required to ensure all mobile equipment is fitted
	with an efficient exhaust systems and a fire extinguisher p Total fire ban days will be observed
	o During construction operations performed by the Proponent's contractors such as welding will be conducted in suitable areas to minimise the risk of fire
	α Fires for rubbish disposal will be lit in accordance with all relevant regulations α Contractors under the control of the Proponent will be required to instruct staff on fire prevention and
	sarety o The Proponent will liaise with the responsible authorities regarding firebreaks. Fuel reduction zones will be created where warranted where the development adjains within loads
	 Hazard reduction burning or grazing will be carried out on the Proponent's land where necessary An advection programme will be interpreted by the state of the first state of the
	with the area

 The planned staged road network will provide alternative routes to either leave the site or reach safety at the waters' edge. These routes will be progressively constructed as development proceeds.

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Table 22 Continued

SUBJECT	COMMITMENT
Dieback	 a All earthmoving contractors working on-site during the construction period will be required to follow recommended washdown procedures a Earthworks will be carried out such that no equipment, spoil or debris will be moved onto conservation areas a The contractors will brief equipment operators on disease control
Groundwater	 Reticulated water will be supplied to residences to avoid the need for shallow bores. Irrigated landscaped areas (eg. College complex), will be supplied by suitably treated sewage effluent water Catchment areas for Lake Mealup will be protected from deleterious inputs by location of recharge basins outside the Lake's catchment No withdrawal of surfical groundwater is planned within the catchment of Lake Mealup.
Rubbish Dumping	o Under an agreement between the Proponent and the Shire of Murray, the Proponent will provide funds to enable the Shire of Murray to select and purchase a suitable waste disposal site for the Point Grey population. The Shire will provide a daily rubbish collection service for wet refuse and a weekly rubbish collection service for dry refuse
Sociological Factors	 a The area of land encompassing the northern tip of Point Grey and the adjoining western foreshore region is to be ceded free of cost to the Crown a The authority in which the reserve is vested, will be notified of the Aboriginal status of the land a Unruly students will be expelled at the discretion of the College Director, and this may result in the cancellation of their visas a Overseas students will be required to have a visa, in accordance with Australian Immigration requirements, valid only while studying at the College a Student transport will be organised by the College. b Specialist counselling, welfare and medical staff will be retained by the College
Conservation Areas	 The Proponent recognises the role of, and will co-operate with, the relevant Government authorities on reserve management The Proponent will incorporate measures within a proposed management programme aimed at minimising the disturbance to conservation areas by people and domestic animals Access to recreation sites will be facilitated via roads provided for the development, following liaison with appropriate Government agencies Provision for access to conservation reserves will only be at the express request of the relevant authority The Proponent will provide first order management measures to protect conservation reserves (eg. provision of interpretative signs, fire breaks, fencing of defined access areas etc) If any area ceded to the Crown is subsequently declared a reserve for conservation, the Proponent will undertake the same commitments as they have for existing conservation reserves No access spur road will be constructed on the boundary of Mealup Point Nature Reserve.
Weed Control	a The Proponent will install firebreaks to minimise disturbance due to fires, and co-operate with CALM activities designed to control weed invasion.
Introduced Animals	 o The keeping of horses on large leisure living lots will be prohibited under local authority planning controls o The Proponent will co-operate with the Shire and CALM as appropriate to ensure all purchasers are aware of the need for domestic pet control.
Traffic	 Formal access will be limited to approved sites The Proponent will liaise with reserve vesting authorities regarding control of informal access to reserves and the provision of public educational material.
Foreshore Areas	 A foreshore reserve of a minimum width of 50m above high water will be created and transferred free of cost to the Crown Vegetation will be retained in reserves except for boat launching, car parking and recreational access areas The Proponent will liaise with the Shire of Murray, CALM and PIMA as necessary to facilitate adequate foreshore management, in accordance with the proposed management programme Any foreshore access points and facilities proposed by the Proponent will be confirmed in detail with the relevant authorities and approved, prior to construction Boat launching sites will be provided at no cost to the community Sites will be preferentially located away from important conservation areas and at least 50m from important water bird roosting sites.
Localised algal accumulations	 Problems associated with algae smells will be monitored by the Proponent in the early part of the development Liaison will be maintained with PIMA regarding any decision to remove local algal accumulations.
Implementation of Management Commitments	o The Proponent proposes to prepare a management programme that will involve the regular recording of environmental data, evaluation of results and, where nacessary, a review of management policies o The Proponent proposes to locate a site manager at Point Grey o The responsibilites of the site manager will include the implementation of the management programme

8.0 BIBLIOGRAPHY

Anderson, J.F. (1981), Survey for Aboriginal Sites in the North Dandalup and Little Dandalup project areas, Western Australia. Report to the M.W.S.S.D. Board, Perth.

(1982), Test Pits at Sites S1660 and 1662, North Dandalup, Western Australia. Report, to the M.W.S.S.D. Board, Perth.

Australian Bureau of Statistics (1971), Census Data, Australian Bureau of Statistics, Perth.

(1981), Census Data, Australian Bureau of Statistics, Perth.

(1986), Estimated Residential Population in Local Government Areas in Western Australia, 1981-1985.

- Berndt, R. (1980), Aborigines of the South-West, in R. and C. Berndt (eds.), 'Aborigines of the West', U.W.A. Press, Nedlands.
- Bettenay, E., Hurle, D.H. and Height, M.I. (1985), Peel-Harvey Estuary Study, Groundwater Studies - Site Specific, <u>in</u> Peel-Harvey Estuarine System Study Management of the Estuary, Bulletin 195, D.C.E., Perth.
- Birch, P.B., Forbes, G.G. and Bott, G.M. (1985), Nutrient Loading into the Peel-Harvey Estuary, in Bulletin 195, D.C.E., Perth.
- Bott, G.M. and Humphries, R.B. (1986), Drain Phosphorus Reductions due to Fertiliser Use Modifications, in The Peel-Harvey Estuary Colloquium, D.C.E., Perth.
- Brown, J. (1980), Vegetation Species List, Nirimba Cay, <u>in</u> D. Muirhead (ed.), 'Nirimba Cay Development', Report prepared for Katanning Holdings Ltd, Western Australia.
- Brown, S. (1983), <u>A Survey for Aboriginal Sites in the Perth Metropolitan Area</u>, Commissioned by M.R.D., Perth, Unpublished Report.

- Collins, P.D.K. (1974), Murray River Basin, Surface Water Resources Survey, Water Resources Section, P.W.D., Western Australia.
- D'Adamo, N. and Lukatelich, R. (1985), Water Quality of the Murray River Estuary. Environmental Dynamics Report ED-85-108, U.W.A., Nedlands.
- Dames & Moore (1986), Water Supply and Environmental Investigations for the Proposed Point Grey Development Pinjarra, W.A., Report prepared for Feilman Planning Consultants, Dames & Moore, Job No. 14932-001-071.

(1985), Community Needs Study, A Socio-economic and Social Impact Assessment of the Proposed Kemerton Aluminium Smelter, Report commissioned by the W.A. Department of Resources Development, Dames & Moore, Job No. 13003-007-071.

- Department of Agriculture (1975), The Peel-Preston Planning Study. Agricultural Potential, Prepared by Rural Economics and Marketing Section, December 1975.
- Department of Conservation and Environment (1980), The Peel-Harvey Estuarine System Study (1976-1980), Hydrology and Meteorology Bulletin No. 89, D.C.E. Perth.

(1983), Conservation Reserves for Western Australia, as Recommended by EPA : The Darling System-System 6, Part II, Recommendations for Specific Localities, Report No. 13, D.C.E., Perth.

(1984), Management of Peel Inlet and Harvey Estuary, Bulletin 170, D.C.E., Perth.

_____ (1985), Peel Inlet and Harvey Estuary Management Strategy, Bulletin 243, D.C.E., Perth.

Department of Industrial Development (1983), The South-West Region - A Regional Profile, D.I.D., Perth.

- Department of Resources Development (1982), Employment and Population in the South-West, 1981-1990, D.R.D., Perth.
- Feilman Planning Consultants (1987), Shire of Murray, West Murray Town Planning Scheme, Amendment No. 58, Amendment Report, Feilman Planning Consultants, Perth.
- Fisheries and Wildlife (1983), 'Second Schedule of Fauna which is Rare, or Otherwise in Need of Special Protection', SWANS 13: 28-30.
- Fisheries Department of Western Australia (1986), State of the Fisheries, 1985, Fisheries Department of Western Australia.
- Hamon, B.V. (1966), 'Continental shelf waves and the effects of atmospheric pressure and wind stress on sea level,' J. Geophys. Res. 71:2883-2893.
- Harrison, G.E. (1983), Low frequency sea level oscillations along the Western Australian coastline, M. Eng. Sc. (Civil) Prelim., U.W.A., Nedlands.
- Health Department of Western Australia (1986), Report on the mosquito eradication campaign survey of mosquitoes in the Bunbury Region, Western Australia. Report prepared for Mosquito Control Review Committee of the Waterways Commission.
- Hillman, K. (1985), The production ecology of the seagrass <u>Halophila ovatus</u> (R. Br) Hook. in the Swan/Canning Estuary, Western Australia, Ph.D. Thesis, Botany Department, U.W.A., Perth.
- Hudgkin, E.P. and Birch, P.B. (1986), Peel-Harvey Estuarine System. Proposals for Management. Report No. 14 : Appendix 1. The background to management, Bulletin 241, D.C.E., Perth.

Birch, P.B., Black, R.E. and Hillman, K. (1985), The Peel-Harvey Estuaries Study Proposals for Management, Report No. 14, D.C.E., Perth.

_____, Birch, P.B., Black, R.E. and Humphries, R.B. (1980), The Peel-Harvey Estuarine System Study (1976-1980), Report No. 9, D.C.E., Perth.

- Howard, M. (1980), 'Aboriginal Society in South-Western Australia', <u>in</u> R. and C. Berndt (eds.), <u>op cit</u>.
- Kinhill Stearns (1985), Peel-Harvey Estuarine System Study, Report on Mandurah Attitudinal Survey prepared for Department of Conservation and Environment Bulletin 235.
- Lenanton, R.C.J., Potter, I.C. and Loneragan, N.R. (1985a), The response of fish and crustacean fauna and the fishery to options for management of the Peel-Harvey Estuary, <u>in</u> Peel-Harvey Estuarine System Study Management of the Estuary, Bulletin 195, D.C.E., Perth.

(1985b), Blue-green Algal Blooms and the Commercial Fishery of a Large Australian Estuary Marine Pollution Bulletin 16:477-482

Potter, I.C., Loneragan, N.R., and Chrystal, P.J. (1984), 'Age structure and changes in abundance of three important species of teleost in a eutrophic estuary (Pisces : Teleostei)', J. Zool. Lond **203**:311-327.

- Lukatelich, R.L. and McComb, A.J. (1986), Nutrient Recycling and the growth of Macro-algae in the Peel-Harvey Estuarine System. Waterways Commission.
- McArthur, W.M. and Bartle, G.A. (1980), Soils and Land Use Planning in the Mandurah-Bunbury Coastal Zone, Western Australia, <u>Land Resources Management Series</u> No. 6, C.S.I.R.O., Western Australia.

, Bettenay, E. and Hingston, F.J. (1959), Soils of the Pinjarra-Waroona Area Western Australia, <u>Soils and Land Use Series</u> No. 31, C.S.I.R.O., Western Australia.

- Main Roads Department (1985), Traffic Patterns Rural Permanent Count Stations, 1984 1985, Rept. No. 0034I, M.R.D., Western Australia.
- Mattiske, E.M. (1986), Effects of Gnangara Mound Groundwater Developments on Native Vegetation of the Northern Swan Coastal Plain, <u>in</u> Dames & Moore, 'Gnangara Mound Groundwater Resources Environmental Review and Management Programme', Water Authority of Western Australia.

- Muirhead, D. (1980), Preliminary Development Concepts and Environmental Impact Statement for the Nirimba Cay Development, Western Australia.
- Nairn, J. (1976), <u>Western Australia's Tempestuous History</u>, Independent Newspapers, Perth.
- National Parks Association of NSW (1980), Policy Statement on Fire Management in Natural Areas. N.P.A. of NSW.
- National Trust (1973), The Peel-Preston Lakelands, National Trust of Australia, Western Australia.
- Novak, V. (1975), Report on Aboriginal Sites of the Lake Peel-Preston Lakelands, Western Australian Museum, Perth.
- O'Connor, R., Bodney, C. and Little, L. (1985), <u>Preliminary Report on the Survey of</u> <u>Aboriginal Areas of Significance in the Perth Metropolitan and Murray River</u> Regions, Australian Heritage Commission, Unpublished Report.

and Quatermaine, G. (1986), Report on the survey for Aboriginal Sites in the vicinity of the Proposed Mandurah to Pinjarra Dual - Carriageway Route, Report to M.R.D., Perth.

- PA Australia (1981), A Study into Recreational Boating Facilities within Western Australia, PA Australia.
- Potter, I.C., Loneragan, N.R., Lenanton, R.C.J. and Crystal, P.J. (1983), 'Blue-green Algae and Fish Population Changes in a Eutrophic Estuary', <u>Marine Pollution</u> <u>Bulletin</u> 14(6), 228-233.

and Manning R. (1986), The biology of the King (<u>Penaeus latisulcatus</u>) and school (<u>Metapenaeus dalli</u>) prawns in the Peel-Harvey Estuary (working title), in prep.

Quatermaine, G. (1986), Report of a Preliminary Study for Aboriginal Sites at Proposed Cliffs International Ltd Developments at Coolup and Bullsbrook, W.A., Report to Maunsell and Partners Pty Ltd.

- Salvado, R. (1977), <u>Historical Memoirs of Australia</u> (translated by E. Stormon), W.A. Press, Perth.
- Schwinghammer, T. (1978), Peel Inlet Mangement Authority Fact Finding Study, Waterways Commission, Western Australia.
 Seddon, (1972), A Sense of Place, U.W.A., Nedlands.
- Skitmore, P. and Bunbury, E. (1985), The Social Scene. Peel-Harvey Estuarine System Study. Management of the Estuary, Bulletin 195, D.C.E., Perth.
- Sinclair Knight & Partners (1987), Point Grey Development, Report on Engineering Services. Unpubl. Report.
- Tong, G. (1985), Modelling Studies of the Dawesville Cut Harvey Estuary, Bulletin 241, D.C.E., Perth.

Town Planning Department (1976), Peel-Preston Planning Study, T.P.D., Perth.

(1984), Mandurah and Districts Planning Study. A Regional Plan for the Shires of Mandurah, Murray, Waroona and Harvey, T.P.D., Perth.

- WAITEC (1986), Business College Study. Unpublished Report prepared for Mallina Holdings Ltd. 28/5/1986.
- WA Tourism Commission (1986), Western Australian Domestic Tourism Monitor Survey, W.A.T.C., Perth.

Water Authority of Western Australian (1987), Sewage Manual, Vol. 1.

Waterways Commission (1979), Peel Inlet Management Programme, Report prepared by Kinnaird Hill deRohan and Young Pty Ltd, November 1979.

_____ (1982), Peel Inlet Management Programme, Joint programme with Peel Inlet Management Authority.

(1986), Waterways Commission Policy Document, Report No. 10.

- Webster, I.T. (1983), Wind-driven circulation on the North West Shelf of Australia. Environmental Dynamics, Report ED-83-065, U.W.A., Nedlands.
- Yeates, J.S., Arkell, P.T., Russell, W.K., Deeley, D.M., Peek, C. and Allen, D. (1985), Management of Agricultural Phosphorus Losses from the Soils of the Peel-Harvey Catchment, in Bulletin 195, D.C.E., Perth

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9.0 STUDY TEAM

Feilman Planning Consultants

Mike Day	Social Environment
Graham Meredith	Principal, Planning

Dames & Moore/Groundwater Resource Consultants

Project Manager	
Lead Consultant	
Environmental Hydrology	
Hydrology (General)	
Word Processing	
Illustration	
Environmental (General)	
Illustration	
Environmental (General)	
Environmental (General)	
Environmental (General)	
Vegetation and Flora	
Principal Investigator	

Sub-Consultants to Dames & Moore

Greg Harold	d Terrestrial and Estuarine Faur	
Gary Quatermaine	Archaeology	
Rory O'Connor	Ethnography	

Sinclair Knight & Partners

Pete	r Bowyer
Roy	Webley

Engineering (General) Engineering (General)

10.0 AUTHORITIES CONSULTED

Bureau of Meteorology Department of Agriculture Department of Conservation and Land Management Environmental Protection Authority Fisheries Department of Western Australia Geological Survey of Western Australia Murdoch University Peel Inlet Management Authority Shire of Murray State Planning Commission University of Western Australia, Botany Department Water Authority of Western Australia Waterways Commission Western Australian Herbarium Western Australian Heritage Committee Western Australian Museum

11.0 GLOSSARY

Adsorbtion:	The physical or chemical bonding of molecules of gas, liquid or dissolved substance to the external surface of a solid.
Aeolian:	Wind-blown; describes a deposit formed by wind action.
Algal Bloom:	A sudden proliferation of algae in water bodies, stimulated by the input of nutrients. (see eutrophic.)
Alluvium:	Unconsolidated detrital material deposited by a stream or river.
Amphipods:	Order of Crustacean, (Amphipoda), includes freshwater shrimps.
Anaerobic:	Living or active only in the absence of gaseous or dissolved oxygen.
Aquifer:	A geological formation capable of receiving, storing and transmitting significant quantities of water.
Artesian:	Artesian and sub-artesian both describe groundwater confined under hydrostatic pressure. Artesian flows at the surface, sub-artesian rises above the confining layer but does not flow.
Aquatic Angiosperm:	A flowering plant that is submerged for the majority of its life cycle.
Bassendean Dune System:	The furtherest inland and oldest dune system on the Swan Coastal Plain.

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Benthic:	Those animals and plants living on the bottom of the sea or lake (crawling or burrowing there; or may be attached), from high water mark to the deepest levels.
Biomass:	The total living matter in an ecosystem.
Biota:	The totality of plants and animals of a specified area.
Calcite:	A very abundant carbonate mineral, CaCO ₃ . Is the main constituent of limestone.
Carbonaceous Shale:	Shale which is rich in organic compounds.
Copepod, harpacticoid:	A group of small, freshwater and marine Crustacea, some of which form a major part of the plankton.
Cretaceous:	Referring to rocks 65 million to 140 million years old.
Crustacean:	Invertebrate, generally aquatic or marine, with a hard carapace or exoskeleton eg. marron, crabs, amphipods.
Diatom:	Microscopic, unicellular plants, occurring singly or grouped in colonies.
Diatomaceous Soils:	A friable, siliceous deposit composed of the skeletal remains of diatoms.
Dieback Disease:	In Western Australia, particularly applied to the effects of the root rot fungus, <u>Phytophthora</u> cinnamomi.
Drawdown:	The decline in water level due to abstraction.
Ecosystem:	A community of interdependent plants and animals together with the physical environment which they inhabit and with which they interact.

Eocene:	An epoch of the lower Tertiary period, after the Paleocene and before the Oligocene.
Estuarine:	Refers to the sedimentary, biological or depositional environment which makes up an Estuary.
Ethnography:	The scientific description of races of men.
Eutrophic:	Pertains to water bodies which are rich in nutrients. See algal "bloom".
Evapotranspiration:	The actual loss of water by evaporation from soil, vegetation and water bodies and transpiration from vegetation.
Exotic Species:	A plant introduced from another locality.
Fluviatile:	Pertaining to the action of rivers.
Guildford Formation:	A plain with medium textured deposits and yellow duplex soils.
Herbaceous:	Pertaining to herbs, which are non-woody vascular plants, having no parts which persist above the ground.
Holocene:	(or Recent) The younger of the two geological epochs in the Quarternary period. The Quarternary being one of the two periods in the Cenozoic era.
Hydraulic Conductivity:	The rate of flow of water in units per day, through a unit cross section, under a unit hydraulic gradient.
Karrakatta Sand:	The yellow-brown sand unit of the Spearwood Dune System.

Laterite:	Iron-rich material which hardens on exposure to the atmosphere and is associated with deeply weathered profiles.
Leederville Formation:	Mostly confined aquifer of siltstone, sandstone and shale of marine or nearshore origin.
Lenticular:	Pertaining to a stratigraphic lens or lentil.
Limestone:	A sedimentary rock consisting mainly of calcium carbonate.
Lithic:	Pertaining to stone or rock.
Littoral Drift:	The movement of material in littoral currents, i.e. currents moving parallel to the shore, within the surf zone.
Macro-algae:	Large algae, able to be observed with the eye.
Mallee:	Pertains to <u>Eucalypts</u> , where a tree has several trunks branching from ground level.
Micro-algae:	Microscopic algae, e.g. Blue-green algae.
Molluscs:	Refers to animals belonging to the Phylum Mollusca, which includes mussels, snails, etc.; mostly aquatic, soft bodied, with hard shell, and muscular foot.
Mysids:	Benthic invertebrates.
Osborne Formation:	A confined aquifer for shale, siltstone and sandstone.
Peaty Soils:	Pertains to soils having characteristics like peat ie. organic soil, composd of partly decomposed plant material.

Perennial:	A plant that continues to live from year to year.
Phanerozoic:	The period of time from the beginning of the Cambrian
	Period to the present day.
Phytoplankton:	Aquatic plants which float or drift passively.
Potentiometric Surface	The surface defined by the level at which water under
	artesian (confined) conditions will rise; also called the
	piezometric surface.
Proteaceous:	Pertaining to those plants belonging to the Family,
	Proteaceae.
Quaternary:	Refers to geological time since the end of the Pliocene
	ie. to Pleistocene and Holocene time.
Siliceous Sand:	A sand containing abundant siliceous material.
Spearwood Dune System:	This system lies between the Bassendean and
	Quindalup Dune System, comprising soft sandy
	limestones. Consists of two distinct landscapes - the
	Cottesloe and Karrakatta units.
Swale:	The low lying area between two sand dunes.
Tamala Limestone:	Consists of calcarenite composed largely of fossil
	skeletal fragments, usually forms ridges parallel to the
	coast.
Transmissivity:	In an aquifer, the rate at which water is transmitted
	through a unit width, under a unit hydraulic gradient.
Water Balance:	An account of all water entering and leaving a system
	over a specific period.
Zooplankton:	Microscopic animals, which are free floating. Are
	mainly Protozoa, small Crustacea, and larvel stages of
	molluscs and other invertebrates.
12.0 GUIDELINES

POINT GREY PROJECT GUIDELINES FOR THE ENVIRONMENTAL REVIEW AND MANAGEMENT <u>PROGRAMME</u>

1. SUMMARY

This section should contain a brief summary of:

- salient features of the proposal;
- alternatives considered;
- description of receiving environment and analysis of potential impacts and their significance;
- environmental monitoring, management and safeguard and commitments thereto;
- conclusions.

2. INTRODUCTION

This introduction should include:

- identification of proponent and responsible authorities;
- background and objectives of the proposal including development concepts;
- brief details, and timing of the proposal;
- relevant statutory requirements and approvals;
- purpose and structure of the ERMP.

NEED FOR THE DEVELOPMENT

This section is concerned with the justification for the project and project costs (in the broad sense) and benefits at local and regional levels. For example the following items should be covered:

- The proposed development should be considered with the context of local and regional residential, educational and tourist requirements;
- benefits to the community of the project including reference to economic, employment and social factors;

 Does the project utilise or make available resources that would otherwise not be available to the community.

4. EVALUATION OF ALTERNATIVES

The evaluation of alternatives is an important part of an ERMP. A discussion of alternative development or land use options should be given. A comparison of these in the context of the stated objectives should be included as well as costs and benefits at both construction and long term stages. In this way, the rationale for not choosing certain alternatives should be clear as will the basis for choosing the preferred option.

The following provide examples of alternatives and their potential impacts for consideration in this section:

- various development options;
- various special arrangements of uses based on environmental consequences.

5. DESCRIPTION OF PROPOSAL

This should include:

- General Concepts
- Leisure Living Areas
- Residential Areas
- College and Campus
- Recreational Areas
- Tourism and Facilities
- Associated Works
 - Water Supply confined groundwater, unconfined groundwater
 - Access
 - Sewage Treatment
 - Waste Disposal
 - Stormwater Discharge
 - Other Works

- Services to the Development
- The Construction Period
 - Operations
 - Employment
 - Site Housing and Facilities

6. EXISTING ENVIRONMENT

This section should provide an overall description of the environment and an appraisal of physical and ecological systems likely to be affected by it.

It should then concentrate on the significant aspects of the environment likely to be impacted by the development (i.e. in particular the processes sustaining the system). Only the processes, habitats, resources and potential resources which could be influenced should be defined. Detailed inventories should be placed in appendices to the ERMP.

Wherever possible in the discussion of physical and biological processes that are essential determinants in the maintenance of habitats and resources, conceptual models or diagrams should illustrate and synthesize the interactions between the processes.

This section should include:

Point Grey

- Physical
 - Landform and Soils
 - Geology
 - Climate
 - Hydrology
 - Hydrogeology
 - Existing Land Use

- Biological biota and their ecosystems set in a local and regional context, including:
 - Flora
 - Fauna with special emphasis on wading bird habitats and fish nursery areas
 - Conservation Areas
 - Estuarine Condition at Point Grey
- Human Environment
 - conservation or recreation aspects, land tenure and zoning;
 - existing human-use patterns;
 - road systems and traffic;
 - landscape;
 - adjacent land uses;
 - historical, archaeological and ethnographic sites;
 - existing social climate and value.

Peel-Harvey Estuary and Hinterland

- The Hinterland
 - Geography and Land Use
 - Population Distribution and Trends
 - Projected Development Trends
- The Peel-Harvey Estuary
 - General Description
 - Existing Uses
 - recreation
 - professional fishing
 - Projected Uses
 - Existing Nutrient and Biological Status
 - Current Management Policy
 - Estuarine Management Alternatives (Stage 2 ERMP for Management of Peel-Harvey Estuary)
 - Development Trends on the Estuary
 - Regional Landscape

System Six Recommendations

7. ENVIRONMENTAL IMPACTS

This is the most important part of the ERMP and the result should show the overall effect on the total ecosystem and social surroundings of the location during and after construction.

The objective of this section is to synthesize all information and predict potential impacts upon the environment in the short and long term, including beneficial impacts and the impacts of alternatives. This should include an assessment of the resilience of the systems identified in 6 to natural and man-induced pressures.

Impacts should be quantified where possible. Criteria for making assessments of their significance should be outlined. In some cases there will be advantage in discussing construction and operation impacts separately.

It will be necessary to determine impacts on individual components of the environment before a final overal synthesis of potential impacts is made.

This section should include but not be limited by consideration of the following:

General

Nutrients (Local and regional context) - Nitrogen and Phosphorus

- Fertiliser
- Treated Sewage Effluent Disposal
- Septic Tank Effluent
- Implications in Terms of Estuary Management (including timing of the project) based on the following alternatives:
 - Existing Status
 - Catchment Management
 - Catchment Management and Dawesville Channel.

It is envisaged that nutrient input from the proposal will constitute one of the major impacts of the project, accordingly it is anticipated that it will be addressed in considerable detail with clear statements on assumptions and philosophies adopted.

General

Water Supply

- Supply requirements until full development
- Alternative supplies
- Expansion and supplementation requirements

Location of Groundwater Supply Area

Prediction of Long Term Harvesting Impacts

Local Shallow Groundwater Responses to Urbanisation

- Water Balance
- Unconfined Groundwater Usage

Conservation Reserves

- Population Pressure
 - Tourist Needs
- Development Impacts
 - Roads
 - Other

Estuarine Fish Resources

- Amateur Fishing
- Professional Fishing

Boating Facilities/Dredging Impacts

- Without Dawesville Channel
- With Dawesville Channel
- Boating Pressure
- Dredging and Spoil Disposal

Flora and Fauna (including habitats) lost or displaced due to project

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Solid Waste Disposal

- General
- Waste Disposal Sites
- Site Selection and Impacts

Foreshore Areas

- Boating/Carparks
- Fishing
- Recreation Areas
- Conservation Areas
 - Sociological Impacts
 - General
 - Economic Benefits
 - Employment during Construction
 - Tourism and Foreign Exchange

Project Development in Relation to Existing Project Population Growth of the Area

Estuary Status and Impacts on the Developments' Population

Construction and long-term impacts on existing adjacent community i.e. noise, increased traffic

Access

Landscape Aesthetics

Existing community services

The final synthesis should include an assessment of the significance and timing of the various potential impacts identified.

8. ENVIRONMENTAL MANAGEMENT

An environmental management programme should be described on the basis of (and cross-referenced to) the synthesis of potential environmental impacts described in 7.

The purpose of the mangagement programme is to demonstrate the manner in which potential environmental impacts can be ameliorated.

Authorities responsible for management should be clearly identified as should management administration, costs and funding including long-term financial contingency. Reference should be made to environmental standards expected.

Elements of monitoring and the environmental management programme should include the impacts identified in 7.

Emphasis should be placed on the manner in which monitoring results will lead, where appropriate, to amendments to the management programme.

Environmental safeguards should be described.

Procedures for reporting the results of monitoring and management to appropriate authorities should be given.

- Nutrient Management including contingencies if nutrient input and export exceeds anticipated or acceptable levels
- Development of Stage Water Supply
- Management of Conservation Areas
- Management of Foreshore Areas
- Management of Localised Algal Accumlations
- Management of Confined or Unconfined Aquifers including Administrative Arrangements for Long-Term Management
- Management and Control of Land Uses on Leisure Lots.

9. SUMMARY OF COMMITMENTS BY PROPONENT

10. CONCLUSION

An assessment of the environmental acceptability of the project in terms of its overall environmental impact and in the context of the proposed management programme should be given.

11. REFERENCES

ERMP GUIDELINES

<u>CONSULTATIONS</u> (details of consultations with government bodies and public interest groups

APPENDICES

Note: These Guidelines should be used in the context of the attached document "Notes for the Preparation of an ERMP".

13.0 PROPOSED TOWN PLANNING CONTROLS

TOWN PLANNING AND DEVELOPMENT ACT, 1928 (AS AMENDED) RESOLUTION DECIDING TO AMEND A TOWN PLANNING SCHEME

SHIRE OF MURRAY WEST MURRAY TOWN PLANNING SCHEME AMENDMENT NO. 58

RESOLVED that the Council, in pursuance of Section 7 of the Town Planning and Development Act, 1928 (as amended), amend the above Town Planning Scheme by:

- Incorporating a new Zone "Special Residential Zone" with appropriate land use and development control provisions.
- Inserting additional Special Use Classifications "College" and "Holiday Accommodation" with appropriate land use and development control provisions.
- 3. Inserting a new Zone "Residential Development Zone" with appropriate land use and development control provisions.
- Rezoning sections of Point Grey from Rural Zone to; Residential Zone, Conservation and Recreation Zone; Special Use Zone - Holiday Accommodation, Special Use Zone - College, Settlement Centre Zone and Residential Development Zone.

Dated this

_____day of _____1987

SHIRE CLERK

TOWN PLANNING AND DEVELOPMENT ACT, 1928 (AS AMENDED)

SHIRE OF MURRAY WEST MURRAY TOWN PLANNING SCHEME AMENDMENT NO. 58

The MURRAY SHIRE COUNCIL under and by virtue of the powers conferred upon it in that behalf by the Town Planning and Development Act, 1928 (as amended), hereby amends the above Town Planning Scheme by:

1.0 RESIDENTIAL ZONE

1.1 Rezoning portions of Murray Locations 75, 299, 729, 738, 1133 and 1145 and sections of roads to be closed, from Rural to Residential, in accordance with the Scheme Amendment Map.

2.0 SPECIAL RESIDENTIAL ZONE

- 2.1 Amending the Scheme Map Legend by inserting a new Zone "Speical Residential" in accordance with the Scheme Amendment Map.
- 2.2 Amending Clause 2.0 of the Scheme Text by inserting a new Zone "No. 10 -Special Residential".
- 2.3 Adding the following new Clause 2.10 to the Scheme Text.
 - "2.10 Special Residential Zone:
 - (1) A Dwelling House is the only permitted use in this zone;
 - (2) Notwithstanding the provisions of the Uniform Building Bylaws not more than on e dwelling house per lot shall be permitted;
 - (3) With the exception of removing timber and natural vegetation as approved by Council to facilitate the building of a dwelling house, access to that house and for the purpose of firebreaks required by a By-law, trees and other indigenous vegetation shall not be felled or cleared;

- (4) The keeping of horses and livestock shall not be permitted;
- (5) No building shall be permitted to be constructed or erected closer than 25 metres to a front or rear boundary of a Lot, or closer than 20 metres to a side boundary. Where topography or other physical attributes of a lot make construction difficult, Council may vary the minimum ssetback requirements;
- (6) The use of land for intensive agricultural purposes and rural pursuits shall not be permitted;
- (7) No development shall be permitted on land with a surface level below 2.5 metres above the Australian Height Datum;
- (8) The average lot size within the Zone shall not be below 1.0 hectare;
- (9) No person shall drain or fill a wetland without the approval of Council;
- (10) Fences shall be constructed and maintained to the satisfaction of the Council on all boundaries between freehold land and Public Open Space;
- (11) The Council will facilitate discussion between land owners and the Bushfires Board with a view to locating firebreaks where they will prevent the spread of fire with adverse effects upon the landscape of the area;
- (12) No dwelling shall be constructed or approved for construction unless supplied by a reticulated water supply.
- 2.4 Rezoning part Murray Locations 727 and 738 and sections of roads to be closed, from "Rural Zone" to "Special Residential Zone", in accordance with the Scheme Amendment Map.

3.0 SPECIAL USE ZONE

- 3.1 Amending Clause 2.9 (1) to read:
 - 2.9.1 "Those uses applicable to the Zone as designated on the Scheme Map are permitted, in addition to those uses listed in the Special Use Zone Schedule."

- 3.3 Rezoning portions Murray Locations 137, 322, 729, 738, 1132 and 1133 from "Rural" to "Special Use Zone - College", in accordance with teh Scheme Amendment Map.
- 3.4 Amending the Special Use Zone Schedule by
 - (i) Inserting in the column headed Description of Land, a new Special Use Zone "College" being portion of Murray Locations 137, 322, 729, 738, 1132 and 1133 are shown on the Scheme Amendment No. 58 map.
 - (ii) Inserting the Permitted Uses Column applicable to the Special Use
 Zone "College" the following:
 - (a) Education Establishment
 - (b) Student and Staff accommodation
 - (c) Recreation facilities
 - (d) Public Worship
 - (e) Car Park

.,

- (f) Public Utilities
- (g) in addition to permitting (a) to (f) Council, at its discretion, may approve
 - (a) Hire Accommodation
 - (b) Offices
 - (c) Shops"
- 3.5 Amending the Scheme Maps by inserting in the Scheme Map Legend an additional Special Use Zone classification "HA Holiday Accommodation".
- 3.6 Rezoning portion Murray Locaitons 727 and 738 from "Rural" to "Special Use Zone - Holiday Accommodation" in accordance with Scheme Amendment Map.

- 3.7 Amending the Special Use Zone Schedule as contained in the Scheme Text by:
 - (a) Inserting in the column headed Description of Land a new Special Use Zone - "Holiday Accommodation" being portion of Murray Location 727 and 738 as shown on the Scheme Amendment No. 58 map.
 - (b) Inserting in the column headed Permitted Uses applicable to this Zone:
 - (i) Hire Accommodation
 - (ii) Restaurant
 - (iii) Private Recreation
 - (iv) Place of Amusement being part of a Hire Accommodation Building
 - (v) Tavern
 - (vi) Hotel
 - (vii) Shop being part of a Hire Accommodation Building.

4.0 CONSERVATION AND RECREATION ZONE

4.1 Rezoning Part Murray Locations 75, 137, 138, 139, 299, 322, 672, 727, 729, 738, 1132, 1133 and 1145, Portion of A Reserve 24739, Reserve 33039 and those portions of land between surveyed cadastral boundaries and high water mark extending from the south eastern corner of A Reserve 2738 in a northerly direction, then south easterly direction to the north west corner of Reserve 2707 (Carrabungup Nature Reserve) and sections of unconstructed road reserves, from "Rural Zone" to "Conservation and Recreation Zone", in accordance with the Scheme Amendment Map.

5.0 RESIDENTIAL DEVELOPMENT ZONE

5.1 Amending the Scheme Map legened by inserting a new zone, "Residential Development Zone" in accordance with the Scheme Amendment Map.

- 5.3 Amending the Scheme Text by adding a new Clause,
- "2.12 Residential Development Zone
- 2.12.1 Except as provided for in Clause 2.12.7 Council will not support any application for approval to subdivide, nor grant planning approval for the development of any land within the Residential Development Zone until the land has been appropriately zoned.
- 2.12.2 Before considering a request for rezoning, Council will require an Outline Development Plan to be prepared, submitted and determined by Council for the whole or such portion of the Residential Development Zone as Council deems appropriate.
- 2.12.3 An Outline Development Plan shall comprise a map or set of maps together with a complementary report which, together details to Council's satisfaction:
 - (i) The relationship of the land to be subdivided to the developed land in the area;
 - (ii) The proposed roads within the Outline Development Plan area and their connection with the road network in the locality, as appropriate and, with other land within the same zone;
 - (iii) The proposed pattern of subdivision for the Outline Development Plan area and nature of all new development;
 - (iv) The analysis of the physical, topographical and environmental characteristics of the area leading to the selection of the land considered to be suitable for subdivision and development;
 - (v) The drainage system and the means by which other services necessary to serve any new subdivision and development are to be provided;
 - (vi) The intended residential density code for the land;

- (vii) Such other information as may reasonably be required by Council;
- (viii) The effect, if any, on the land by floodways;
 - (ix) The method of effluent disposal.
- 2.12.4 Following receipt of approval of an Outline Development Plan by the Council, the Council shall resolve to initiate an Amendment to the Scheme by rezoning part or all of the land comprised within that Plan for the respective purposes shown thereon and amending documents shall be prepared accordingly.
- 2.12.5 The Council shall -
 - (a) append a copy of the Outline Development Plan to the amending Documents forwarded to the State Planning Commission and Minister for preliminary approval;
 - (b) ensure that a copy of the Outline Development Plan is available with amending documents for the duration of the period for which the amendment is exhibited for inspection by the public;
 - (c) examine the content of the Outline Development Plan in the light of any submissions received and may amend or require amendment to the Plan consistent with modifications considered by Council to be appropriate to the Town Planning Scheme Amendment;
 - (d) adopt the Outline Development Plan as may have been amended and make the Plan available for public inspection as a guide for subdivision and development;
 - (e) forward a copy of an amended Outline Development Plan with the amending documents when requesting the final approval of the Minister to the Amendment.
- 2.12.6 Adoption of an Outline Development Plan by Council shall not preclude subsequent amendments being made to that Plan or the preparation of a new Outline Development Plan where Council considers such amendments or the preparation of a new Plan, to be appropriate.

- 2.12.7 Notwithstand the foregoing, the Council may recommend approval of an application to subdivide, or grant planning approval for development, provided it is satisfied that approval of such subdivision or development would not prejudice the overall subdivision and development of other land included within the Residential Development Zone."
- 5.4 Rezoning part Murray Locations 75, 138, 139, 293, 299, 672, 727, 1132, 1133, 1145 and sections of roads to be closed, from "Rural Zone" to "Residential Development Zone".

6.0 SETTLEMENT CENTRE ZONE

6.1 Rezoning portion of Murray Locations 1133 and 738 from "Rural Zone" to "Settlement Centre Zone".

In accordance with the Scheme Amendment Map.

Adopted by resolution of the Council of the Shire of Murray at the meeting of the Council held on the day of 1987.

PRESIDENT

SHIRE CLERK

Adopted for final approval by resolution of the Shire of Murray at the meeting of the Council held on the _____ day of _____ 1987.

PRESIDENT

SHIRE CLERK

Recommended/Submitted for final approval by the State Planning Commission

CHAIRMAN OF THE STATE PLANNING COMMISSION

DATE:

MINISTER FOR PLANNING

DATE:

Final Approval Granted

FIGURES



LOCATION OF POINT GREY STUDY AREA

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0 1k

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CONCEPT PLAN

Figure 2



LOT DEVELOPMENT AND POPULATION TRENDS











ACCESS ROAD LOCALITY PLAN



(x x) Ameann C10-N MEALUP PROPOSED SEWERAGE CONCEPT PLAN (SOURCE: SINCLAIR KNIGHT & PARTNERS) PROPOSED ROAD NETWORK Figure 6



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THOMAS PEEL COLLEGE-AVERAGE WORKFORCE ESTIMATES DURING CONSTRUCTION



TOPOGRAPHY OF POINT GREY DEVELOPMENT AREA



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EXPLORATION BORE

APPROXIMATE REDUCED LEVEL OF WATER TABLE

ASSUMED DIRECTION OF GROUNDWATER FLOW

GROUNDWATER CONDUCTIVITY IN MICRO mhos/cm (CORRECTED TO 25°C)

1000- ISO CONDUCTIVITY CONTOURS (MICRO mhos/cm)

APPROXIMATE EXTENT OF FRESH WATER LENS (<1000mg/L)

GEOLOGY

TAMALA LIMESTONE (QUATERNARY)

LEACHED & REWORKED TAMALA LIMESTONE (QUATERNARY)

SAND, F-fine, M-medium, VC-very coarse (QUATERNARY)

CLAY, SAND (QUATERNARY TO RECENT)

42500

42400

43400

51000

EAST

PEEL INLET ∇

HYDROGEOLOGICAL CROSS SECTION



PROPOSED AND EXISTING CONSERVATION RESERVES





WETLANDS AND NATURAL BUSHLAND AREAS WITHIN THE WAROONA MOUND



BATHYMETRY OF PEEL INLET AND HARVEY ESTUARY



AQUATIC BIRD CENSUS LOCATIONS


* MACRO ALGAL SAMPLING SITES

- 1 Point Grey Site
- 2 Point Grey Site
- 3 Point Grey Site
- 4 Point Grey Site
- 5 Coodanup site
- 6 Channel site
- 7 Falcon site

A COMPARISON OF ALGAL BIOMASS FOR SELECTED SITES NEAR POINT GREY AND PEEL INLET







WITH MANAGEMENT (Maximum load of 4.5 t/yr P)



PREDICTED PHOSPHORUS LOADING FROM THE DEVELOPMENT OVER TIME



UPPER LEEDERVILLE AQUIFER RECHARGE ZONE



SCHEMATIC LAYOUT OF SHALLOW GROUNDWATER SUPPLY SIMULATION

