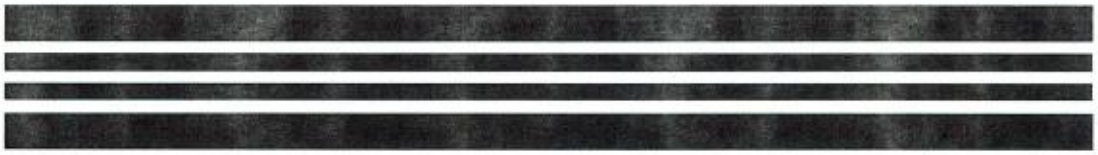

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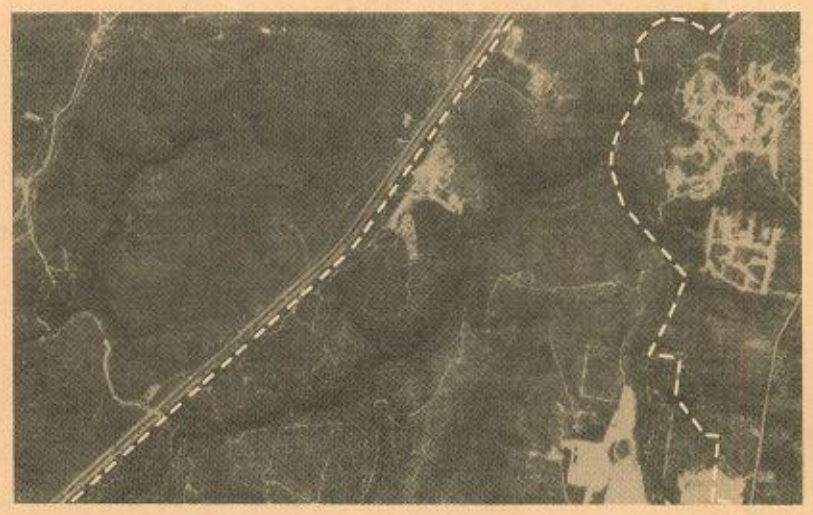
West Menai release area : environmental study

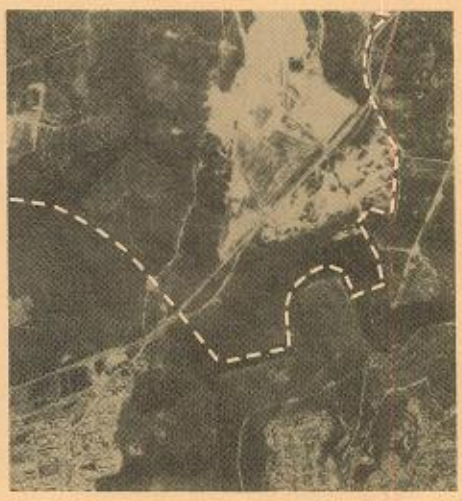
OF SUTHERLAND .

WEST MENAI RELEASE AREA

Environmental Study

VOLUME 1 : REPORT





Neil Bird & Associated Consultants Pty Ltd

in association with

R Travers Morgan Pty Ltd

Hirst Consulting Services

Hollingsworth Consultants

January 1984

SHIRE OF SUTHERLAND

WEST MENAI RELEASE AREA

Environmental Study

VOLUME 1 : REPORT

Neil Bird & Associated Consultants Pty Ltd

in association with

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Hollingsworth Consultants

January 1984

SUMMARY AND RECOMMENDATIONS

THE CONTEXT OF THE REPORT

Since the early 1960's, the Menai area has been considered by the Government, as a potential area for urban expansion. The Sydney Region Outline Plan, published by the State Planning Authority in 1968, foresaw Menai as a major urban development area.

Development of Menai New Town Stage I commenced following gazettal of Interim Development Order No. 23 in November 1971.

By mid 1981, the detailed planning and development of the suburbs of Bangor, Menai, and Illawong was well advanced and the Government decided that consideration should be given to the commitment of Stage 2, the West Menai Release Area. Most of this land is, or will be, Crown Land and therefore has the potential for the closest coordination with Government servicing programmes.

Under the Environmental Planning and Assessment Act, 1979, it is the responsibility of Council to prepare the Local Environmental Plan (LEP) to guide the development of West Menai. The Department of Environment and Planning invited Council, by letter of 7 September 1981, to consider a resolution under Section 54 of the Act to prepare an LEP for the release area.

On 2 November 1981, Council resolved to do so and consequently, on 2 December 1981, the Department of Environment and Planning advised Council that an Environmental Study would be required.

An Environmental Study assesses the natural and man-made environment of the study area in terms of its opportunities for and constraints upon various uses. The impacts of the interaction between the environment and an identified preferred use are demonstrated.

The planning consultant Neil Bird and Associated Consultants was appointed in October 1982 to undertake the Environmental Study under the direction of a steering committee representing the Sutherland Shire Council, Department of Environment and Planning, and the Crown Lands Office.

The consultant has addressed the Study Specifications set out in Appendix J of the Report.

Following exhibition of this Study, Council will consider submissions from the public and relevant authorities, and determine and adopt the aims and objectives of the draft Local Environmental Plan. The draft LEP, when certified by the Department of Environment and Planning as to its compatibility with State and Regional Policies and Plans, will be exhibited for public comment. After consideration of submissions, the Council will submit the draft Plan, as amended if necessary, to the Department. Detailed planning and development may commence following adoption of the Plan by the Minister for Planning and Environment.

FINDINGS

Subject to the recommendations set out in this summary:

a. The West Menai Release Area is capable of urban development with a potential for 5,000 home sites for over 18,000 people, almost 60ha of industrial land and 800ha of open space.

b. Examination of financial, environmental and servicing factors indicates that development is feasible.

c. The logical staging arrangements would be:

Stage I — Planning areas 25 and 26* which adjoin the south-west of I.D.O. 23 and which can be serviced by the extension of existing mains.

Stage II — Planning Area 35 in the north will be directly served by the sewer and water viaduct which will cross Mill Creek in that vicinity.

Stage III — Areas generally south of Stage II adjoining Heathcote Road - Planning Areas 34, 33, 32.

Stage IV — Planning Areas 30, 31, 27(part), and 28, which are influenced by the proposed Barden Creek fill area.

Stage V — Planning Area 36 in the north. Could be earlier if sewer available.

Stage VI — Areas in close proximity to the 1.6km AAEC exclusion zone which are affected by the need for a major water reservoir, and to a lesser extent, the artillery firing (i.e. part Area 28 and the greater portion of Area 29).

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* Planning areas referred to throughout the study are based on contiguous land units with common characteristics and are depicted in Map 11.

Final structure plan and staging arrangements would be greatly influenced by the alternative decisions on the position of any major road link and the location of the MWDA facility.

d. The best planning solution to provide a high degree of access between West Menai and East Menai would be a road from Barden Road/Old Illawarra Road west to Heathcote Road.

The cost of the road would be very high involving at least one high level bridge over the creek gorges.

e. The location of and responsibility for the road connections require further engineering investigation and cost benefit analysis.

RECOMMENDATIONS: GENERAL

The following recommendations concern the continued planning of the Release Area:

a. That the engineering requirements for the major east-west road link and its location be finalised as a basis for the preparation of an LEP and any supporting development control or structure plans.

b. That part of Planning Area 29 adversely affected by services and/or artillery noise, be excluded from the LEP until such time as services are available and longer term community land requirements are more fully evident. The alternative of utilising upper Mill Creek (including lands within the 1.6km exclusion zone) for waste disposal requires further investigation and appraisal.

c. That planning for the West Menai Release Area be pursued by Council through the preparation of a draft LEP and by due process to adoption of the Plan. In accordance with Government programmes, lot production should commence by 1986/87.

d. That following adoption of the LEP, a major open space study be undertaken to formulate a management policy for open space resources.

e. That Council prepare a Social Plan as a basis for determining the type and extent of community facilities and services to be provided for in the LEP.

RECOMMENDATIONS: KEY ISSUES

Key issues were identified in the Brief and during the course of this Environmental Study. These had a considerable bearing on the FINDINGS of the Study and therefore recommendations related to each of these issues have been highlighted in this summary. References to page numbers in the body of this report are included for convenience.

NO.	KEY ISSUES	REF	RECOMMENDATIONS
1	**ACCESS**		
	a. Requirement for east-west road links to provide convenient access to existing and planned facilities	36-38 68-69 86-87 App D	i) That a decision on the location, design standard and number of east-west links be made following more detailed assessment of feasibility and need.
	b. Responsibility for provision of regional access through the Study Area.	App D	ii) That in the event of road requirements being identified as beyond the responsibility of the land developer, the matter be be resolved through the Government or its agencies before any commitment to an LEP is made.
2	**REGIONAL WASTE DISPOSAL REQUIREMENTS**		
	a. 600,000 residents of southern Sydney contribute to waste disposal at Lucas Heights.	30 65-66	i) That, as Bardens Creek is in its natural state and bordered by lands with residential potential in the short term while Upper Mill Creek is environmentally degraded, highly accessible and not suitable for residential uses in the medium term, consideration should be given to accommodating regional waste disposal facilities at Upper Mill Creek.
	b. Existing tip reaching capacity.	30	
	c. New tip, as part of 30-40 year plan, required to be operational by 1986.	30	
	d. The resolution of		ii) That waste disposal sites

NO.	KEY ISSUES	REF	RECOMMENDATIONS
	the West Menai LEP is therefore dependent upon the outcome of the MWDA's development application to fill Barden Creek, or any other part of the Release Area. MWDA's proposals are subject to a separately prepared Environmental Impact Statement.	65-66	be planned and managed for an ultimate long term use. iii) That development be staged and waste disposal managed to ensure minimum conflict between waste disposal operations and residential, recreational and other proposed land uses.
3	**ATOMIC REACTOR**		
	a. Land use and population restrictions apply from 1.6km to 4.8km from reactor.	31 64 114	i) That development conform to land use and population restrictions set down in guidelines adopted by State Government.
	b. Minimal uses allowed in 1.6km exlusion zone.	64 116	ii) That planning be flexible to allow for relocation of the reactor.
	c. Obsolescence and other factors could result in further changes in policy.	31	iii) Low demand uses, e.g. waste disposal, be located within 1.6km exclusion zone.
4	**HOLSWORTHY ARTILLERY RANGE**		
	a. Noise and vibration by gun fire.	50-51 68,113	i) That residential development be excluded from areas affected by

NO.	KEY ISSUES	REF	RECOMMENDATIONS
	b. Long term use.	32,50 68,113 122	artillery noise in excess of levels recommended by the National Acoustics Laboratory, i.e. the most south-westerly part of the site. ii) That planning be flexible to allow for any down-grading of use on the Holsworthy range.
5	**BUSH FIRE**		
	a. Most of the Study Area is rated high fire hazard in its present undeveloped condition.	55-60	i) That suitable arrangements be made with appropriate authorities to provide for adequate and on going hazard reduction along both sides of Heathcote Road.
	b. Following development perimeter areas would continue to be rated high fire hazard	59-60 114-115 125	hazard reduction on the slopes to the west of Heathcote Road down to Deadmans Creek. ii) That planning be flexible to allow for any down-grading of use on the Holsworthy range. iii) That perimeter dwellings should be controlled for external facade design and construction materials.
6	**SERVICING**		
	a. Services aqueduct planned across Mill Creek	34	i) That service authorities maintain their programmes to

NO.	KEY ISSUES	REF	RECOMMENDATIONS
			construct an aqueduct for sewer, water and electricity across Mill Creek by 1986/87.
	b. Water service restrictions due to topography.	33 70	ii) That optimum use of services be made through maximum utilisation of demand.
	c. High cost of services due to terrain.	70 125	

IMPLICATIONS AND IMPACT

The following checklist indicates aspects of the impact of development of West Menai on the existing environment which were addressed in this Study.

ISSUE	REF
1. ACCESS	
a. Increased demand for external regional roads.	App D
b. Regional traffic demands on Release Area roads.	App D
c. Demand for roads in Release Area generated by potential 8000 vehicles.	App D
d. Demand for public transport and impact of East Hills railway extension.	App D
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. services	30
. noise	53
. visual intrusion	65,112,120
. open space	104,115-118
. structure plan	105-106,123
3. ATOMIC REACTOR	
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b. Sterilization of uses in exclusion zone.	64,116
c. Impact of low waste burial ground.	31,114
4. ARTILLERY FIRE	
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5. BUSH FIRE	
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b. Implications of adopting Bush Fire Policy restrictions on hazard rating reduction.	60,115
c. Implications of Bush Fire policy on lot yield.	115,123
6. SERVICING	
a. Implications of water supply restrictions on staging and access provision.	34,70
b. Implication of Telecom's requirement for micro-wave receivers on staging and visual impact.	35
c. Impact of sewer carrier on staging and natural environment of valley system.	34-35,70
d. Implications of high cost of servicing on staging and phasing.	70,125
7. GEOLOGICAL RESOURCES	
a. Implications of not allowing extraction of surface resources of: . clay/shale . sandstone . dimension stone	App A
b. Implications for urban development by allowing extraction.	112
c. Implications of not adopting recommended design criteria for subsidence.	112
d. Implications for adopting the criteria on building costs, servicing.	112

ISSUE	REF
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c. Implications of population of 18000 on demand for other land uses: . industry . institutions etc	109-111
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b. Implications of future tip area of fulfilling some regional open space requirement.	118
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a. Implications for Sandy Point of development of preferred strategy: . access . services . community facilities.	32-33, 113-114

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1. INTRODUCTION

1.1 Background to Study

The Menai area, which includes the localities of Illawong, Lucas Heights, Alfords Point and Bangor, is situated on a sandstone plateau bounded to the north by the Georges River and to the east by the Woronora River. The Holsworthy Artillery Range and the AAEC Research Laboratories provide an effective barrier to development to the west and south.

Although not well served by roads and transport, the Menai district has for some time been considered by authorities as having potential for urban development. Planning for the area in the late sixties and early seventies identified some 38 precincts suitable for development and the first 24, generally to the east of Mill Creek and Old Illawarra Road, were considered in more detail for release for urban purposes.

Closely associated with this Menai land released in 1971, under Interim Development Order 23 the urban release area of West Menai was announced by the Government in 1974. However, due to a number of constraints including servicing, access and availability of land in the early stages, planning of West Menai was delayed.

In 1981 the State Government foreshadowed the early release of the land, primarily for residential purposes, subject to an environmental study. Most of the land at West Menai is, or will be, Crown Land and for this reason the Crown Lands Office, as the authority responsible for the land, decided to establish the development capability of the area and to initiate the planning procedures necessary to permit development at the earliest practical time commensurate with infrastructure funding programmes and market demands. To this end, a study area was defined and consultants appointed to carry out an environmental study.

The study area, which essentially embraces planning areas 25 to 36 of the previous strategy, is a tract of some 1,600 ha bounded on the west by Heathcote Road, the north by Georges River, the east by Mill Creek and Illawarra Road, and the south by the limits of influence of the Australian Atomic Energy Commission's establishment at Lucas Heights. Map 1 shows the extent of the study area and its relation to the Sydney Metropolitan Region.

1.2 Study Objectives

Neil Bird & Associated Consultants Pty Ltd was appointed principal consultant with a brief to meet the following goals and objectives:

Study Objective

The Government's announcement of the Release Area and Investigations by service authorities to date indicate that urban development of the area is desirable.

The objective of the Environmental Study is to examine the study area for its potential for urban development to disclose alternate uses and the impacts of any decision.

Planning Goal

The goal is to produce a Local Environmental Plan which will allow development to proceed at an early date with a minimum involvement of resources (planning and engineering) by Council and the Department of Environment and Planning. The Local Environment Plan will set performance standards, allowing many forms of development without consent. These will be in addition to the stated aims and objectives of the LEP which must be determined by Council as part of the process of preparing the draft LEP.

Specifications for the study as set down in the consultant brief are included in Appendix J.

Because of the complex nature of the assignment, R Travers Morgan Pty Ltd, Hirst Consulting Services and a number of specialist subconsultants were included in the study team.

1.3 Structure of Report

The environmental study report is set out as follows:

Chapter 2: Natural Environment describes the key environmental characteristics of the study area including topography, drainage and slope, geology and soils, flora, fauna and climate. This is mainly a record of what exists on the site but in some instances, such as air pollution risk, broad constraints to development are identified.

In **Chapter 3: Man-Made Environment,** the impact of man on the locality from earliest times to the present is considered. A section on archaeology summarises the findings of a separate subconsultant study while other topics covered include district population, existing land uses, access, water quality, noise and bush fire hazard.

Conclusions drawn in the background studies described in Chapters 2 and 3 are brought together in **Chapter 4: Development Potential.** The study team identified constraints to development such as slope, subsidence, noise, vegetation, archaeological sites, committed land use, access, services, and bush fire hazards, while opportunities for development were also highlighted. Geological resources not yet extracted, landscape features, environments suitable for recreational activities, and a growing demand for housing which could be met in this district were all seen as opportunities for development.

Chapter 5: Development Options sets out a number of broad options for development evaluated by the study team. A preferred strategy and structure plan is described in more detail and supplemented by implementation guidelines. The impact of the preferred strategy on the natural environment and on a future population is assessed and the report concludes with a section on development phasing and financial considerations.

2. NATURAL ENVIRONMENT

2.1 Topography

The limiting factor in the development of West Menai is its topography. It dominates all other constraints to urban development in a way which is uncommon in the Australian urban environment. The problems associated with the topography of West Menai are severe and expensive to solve.

The most obvious feature of West Menai is a deeply dissected sandstone plateau which has been uplifted and tilted to the north. Because of the gentle northward slope of the surface, all drainage is generally in the northerly direction. A jointing pattern in the sandstone superimposes secondary control on the drainage pattern, so that while the major streams flow north, tributaries branch off to the east and west.

The major watercourses have incised deep and precipitous valleys in the sandstone plateau. Aside from the Woronora River, which adjoins the southeastern corner and drains a different catchment, there is only one major stream in the study area (Mill Creek). It has four significant tributaries. Three of these tributaries drain the southern half of the study area; one joins Mill Creek near its mouth to the north. The Mill Creek catchment drains into the Georges River, which forms the northern boundary of the study area.

Roads have generally been constructed on the interfluves; Heathcote Road and New Illawarra Road define the Mill Creek catchment.

The sandstone cliffs overlooking the Georges River and the high plateau which rims the western boundary are of regional landscape significance. The former provides a dramatic backdrop to the river, while the high plateau forms part of the southern skyline when viewed from Botany Bay and the lower-lying suburbs in the southern part of Metropolitan Sydney.

The sandstone cliffs overlooking Mill Creek are of local landscape significance because they provide visual access and orientation to the dominant natural features of West Menai: high plateaus and steep stream valleys.

Because of the nature of the site, slope characteristics provide a significant constraint to development.

Map 2 shows the distribution of the major slope classes in the study area. Steep slopes enhance processes, such as erosion, bush fire hazard, noise transmission, and subsidence after mining. These topics are discussed elsewhere in this report. The cost of providing services and road access across and along steep slopes is much greater than on gentle slopes. Slopes greater than 25%, or less than one percent, are not recommended for development. Such topography comprises about 30% of the total study area.

The fact that West Menai has thus far remained undeveloped is primarily due to its local topography.

2.2 Climate

Climatic information is necessary in a study of this type for two reasons:

i) it provides important guidelines for the sensible design and orientation of urban development, particularly with regard to predominant winds; and

ii) it permits analysis of the extent to which meteorological conditions may enhance or disperse man-made air and noise pollutants in the study area. The dispersion of the Holsworthy artillery noise is affected by meteorological conditions.

The regional climate may be described as warm-temperate with a maritime influence which decreases rapidly westward. The Bureau of Meteorology records show that, averaged over the long term, West Menai receives adequate and reliable rainfall spread fairly evenly throughout the year (refer to Table 2.1). However on an annual basis, there are often protracted periods of very dry conditions, particularly in summer months, and also periods of abnormally high rainfall.

The climatic averages for Lucas Heights, the nearest recording station, are shown on Table 2.1. The period of record is 24 years.

Mean rainfall for individual months ranges from 45 mm for July to 132 mm for March. Over the long term, rainfall is greatest from January to March, with a secondary peak occurring in June. The mean annual rainfall is 1,016 mm.

The surface wind data from the Lucas Heights meteorological station has been graphed as monthly 0900 and 1500 hour wind rose diagrams in order to provide a rapid but comprehensive visual summary of the wind information. These diagrams are presented in Appendix K.

Surface air, which is cooled at night under the influence of nocturnal temperature inversions, tends to drain down the slopes from higher ground. These drainage "breezes" then proceed to flow along the valley contours towards the coast (Douglas, 1982). This means that the night and early morning drainage (katabatic) flow is northward down the Woronora and Mill Creek valleys to the Georges River, where it drains eastward into Botany Bay.

During the day there is a recirculation of the airflow, and it may move back up the valleys, under the influence of the Botany Bay breeze and the sea breeze.

The stronger surface winds are generally southerly and may occur throughout the year, but are most frequent in the afternoon and evening during the summer months. Winter months exhibit stronger and more frequent westerly winds (up to about 50 km/hr) while the summer months are characterised by the sea breeze near the coast which rarely exceeds 40 km/hr.

Temperature inversions occur when the lower air mass is colder than that above, with atmospheric temperature increasing with height. This happens when air near the earth's suface is preferentially cooled during rapid radiant cooling of the earth's surface on cold, clear nights. Air inversions are common in the Sydney basin, and often last well into the daylight hours. The frequency of inversions at Lucas Heights has not been measured, but at other localities in the Sydney region inversions occur almost every night in winter and on slightly more than 50% of nights in summer.

2.2.1 Air Pollution

Air pollution is possible from the following sources (listed in increasing order of perceived risk):

i) Gaseous emissions from the AAEC HIFAR reactor or ancillary equipment. Advice has been received from the Health Commission of NSW that there are no significant concentrations of any gaseous emissions from the AAEC Research Laboratories in the study area and they are not aware of any meteorological conditions which are likely to significantly affect the exposure levels of the radioactive component of any gaseous emissions. Therefore, this threat is regarded as negligible.

ii) Odours and dust from the MWDA solid waste disposal area. This hazard is greatly minimised by modern compartmentalising and compaction techniques.

iii) Gaseous or particular emissions from any future industry which may develop in the area. These should be adequately controlled by SPCC air quality regulation and monitoring.

iv) Odours from the decommissioned liquid waste disposal area. Unpleasant smells are noticeable within 50 - 100 m of the periphery of the site, particularly downwind. The degree of toxicity, if any, is unknown.

v) Smoke from bush fires in the area. Bush fires are a frequent occurrence in this district, particularly within and adjacent to the Holsworthy military training reserve. The greatest period of risk is during hot, dry weather in mid to late summer.

The higher, elevated land on the plateaus is reasonably well ventilated over most of the year and should not pose any significant hazard from air pollution (Douglas, 1982). However, as temperature inversions are probably a common occurrence in the valleys, this phenomenon may delay the escape of smoke or fumes during night time and early morning. The stability of the air in an inversion is very great and pollutants tend to concentrate in inversion layers.

Furthermore, the Defence Impulsive Noise Study (DINS) of the Holsworthy artillery range (refer Section 3.9) recognised higher noise levels at the surface during periods of inversions and a noticeable drop in surface noise at nearby monitoring stations (including West Menai) as the inversion broke up.

TABLE 2.1: CLIMATIC DATA FOR THE MENAI AREA

Station Name: Lucas Heights

Number 066078 **Latitude:** 34 deg. 3 min S **Longitude** 150 deg 59 min E
Elevation: 158.5 m

(Adapted from Bureau of Meterology records, 1982; averages for records since 1958)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature:													
Mean daily max temp	25.9	26.0	24.7	22.3	18.9	16.2	15.8	17.2	19.5	21.6	23.4	25.8	21.4
Mean daily min temp °C	17.4	17.6	16.1	13.3	10.1	8.2	6.6	7.4	9.3	11.9	13.7	15.9	12.3
Mean Rel. % Humidity													
9 am	69	72	72	71	71	74	69	66	62	61	63	65	68
3 pm	62	64	62	57	55	57	50	50	51	56	57	59	57
Mean Rainfall (mm)	121	92	132	86	78	113	45	62	55	77	84	73	1016
Mean No. Rain Days	12	11	12	9	9	11	6	8	9	11	11	12	119

2.3 Geology and Soils

This section is a summary of Appendix A and provides a background to the discussion of geological resources in Section 3.3 (Land Use and Planning).

2.3.1 Geology

The surface rocks of the study area are mainly Hawkesbury Sandstone although outcrops of the lower shales of the Wianamatta Group occur on the higher plateaus. The Hawkesbury Sandstone consists predominantly of uniform, massive, thickly bedded, medium to coarse grained quartzite and sandstone with some interbedded lenses of shale and conglomerate. Clay and shale lenses of limited extent can occur in the Hawkesbury Sandstone. Interbedded shale, clay and sandstone occur in the "Little Forest" area, where up to eight metres of clay and shale are exposed in the Harrington quarry. The shale typically consists of light to medium grey silty clay with numerous fine sandy partings near the base of the lens. The clay in the Hawkesbury Sandstone is low in iron content and usually highly plastic. It fires to a cream colour because of its high kaolin content. It is particularly valuable as a blending clay in the manufacture of clay pipes, tiles and bricks because it provides the water-proofing qualities which are required.

Outcrops of the lowest formation of the Wianamatta Group, the Ashfield Shale, occur as thin, residual, ridge cappings along Heathcote Road. These clays are usually iron stained and often sandy; as a result they are usually of little economic value. To the east of Old Illawarra Road, south of Menai Road, and outside the study area boundary, a thicker deposit of the Ashfield Shale overlies the sandy transition beds above the Hawkesbury Sandstone.

Lateritic gravels occur as residual deposits on the tops of the plateaus.

The Narrabeen Group lies beneath the Hawkesbury Sandstone and consists of a number of sandstone and claystone formations. This group overlies the Illawarra coal measures which contain coal reserves at a depth of 700 m and greater.

Map 8 shows the location of shale outcrops and other geological resources within the study area.

The sandstone terrain is broken by a well-developed set of tectonic joint patterns which generally trend north-south and east-west. Stress release joints, suffering from erosional effects, are also evident along the sides of the deep gorges.

The principal geological resources within the region are:

i) sandstone - used mainly for roadbase and flagstone but also some high quality dimension stone;
ii) clay and shale used for brick, pipe, tiles and other clay products;
iii) laterite - used for road gravel;
iv) sand - used for building purposes (cement, concrete, fill); and
v) coal - two seams below 700 m depth, one of hard coking coal, and one of steaming coal.

The coal beneath the study area occurs in two seams, namely the Bulli seam which is approximately 1.3 m thick at a depth of 700 m and is considered to be good quality, hard coking coal and the Wongawilli seam which is about three metres thick at a depth of 780 m and is considered to be softer steaming coal (Department of Mineral Resources - verbal communication).

Because of the depth of the relatively thin seams and the amount of intervening waste material, they are not regarded as economic to extract at the present time using conventional longwall techniques. However if they were mined in the future, a minor amount of subsidence could be expected at the surface. This is discussed in more detail in Appendix A.

2.3.2 Soils

Because soils are derived primarily from the parent rock which underlies them, they generally reflect the same composition and nutrient composition. The soils in West Menai are derived from sandstone, laterites and some weathered shale. These soils are generally sandy, low in nutrients and organic content, and highly erodible.

The dominant soil type is the skeletal/colluvial soils (over one-third of the study area) with nearly as much of the area covered in shallow sand. This material can hardly be called "soil" at all, since it contains very little humus and provides little plant nourishment. This soil type is very highly erodible when the vegetation cover is disturbed. When this occurs large amounts of sandy sediment are contributed to the Georges and Woronora Rivers.

The soil types which occur in the study area are shown on Map 3. This information was originally produced by the Soil Conservation Service (SCS) as part of the Environmental Control Study of Botany Bay (SPCC 1979).

Further detailed information concerning soil type, erodibility and limitations to development are discussed in Appendix A. Also the reader is referred to Section 6 of the SCS report for discussion of the erosion problem at West Menai.

Soil erosion is a serious problem at West Menai at the present time.

Map 4 depicts those areas which it is considered should, or should not be developed with regard to erosion potential. Also identified on this map are those areas which have severe physical limitations to urban development but which could be overcome with detailed site investigation and careful engineering design.

Included in this latter category is the night soil area, shown as a stipple pattern on Maps 3 and 4. Several portions of land have been leased by the Commonwealth to Sutherland Shire Council for the purpose of night soil disposal and, separately, for liquid trade waste disposal (see Section 3.8 for a more complete description).

The liquid waste area can never be used for any purpose whatsoever because of the shallow depth of cover and unstable nature of the waste materials.

The area used for night soil burial has gradually been reduced as the number of pans requiring servicing has been reduced (presently to about 340). The soil is rich in humus and the site may be suitable for future use after lying fallow for fifteen years (Department of Health verbal communication). Testing of the soil would be required to determine

whether there is contamination by pathogenic organisms or their spores. If testing proved satisfactory, grading or even removal of top soil may be required before development could proceed.

As a result of quarrying, land fill operations, borrow areas and uncontrolled recreation by off-road vehicles, the study area shows signs of moderate to severe sheet and gully erosion. Most of the creek drainage lines reveal some abnormal sediment accumulation; the worst example of stream sedimentation observed is in the unnamed western tributary of Mill Creek at the northern end of the study area. In some of the downstream sections of that tributary large sandbars and migrating lobes of sediment are present. If any value is attributed to these streams at all, then erosion will have to be stopped at the source; even then it will take many years of flood scour to return the streams to their original gradients and character.

It is recommend that Mill Creek and its western tributary be protected from further sedimentation because of their high ecological and aesthetic value (refer to Sections 2.4 and 4.1).

The best means of reducing erosion and maintaining natural stream profiles in West Menai is by urban development of the plateaus. Landscaping and revegetation will halt further erosion of the plateaus, while the hard surface provided by roads, footpaths and roofs would maintain significant stormwater runoff to the creeks. This stormwater flow will aid in the scour of the unnatural sedimentation in the drainage lines and return them to their natural condition, possibly even more quickly than they otherwise would. The natural rock substrate of the drainage lines will prevent unwanted increased erosion as a result of any increased runoff.

2.4 Vegetation and Fauna

2.4.1 Vegetation

The vegetation of West Menai is, for the most part, typical of the Hawkesbury Sandstone vegetation associations which occur within the Sydney Region. Although these associations of plants are common locally, they are also unique to this region and are distinguishable from any other plant associations in the world. In its luxuriant forms, particularly on shales or in creek valleys, this vegetation is undoubtedly attractive. There are also a few plant species found at West Menai which are rare or have a very limited distribution.

In a regional context the area lacks any special significance for flora or fauna. This is because it is a relatively limited area, and the original vegetation, particularly open-heath and scrub, has suffered extensive disturbance. Furthermore, there are a number of substantial reservations of similar habitat within the region, most notably Royal, Ku-ring-gai Chase and Brisbane Waters National Parks for coastal heath or scrub and swamp forest vegetation, plus Blue Mountains and Wollemi National Parks for open forest (wet and dry sclerophyll) and woodland vegetation.

However, there are parts of the West Menai area that are significant locally. The vegetation and complex macro-habitats of the steep valley and sideslopes of Mill and Bardens Creeks produce the most diverse habitat in the area, both in terms of structure of the vegetation and its floristic composition. Correspondingly, the fauna of open forest areas on the steep valley slopes would also be more diverse than in other habitats.

Additional and more detailed information related to the flora and fauna of West Menai is presented in Appendix B.

2.4.2 Vegetation Types

All vegetations has been described using the Specht et al (1974) structural classification scheme. Details of the dominant species in each structure class can be found in Appendix B.

Open-Forest

In all the drainage lines, where increased shade, moisture, and shelter are available, the dominant vegetation is open-forest (wet, dry, and swamp sclerophyll, using the Williams classification). The dominant trees of this habitat are 10-25 m tall, with approximately 50% projective foliage cover. Four types of open-forest may be distinguished:

Type 1: occurs on Hawkesbury Sandstones, mainly in sheltered positions along major watercourses;
Type 2: occurs on Wianamatta Shales locally on the plateau surface because of the water retaining capacity of the soil, the trees are spaced more closely than in Type 1;
Type 3: occurs on the alluvium of the Georges River and lower Mill Creek, in areas of high salinity; and
Type 4: occurs on the alluvium of the Georges River and lower Mill Creek, in areas of low salinity.

The dominant species in each type are described in Appendix B.

Woodland

The dominant trees of this habitat are 10-20 m tall, with approximately 25% projective foliage cover. There is a close botanical affinity with open-forest (Type 1). Woodland is lower and more open than the forest because it occurs in more exposed areas and on shallower soils.

Low Woodland, Open-scrub and Open-heath

These habitats are best treated together because they occur as a complex mosaic in response to local conditions of soil depth and moisture. A unifying feature is the occurrence of dwarf eucalypts in all habitats. In low woodland, the dominant trees are 5-10 metres tall with approximately 20% projective foliage cover; in open-scrub, the dominant shrubs are two to five metres tall with approximately 50% projective foliage cover; and in open-heath, the dominant shrubs are less than two metres tall with approximately 40% projective foliage cover. In some areas, particularly beneath electricity transmission lines, these structure classes have been induced by the periodic felling of trees in the original open-forest or woodland.

Low Closed-Forest (Mangroves)

This habitat has dominant trees less than eight metres tall, with greater than 70% projective foliage cover. It is confined to alluvial deposits of the Georges River and lower Mill Creek, where tidal inundation occurs regularly. The dominant tree is **Avicennia marina**; the subordinate **Aegiceras corniculatum** occurs as a small tree or shrub. Both species occur along Mill Creek to the limit of tidal influence, but only where the shoreline is muddy and has an almost horizontal gradient.

Sedgeland (Saltmarsh, Samphire)

This habitat consists of sedges and herbs less than one metre tall, with approximately 50-70% projective foliage cover. It is associated with low closed-forest on alluvial deposits, but where tidal inundation is infrequent. It is dominated by the sedge **Juncus kraussii**, and the succulent herbs **Sarcocornia quinqueflora** and **Suaeda australis.**

2.4.3 Mapping of Vegetation Units

Because of constraints imposed by scale, and also for practical purposes of management and planning, the vegetation has been mapped as three major units:

Unit 1: Open-forest - Types 1, 2, 3 (including low closed-forest and sedgeland) and 4. Each type is differentiated on the map. However, the mangrove and sedgeland areas are too small to be distinguished at these scales.

Unit 2: Woodland

Unit 3: Low woodland, open-scrub and open-heath. Because these vegetation types are a complex mosaic, they are mapped together as one unit. There is no planning requirement that they be separated.

Disturbed areas are also indicated. These are areas disturbed by human activities, such as removal of laterite, trail bike riding etc. What remains of the original vegetation is still in its original structure class. This is particularly applicable to the heath on the plateaus, which is disturbed in most cases.

Areas of induced vegetation are also plotted. These are vegetation classes which are not the original natural structure but have been induced to a lower height and/or density for some reason. The most notable example in West Menai is where original open-forest or woodland areas have been cleared and/or reduced in height for reasons of safety within the electricity transmission easement.

The vegetation is shown on Map 5.

2.4.4 Rare or Restricted Plants

The flora of West Menai contains at least five plants of special interest; one is on the endangered species list, the other four are uncommon but are not considered vulnerable or endangered (Specht et al 1974).

The endangered plant is **Melaleuca deanei**, a shrub with paper bark, 1-3 m high. It is rare and its range is restricted to wet heath habitats of the central coast and adjacent plateaus. Its only known occurrence in the Menai area is at two sites: the most significant patch is on the western side of Heathcote Road about 0.5 km north of the junction with New Illawarra Road. This site is outside the study area boundaries but is in the bush fire control burn area.

The second site is a single plant specimen located in a trail bike area in the southwest corner of the study area. Its location is shown on Map 5.

Every effort should be made to protect this plant during development, particularly with regard to land clearing and bush fire control burning.

Of the other four uncommon plants, three are small shrubs: **Grevillea capitellata** is confined to the Central Coast plant region of NSW and is at its southern limit of distribution is West Menai; **Leucopogon amplexicaulis** is restricted to the Central and South Coasts; and **Tetratheca neglecta** is confined to the Central Coast and Central Tablelands (Jacobs and Pickard, 1981). The fourth is a tall shrub, **Acacia rubida** which apparently has a very limited distribution (Moore, verbal communication) and occurs in the upper reaches of Mill Creek.

The **Grevillea** is common on the disturbed open-heath areas of the plateaus, and the dry, shallow sideslopes of some drainage lines. **Tetratheca** occurs in the northeast corner of the study area (Schoer, verbal communication).; and the **Leucopogon** occurs in damp or protected gullies (Fairley, verbal communication).

A proposal for a field studies centre has been made for the area around Land Unit 35.1 and the drainage lines to the Georges River (A. Strom, 1970). It has a high education value in demonstrating a wide variety of vegetation habitats particularly in estuarine ecosystems. Consequently, we have adopted the concept of a field studies centre, in combination with other educational/scientific uses and we recommend that a nature reserve be declared over land shown on Map 12. This proposal is summarised in Appendix B.

2.4.5 Fauna

The relative conservation value of the study area with respect to fauna and their habitats is presented visually on Map 6.

Avifauna

Details of the avifauna of West Menai are found in Appendix B. A total of 79 bird species were recorded at West Menai during our field survey. All species are moderately common to abundant in NSW. The only species of special interest is the Rock Warbler; it is a moderately common ground bird confined to Hawkesbury Sandstone and associated limestone of central eastern NSW, where it nests in caves. It is the only endemic bird of NSW and it inhabits relatively undisturbed open-forest and woodland. It is locally numerous along Mill Creek.

Mammal Fauna

It is generally acknowledged (I. Pulsford, verbal communication) that the diversity and density of mammals is quite low in sandstone areas, presumably due to the lack of permanent water, lush understorey, and soil for burrowing/scratching for food or shelter. A list of mammals likely to occur at West Menai is found in Appendix B.

Insect Pests

The potential health risk posed by insects appears to be minimal. Mosquitoes are numerous along Mill Creek, and biting midges may be expected on the alluvial flats. These insects could be a nuisance to visitors. The effective treatment of wastes in the MWDA landfill area appears to have eliminated any health or nuisance risk from large populations of flies.

2.4.6 Recommendations

The areas shown on Maps 5 and 6 as being of high conservation status should be left undeveloped.

Allowance should be made for a regional park in the southwest corner of the study area. It is suggested that an area of about 20 ha of open-forest on the Wianamatta Shale and on the upper reaches of Mill Creek could be set aside in the approximate location shown on Options 2 and 3 (Fig. 5.1.2).

Consideration should be given to a field studies centre/community centre/Aboriginal cultural centre on land unit 35.1 as shown on Map 12.

Development of West Menai should be restricted as much as possible to the plateaus, particularly those areas already disturbed. Further clearing of the heath/scrub/low woodland complex would have a negligible effect on the conservation value of the area, except where rare or endangered plants are involved.

Every possible precaution should be taken to preserve any individual plants of Melaleuca deanei, an endangered plant. Its only known occurrence in the area is along Heathcote Road, about 0.5 km north of the junction with New Illawarra Road. Care should also be exercised to avoid disturbance to the other uncommon species described in this report.

Vegetated corridors across Heathcote Road from the Mill Creek valley to the Holsworthy training area should be provided where possible. This would permit and encourage the ready movement of fauna, particularly birds, between Mill Creek and the extensive vegetated area of the adjacent military training ground.

2.5 Landscape

2.5.1 Internal Visual Character

Apart from the extensive despoiled areas of the plateaus, the predominant landscape character of West Menai is that of a natural semi-wilderness area under great pressure because of its close juxtaposition to a major city. Despite this pressure the site contains some areas and features of considerable landscape value. The sculptured topography and variety of vegetation offer a number of different visual experiences, from the relatively flat open environment of the spur tops, through the junction of plateau and valley where the escarpment edge offers periodic views over and beyond the site to the small-scale enclosed environments without views down into the creek bottoms. On the high points (see Map 10) there are some panoramic views to the city and to the Blue Mountains. In the valleys, the mangroves along the lower Mill Creek and Georges River banks, tidal salt flats along the edge of the Georges River, and the gentler wooded grades of the upper creeks deserve particular mention. There are prominent sandstone outcrops on the escarpment edges, particularly along the lower reaches of Mill Creek and Georges River.

2.5.2 Regional Significance

The height of the plateau top makes the site visible in part from the Blue Mountains and from suburban city areas. The most significant elments in a regional context are the Georges River and the tidal areas of Mill Creek, important water recreation resources for which the visual character should be preserved. The Woronora Valley, though not as accessible as the Georges River, is also of regional significance. In the preservation of visual character the skyline is as important as the river foreshores.

2.5.3 Existing Visual Intrusions

A number of existing elements intrude across the site or impinge on the visual character of parts of the site. The most significant of these are the waste disposal tip east of the upper Mill Creek and three quarries within the site. Here the land use has destroyed the original vegetation cover and land form detail. Fortunately the waste disposal tip is

screened by the ridge to the west of it from most of the site, although this may not remain the case with further expansion of the tip. Next in importance are electricity power lines traversing the northern section to the major SCC substation across the Georges River which dominates the view from the escarpment top at the northern end of the site, the scarring of vegetated slopes caused by new roads and subdivisions on the east site of Mill Creek which will partly but not completely heal in time, and the noise and visual intrusion of Heathcote Road itself and the trail bike areas. The Lucas Heights development is apparent but not dominant at the south end of the site.

2.6 References

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Jacobs, S.W.L. and Pickard, J. (1981). Plants of New South Wales, Syd. Nat. Herb.

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Specht, R.L., Roe, E.M. and Boughton, V.H. (1974). Conservation of Major Plant Communities in Australia and Papua New Guinea. CSIRO Melbourne.

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3.0 MAN-MADE ENVIRONMENT

3.1 Archaeology

3.1.1 Introduction

The Woronora Plateau and the coastal estuarine outcrops of Hawkesbury sandstone are generally found to be rich in archaeological relics. For this reason considerable effort was expended during this environmental study to examine the archaeological significance of West Menai.[1]

Two earlier surveys of Bardens Creek had been conducted by Silcox (1980) and Attenbrow and Negerevich (1981), on behalf of the Metropolitan Waste Disposal Authority (MWDA). Surveys by Attenbrow (1981) and Brayshaw (1982) examined a site for a proposed concrete batching plant (shown as Area 11 on Map 7). A detailed archaeological report, including a summary of the Bardens Creek reports is provided in Appendix C.

3.1.2 Results of the Survey

A variety of archaeological relics has been identified in the West Menai area as being evidence of Aboriginal habitation within the last 3,000 years. The study area is regarded as being relatively rich in archaeological significance, with a total of 23 sites positively identified to date and a further 13 designated as potential occupation shelters.[2]

The Silcox survey of 1980 recorded 13 sites within the Bardens Creek catchment. As a result of Silcox's recommendations, surface collections and test excavations were made at the shelter sites in Bardens Creek and the art and the axe grinding grooves were recorded in detail by Attenbrow and Negerevich (1981).

Within the remainder of the West Menai study area, five sites had been recorded prior to the current archaeological survey. Possibly three of these pre-recorded sites were relocated and identified during the current

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1. Twenty person-days were spent in the study area by qualified archaeologists.
2. A potential occupation shelter has no visible signs of occupation such as art on the walls or occupation material on the ground; however, it does have an earth deposit which may contain archaeological evidence below the surface. Excavation is required to verify this possibility.

survey. This means that up to 20 new sites (including both positively identified and potential occupation shelters) have been identified as a result of this survey.

Not all areas were surveyed in detail, so there is a high probability of the existence of other sites yet undiscovered.

The locations of all known sites as well as the areas surveyed in detail are shown on Map 7.

Small stone artefacts (chips and flakes from implements) were found at two sites, M2 and M9; shells were found at six sites, near the Georges River: M2, M3, M4, M5, M7, M8.

Art was represented at sites M1, M6 and M8 and included hand stencils and figurative motifs. The hand stencils at site M6 are white, while those at site M8 are red. The figurative motifs at site M1 are in white and charcoal.

Shelter sites appear to be concentrated along and adjacent to the Georges River, and upstream on the major creeks where the valleys widen out. The absence of sites along the steep valley sides is apparently due to fewer available shelters and inaccessibility.

Axe grinding grooves were confined to the southern end of the study area, in the upper reaches of creeks where the valleys are wider, the creek beds are accessible, and wide outcrops of level sandstone occur.

Narrow grooves, perhaps used for sharpening spears, are common; more unusual is the large groove at site M10. Grooves of similar proportions to that at site M10 have been found in the north Hawkesbury region, but to date no use has been suggested for them. One possible use was for the

grinding or leaching of cycad nuts (from the Burrawang, or **Macrozamia sp.**) in an effort to detoxify them. Ethnographic evidence indicates that the use of cycads was widespread at the time of early European contact.

3.1.3 The Sites as a Complex

The sites so far recorded in the study area fall within the range of site types found within the catchments of the eastern Georges River and the Woronora River. The association of site types, i.e. shelters with occupation and/or art, engravings and axe grinding grooves, is the same as in the nearby areas. The absence of engravings is surprising; perhaps more may be said about their distribution when Areas 2 and 3 have been surveyed (see Map 7).

Open middens were also absent. However, they would not occur where river banks were steep, and most of the flatter areas near the river and lower Mill Creek were very densely vegetated. One possibly suitable point on the river had been disturbed. Siltation along lower Mill Creek may have obscured midden deposits.

Ten sites were recorded in the Mill Creek catchment, excluding Area 1 (Bardens Creek). With 11.5 km of watercourse, this represents 0.9 sites per km, compared with the Bardens Creek ratio of 1.6 sites per km of watercourse.

The sites are concentrated in two areas: along and adjacent to the Georges River and towards the tops of the valleys. As all sites in both areas are accessible from the ridges, it seems likely that access from one area to another was via the ridges rather than the steep, heavily vegetated creek valley. This mode of access has also been postulated by Dallas (1982) for sites at Bents Basin, on the upper Hawkesbury River.

With reference to subsistence movements of the Aborigines, the sites are within easy reach of the Georges River estuary, the Port Hacking estuary (10 km to the east), and the coast (15 km). It is therefore likely that, as Attenbrow suggests, the sites were occupied by tribes or bands who stayed predominantly near the coast, and that these sites were utilised while hunting or gathering during periods when marine resources were less plentiful or when they wanted a change of diet.

3.1.4 Recommendations

The following recommendations were developed in consultation with the National Parks and Wildlife Service (NPWS) of NSW.

It is the view of the NPWS that:

a) all sites, including potential occupation shelters, should be left in their natural state wherever possible; and
b) any sites or potential sites which are likely to be disturbed should be recorded in detail, and test excavations made in the deposits.

Sites M2 and M7 could be excluded from further study, since it is unlikely that significantly greater information would accrue from more detailed investigation.

Threats to the sites occur in two forms - development and recreation. Most sites occur on slopes too steep for housing development and are therefore likely to be in passive recreation areas. However, other aspects of development such as roads and reticulation systems may also present a threat.

Occupation sites which contain no art, and also potential occupation shelters, are considered unlikely to be at risk if included in open space areas. They may be subject to graffiti, but their unremarkable appearance should protect them from more serious disturbance.

Therefore, it is recommended that all occupation sites or potential occupations sites which contain no art be surrounded by at least a ten metre buffer zone of open space.

Three of the sites identified contain art. The two stencil sites on the Georges River, sites M6 and M8, have already been subjected to graffiti and in neither case does the deposit give the impression of containing significant archaeological material. Site M1, a painting site, has not been subjected to graffiti and seems quite undisturbed. It is quite accessible, however, and positive measure should be taken to ensure its protection.

It is therefore recommended that sites M6 and M8 be left as they are and included in open space, with NPWS giving consideration to the erection of signs designating them as Aboriginal sites. This might have the effect of arousing a deeper level of public interest, discouraging further graffiti, and distracting attention from the third painting site, M1, which is relatively undisturbed. More detailed recording of the art at these sites is not considered necessary.

Two approaches are suggested for protection of site M1:

a) the site could be incorporated into a private garden and a covenant placed on the title of the block, under the Conveyancing Act, to draw any future purchasers' attention to the fact that the land is affected under Section 90 of the National Parks and Wildlife Act of 1974; or
b) the surrounding bush could be left intact and not upgraded so that depositional processes are not altered to the eventual detriment of the site. Needle bush (**Hakea sp.**) or other thick shrubs could be planted in front of the site to obscure it from view and deter visitors.

It is also suggested that NPWS consider monitoring the state of preservation at site M1. In this case NPWS would need to be informed when development was completed in order to take this matter in hand.

Therefore, it is recommended that the M1 painting site be subject to positive protection measures and monitoring by NPWS.

Site M9 is an occupation shelter which contains 32 axe grinding grooves. It is recommended that this site be retained intact, perhaps being incorporated into a park with a sign designating it an Aboriginal site.

If destruction of a portion of the site is absolutely unavoidable, the shelter and smaller sets of grooves should be left intact and the larger groove site recorded in detail. Similarly, if the whole site must be destroyed all of the axe grinding grooves should be recorded in detail and a test excavation undertaken at the shelter.

Site M10 contains axe grinding grooves and a larger groove. This site should be left intact, with care taken not to increase the rate of water flow and hence the rate of weathering.

It is recommended that sites M9 and M10 be noted as significant axe grinding groove locations and that they be given special protection as described above.

It is further recommended that development should be planned so as not to cause subsidence or alterations to drainage patterns which might affect shelters or other sites.

This recommendation is also directed at the Department of Mineral Resources with regard to coal mining under the study area, and any subsidence it may cause.

Advice on these matters could be sought from an archaeologist and/or a geologist at a more advanced stage of planning.

Any detailed recording, excavation and analysis of sites which becomes necessary should make comparison with the work already performed in Bardens Creek by Attenbrow and Negerevich (1981).

NPWS should be informed about plans for public recreation areas such as the proposed regional park in upper Mill Creek and the proposed field studies centre on lower Mill Creek so they can be assessed in relation to the archaeological sites.

Any unsurveyed sections within the study area (refer to Map 7) should be properly surveyed by a qualified archaeologist if any development is proposed which would directly affect potential sites.

If any further sites are located during the course of development the NPWS must be informed immediately.

According to the NPWS Act of 1974 it is illegal to damage, deface or destroy a relic without written consent of the Director. Such consent must be obtained in relation to any site or potential occupation site to be affected by development. Applications for consent should be directed

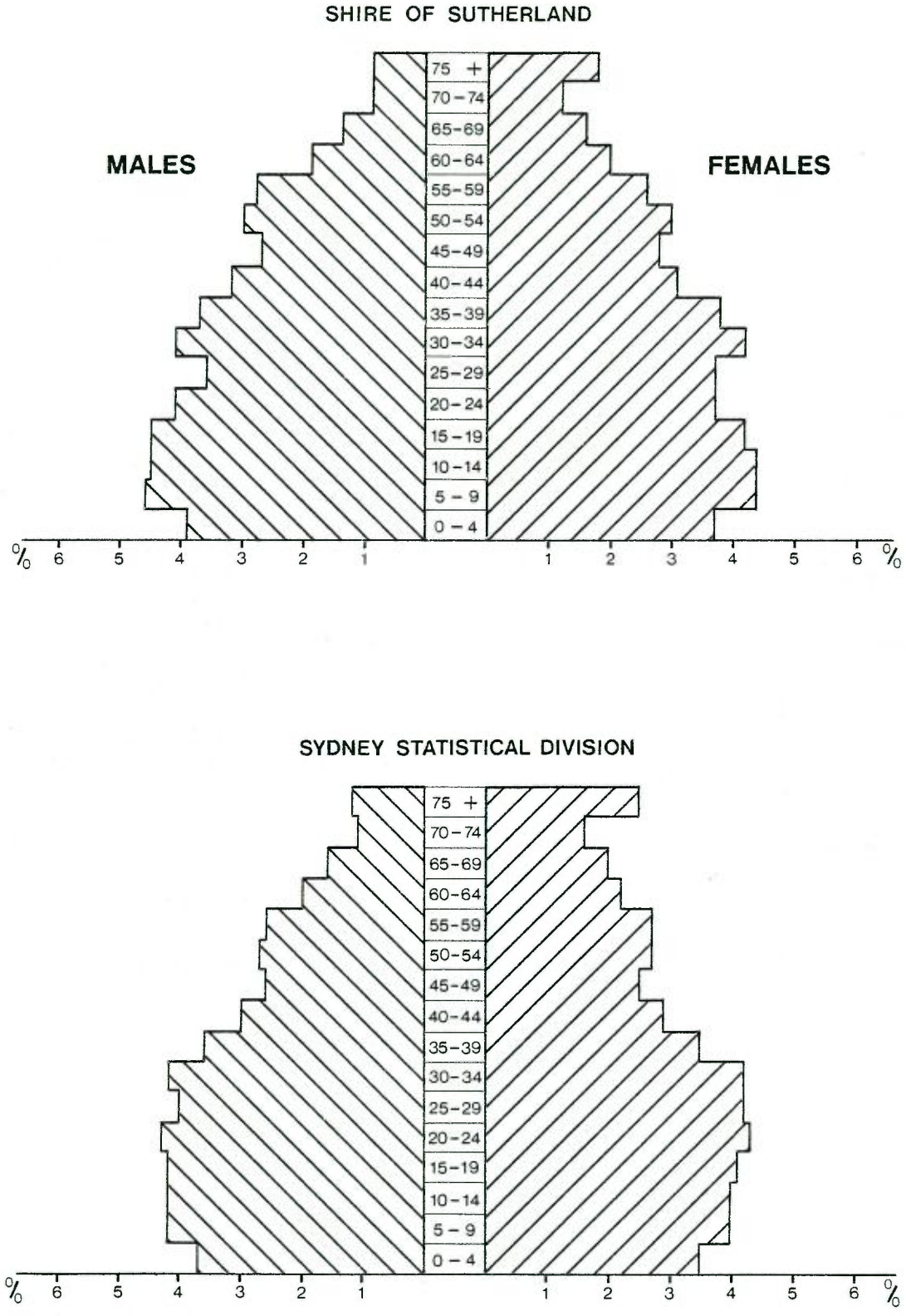
to the Regional Archaeologist in Central Region Office of NPWS at Parramatta.

3.2 Population

The Shire of Sutherland had a population of 165,336 at 30 June 1981, with a total of 54,604 dwellings and an average occupancy rate of 3.18 persons per occupied private dwelling. Within the Shire, the Menai district had a population of 5,696, with a total of 1,959 private dwellings, an average occupancy rate of 3.58 persons per occupied private dwelling and a marginal occupancy rate of 3.60.

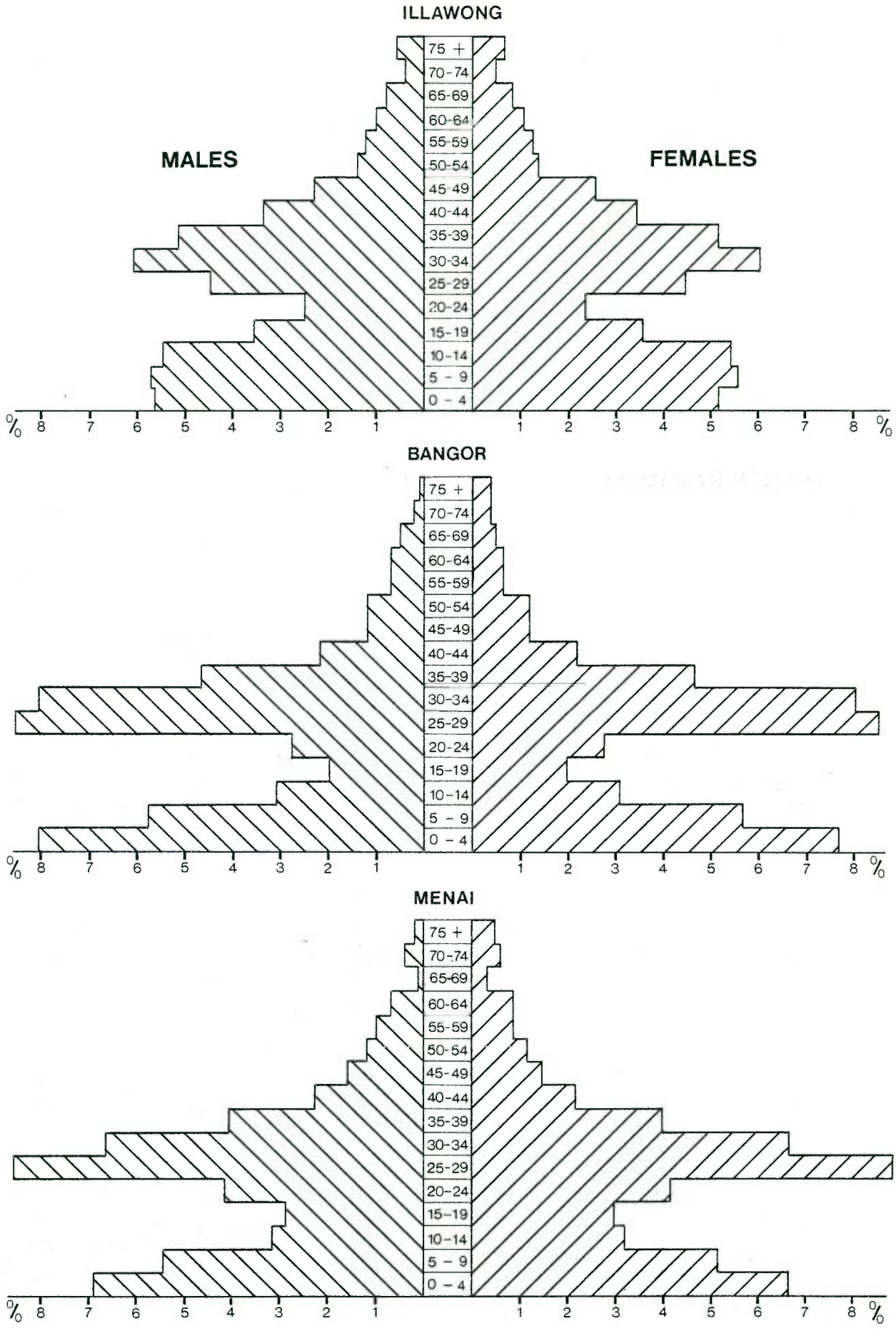
During the decade preceding 1971, Sutherland experienced an average annual growth rate of 3.3%. However, more recently this rate of growth declined to 0.7% from 1971-76 and increased only marginally to 1.1% from 1976-81. From 1976-81 Menai's population grew by 4,095, an average annual growth rate of 32.7%, and the district accommodated 48% of the Shire's total growth.

Sutherland's age structure is closely aligned with the average age structure for the Sydney Statistical Division, implying a well established residential population for the majority of the Shire which has passed its peak of child rearing with minor evidence of gentrification (see Figure 3.2.1). The Menai district, being a new residential area, has an age structure and occupancy rate which suggest that it provides a market for the first home buyer with a young family (see Figure 3.2.2).



Source: A.B.S. 1981 Census

Figure 3.2.1



Source: 1981 Census Data From Shire Of Sutherland

Figure 3.2.2

3.3 Land Use and Planning

Because of its location the West Menai area had formerly tended to suffer from the "out of sight, out of mind" syndrome. There appeared to have been some minor rural activities in the past, but the area was mainly used for quarrying, waste disposal and defence purposes. Most of the valleys, because of their inaccessibility, have retained some of their natural characteristics, but the ridges have degenerated significantly from an environmental point of view. To the passer-by it is the abandoned car bodies and the large areas stripped of topsoil which are the main visual features.

Leases & Occupations

The study area has been under the control of either the State or Commonwealth Government and therefore formal activities have been subject to lease or licence agreements with these bodies. These leases/licences for the extraction of geological resources are scheduled in detail in Appendix A. In summary, the main activities are as follows:

A) Quarrying, complete or virtually complete:

- A kaolin clay pit south of New Illawarra Road on the Woronora River catchment.
- A roadbase quarry to the west of New Illawarra Road near Bardens Lane.
- A dimension sandstone quarry on the ridge above the MWDA operation formerly worked by McMahon.
- Shale quarries at Little Forest operated by the Public Works Department, A R Harrington, and D E Shepherd and J P Bourke.
- Laterite roadbase scraped from ridges at various locations of Heathcote Road.

B) Quarrying operations continuing or proposed:

- A crushed sandstone quarry operated by the Readymix-Farley Group in the northwest of the study area.
- Proposals by Gosford Quarries Pty Ltd to renew and expand the lease for the dimension sandstone operation or relocate to another lease.

- A proposal to quarry for crushed sandstone on the knoll just to the west of New Illawarra Road at the southern extremity of the study area.
- A proposal to extract white clay from a site adjacent to the Lucas Heights reservoir requires an urgent assessment of the value of the site if alternative land uses are to be considered.
- A current assessment is planned by the Department of Mineral Resources of the extent and value of the Wianamatta shales at Little Forest particularly in the night soil dumping area in the southeast corner of Little Forest.

C) Waste disposal operations:

- The MWDA solid wate disposal facility at Lucas Heights serves some 600,000 residents of the southern part of the Sydney region and is nearing its volume limit under the existing design criteria. The remaining capacity of the tip will allow the present rate of fill to continue until late 1986. However, MWDA-leased land to the north and northeast of the existing fill has not been used, and is not likely to be used if another facility goes ahead nearby in the next few years. The close proximity of new residential development has exerted some pressure to minimise fill activities on the northeast corner of Stage I.
- A proposed MWDA operation in Bardens Creek is planned to accommodate the waste disposal needs of the southern sector of the metropolitan region for at least 35 years (other alternatives are also being investigated).
- Disposal of liquid and solid trade waste by Industrial Waste Collection Pty Ltd on a part of Portion 16 leased from the Commonwealth for that purpose has ceased. Post-disposal survey has shown that dumping has exended beyond the lease boundary and has included part of Portions 249 and 251. Leachate is currently a problem.
- Sutherland Shire Council night soil disposal areas at Lucas Heights and Little Forest presently service about 340 pans. The original lease to the SSC from the Commonwealth expired at the end of 1982 and occupation of this site is now on an annual permissive occupancy tenancy until alternative arrangements can be made for the remaining pans.

- AAEC burial ground for low and medium level radioactive solid waste is located in part of Portions 251 and 253. This burial activity took place from 1960 until 1968 when burial ceased, but the land is permanently unfit for any other use.

D) Other Leases and Occupations:

- a model aeroplane club off Heathcote Road;
- a gun club off Heathcote Road at the south end of the site;
- a pony club off Old Illawarra Road; and
- a concrete batching plant off Old Illawarra Road.

In addition to these leases services easements for transmission lines traverse the site from north to south along the eastern edge and from east to west above the Georges River.

All known landuses, past, existing or proposed, are shown on Map 8.

Australian Atomic Energy Commission

The AAEC has defined a 1.6 km radius exclusion zone around its reactor, and this limit defines the southern boundary of the site. The AAEC also intends to retain control over Portions 251, 252 and 253 within the study area and is planning to control part of Portion 16. While other plans for this additional parcel of land are possible, it is assumed that it has been retained by the Commonwealth primarily to provide a buffer between urban development and the existing low and medium level radioactive waste burial area on part of Portions 251 and 253.

Statements made available to the study team suggest that, as a neighbour, the AAEC should present no environmental threats to development of the study area, but proposals for residential development were checked to ensure population aggregates do not exceed the State policy of 5,000 persons in any 20 degree sector within 4.8 km of the reactor. It is conceivable that obsolescence and new perspectives on nuclear energy could change these policies but it is not practicable to take such speculation into account at this stage. However, planning authorities should maintain a close liaison with the AAEC and monitor changes in nuclear technology and its environmental impact.

Holsworthy Artillery Firing Range

After using the area for manoeuvres since the early part of this century, the Army has relinquished, or is about to relinquish, its control of lands within the study area. It still remains a neighbour for the length of Heathcote Road which is the eastern boundary of the Holsworthy Artillery Range. Although studies are proceeding to identify locations for new defence facilities in country areas of NSW (including an artillery firing range), it is unlikely that the role of the Holsworthy area will change in the foreseeable future.

Army operations are, to some extent, incompatible with urban development on account of noise and bush fire hazard. The environmental significance of each of these is discussed in Sections 3.9 and 3.10 respectively.

Informal Activities

In addition to the uses for which land has been specifically set aside by lease or licence there are many informal activities which take place in the West Menai area. These include boating, running, orienteering and trail bike riding. The last of these has had a significant environmental impact on the area by not permitting regeneration of vegetation in some of the areas which have been quarried for topsoil and roadbase. Trail bike riding is incompatible with residential development but fulfills a district need which is not readily met elsewhere. Regardless of whether alternative locations for such activities can be found when residential development proceeds, consideration should be given to finding suitable management techniques for allowing the trail bike riders to remain in the area until it is needed for residential purposes.

Sandy Point Village

Sandy Point is an isolated community of some 150 households (population 55)? located immediately to the northwest of the study area. The main road in the settlement, St George Crescent, joins Heathcote Road near the study area boundary and follows the spur down to the banks of the Georges River adjacent to its junction with Deadmans Creek.

Development comprises mainly larger residential lots along St George Crescent and one or two cul-de-sacs. Services are limited with only a small corner store, public telephone and postbox, and boat launching facilities. The attraction of the locality is obviously the proximity of the Georges River and many of the properties on the higher ground have spectacular views of reaches of the river and development along the northern bank. Where there are now views, dwellings are located in a pleasant bushland setting.

Apart from some new development at Pleasure Point across Deadmans Creek and in the vicinity of the East Hills footbridge (some 3.5 km and 6 km respectively by road from Sandy Point), the nearest built-up areas are at Hammondville (8 km west along Heathcote Road) and Heathcote 12 km to the southeast.

Planning Considerations

The study area is at present subject to Cumberland County Council and Sutherland Planning Schemes which limit uses generally to rural and other non-urban activities. Proposals to develop the area for urban purposes will require, at the completion of this study, the preparation of a draft local environmental plan which, after public exhibition, will become the principal planning instrument for the West Menai area.

Among the planning considerations which are addressed elsewhere in this report are:

- the buffer zones required around the liquid trade waste and AAEC burial ground, and the use to which adjacent land should be put;
- the future requirements of the Department of Health for the use of the night soil dumping areas;
- the future of the recreational/club activities which at present operate in the study area; and
- the possible uses for the AAEC 1.6 km exclusion zone, and the concerns of the Department of Administrative Services regarding active/passive use of the area;
- the uses to which the existing quarry sites could eventually be put, including comments on the rehabilitation which should be required.

3.4 Utilities and Services

The provision of utilities and services to the West Menai area presents a substantial constraint to development because of its location relative to other parts of the Metropolitan region and its general topography of comparatively narrow ridges between deep valleys.

3.4.1 Water Supply

This service appears to be the main constraint to the extent and timing of development of the study area. Improvements to the existing Lucas Heights reservoir and the sharing of an aqueduct crossing of Mill Creek in the vicinity of Rosewall Avenue will permit the areas east of Bardens Creek and west of Mill Creek below AHD 100 to be serviced after 1986. The remaining areas to AHD 120 (which would exclude about 100 ha in the southwest corner of the study area and a small knoll in the middle of the site) may be serviced as soon as a link road is completed across Bardens Creek and Mill Creek. Any proposed development of the high land to the southwest of the site cannot be provided with a water supply from existing facilities and will require the construction of a new tank and pumping station estimated to cost in the order of $1 million in addition to normal reticulation costs.

3.4.2 Sewerage

In anticipation of an urban release at West Menai, preliminary plans have been prepared to sewer developments as they are supplied with water. An existing sewer main along the eastern bank of Mill Creek has been constructed with sufficient capacity to accept a branch main from new development on the western side. An aqueduct is planned across Mill Creek just below the tidal limit and a main running along the western side of the Mill Creek valley could serve most areas envisaged for development.

Early indications are that the northwest of the study area in the vicinity of the existing Readymix-Farley quarry might be sewered more economically by pumping across the ridge to the Mill Creek carrier. This should not present difficulties in staging as quarry operations will constrain residential development for at least 10 years.

The MWSDB does not plan to extend its main south of the junction of Mill and Barden Creeks until a reasonably concentrated development can be assured.

3.4.3 Electricity

After commissioning a new substation at Menai in 1986 and obtaining a crossing of Mill Creek at the northern end either by a joint services structure or aerial cables, the Sydney County Council will be able to service the West Menai area.

Eventually it will be desirable to provide an alternative 11 kV service from the south end so power is not disrupted by bush fires or structural damage and to this end a road link or services corridor in the southern part of the site is considered desirable.

3.4.4 Telephones

The cost of providing a cable link to West Menai is prohibitive and Telecom has advised that it will not require access to the services aqueduct or road links for this purpose. It will instead be seeking sites for exchanges with unobstructed radio links but no sites have yet been identified. Early attention to this is required as such sites will have consequences for detailed land use planning and visual amenity.

3.4.5 Community and Commercial Facilities

Menai town centre is planned to provide a comprehensive range of community facilities when it is established. In the meantime, residents in the new areas will have to travel to Sutherland for most services. It is likely that children from early developments at West Menai will have to attend Menai Public School until numbers are sufficient to justify new schools at other locations.

A new supermarket-dominated centre at Bangor provides for the shopping needs of Illawong, Menai and Bangor while Sutherland, Bankstown and Miranda are regional centres used by the present Menai population. These are relatively remote from West Menai and shopping facilities will have to be provided for the new population.

3.5 Access

3.5.1 Road Network

This section reviews the existing road and public transport network in the Menai area. Existing transport facilities are illustrated in Figure D1 of Appendix D.

The present road network skirts the perimeter of the West Menai study area. The major roads are Heathcote Road and New and Old Illawarra Roads, which border the west, south and east respectively.

East-west access beyond the study area is provided by Heathcote Road and by Menai Road between Menai and Sutherland. The Old/New Illawarra Road route provides north-south access between Heathcote Road and Alfords Point.

These major roads are of variable standard, generally providing only two traffic lanes. Alfords Point Bridge has two traffic lanes, with provision for duplication. The Menai Road bridge across the Woronora River is a two-lane low-level bridge. The substandard alignments of the approaches to the bridge are a constraint on increasing that east-west corridor capacity.

3.5.2 Roadworks Proposed

Major roadworks are proposed in the area in the medium to long term to cater for future urban development. Figure D2 of Appendix D summarises the proposals of the State Government's Urban Development Committee. These proposals are discussed in detail in Appendix D. Based on projected traffic demand levels, they appear to be sound in principle, with the timing of construction dependent upon need for the works being established.

In terms of impact of roadworks on the study area, the east-west link road between Old Illawarra Road and Heathcote Road will have the greatest impact. Its phasing is also critical to the phasing of services and utilities for areas in the middle of the study area and west of Mill Creek.

3.5.3 Traffic Volumes

The annual average daily traffic volumes on the major roads in the vicinity of Menai were reviewed; the figures are presented in Table D2.1 in Appendix D. These figures show a generally consistent annual increase on Heathcote Road west of Princes Highway, with volumes at West Menai (Deadmans Creek bridge) being more static, though with a 17 percent rise between 1979 and 1981.

Volumes on Menai Road have increased very substantially over the period 1971-1981 though the rate of increase has tapered off in the latter half of the decade.

In the north-south corridor, volumes on New Illawarra Road, Old Illawarra Road and Alfords Point Road have all increased substantially over the decade, with marked increases between 1979 and 1981.

Peak hour traffic volumes (see Figure D3 of Appendix D) show that the heaviest movement is from Sutherland to Alfords Point in the morning and the reverse in the evening, the one-way volumes being about 900 vehicles per hour in each period.

3.5.4 Public Transport

The metropolitan rail network does not serve the Menai area. The nearest railway station is at Sutherland on the Illawarra Line which is about 5.6 km by road from Menai.

The nearest alternative station is at Padstow which is 8.3 km by road from Menai on the East Hills Line. A proposal to construct the East Hills-Glenfield rail link would provide residents of West Menai with ready access to rail transport at Holsworthy some 6 km west.

Both of these trunk lines provide a radial service with the City of Sydney. Redfern is the first station on either of these lines where transfers can be made to all other metropolitan lines. Peak hour service on the Illawarra Line is to a high level, with service headways of about

seven minutes. Service headways on the East Hills Line are about double these, thus providing a less frequent but still adequate service. The service would improve considerably if connection were made to the Southern Line at Glenfield.

Bus services into West Menai are provided by Route 237 of the Woronora Bus Company. This route is a round trip between Sutherland and Padstow via Menai. School bus services are additional. Patronage on Route 237 is currently low, according to the operator, but is gradually improving. Two round trips are made in each peak period.

There are no regular bus services in the Lucas Heights and West Menai areas.

In conclusion, current public transport in Menai is via a relatively low frequency bus service to both Sutherland and Padstow. At either destination, transfer can be made to the rail network, which provides a reasonable service towards the City of Sydney, but involves transfers to other lines for western suburbs destinations.

3.6 Employment

Sutherland generally displays high socio-economic characteristics, with a large and growing white collar workforce and a lower porportion of its workforce in the manufacturing sector than is typical for the Botany Bay region (DEP 1979) (see Figure 3.6.1).

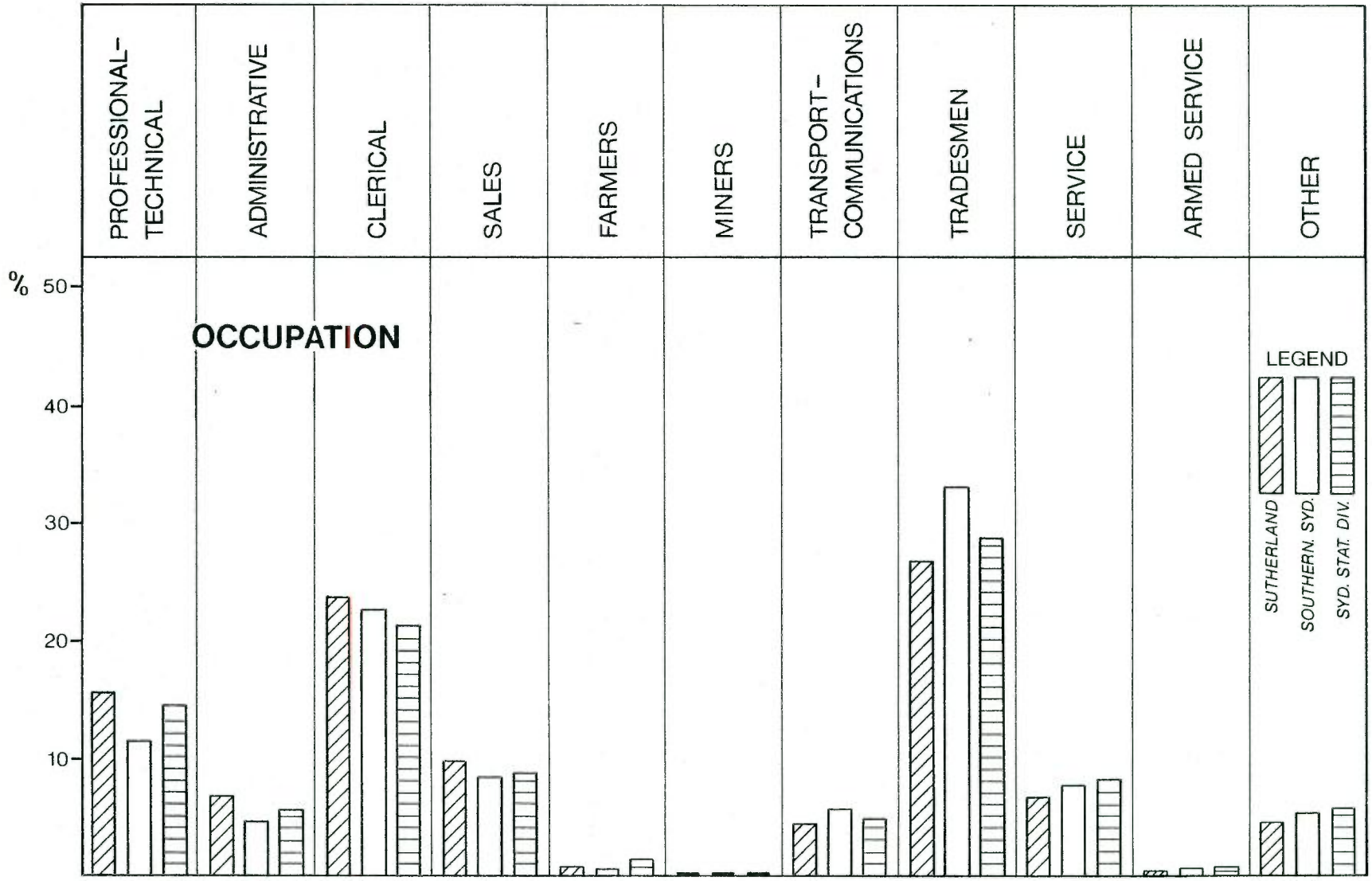
Household incomes are generally high average and in particular, the highest category (greater than $26,000) is significantly higher than the Sydney average. By comparison, individual incomes are only marginally higher than average, suggesting that the higher household incomes are a result of combined incomes. This conclusion is supported by Sutherland's workforce participation rate of 49.1% which is marginally higher than the Sydney average of 47.6% (see Figures 3.6.2 and 3.6.3).

Sutherland had only 53 jobs for every 100 workers in 1981, and 42 of these were filled by local residents. The remaining 58 percent are forced to commute mostly by car to employment within central and southern Sydney. The provision of local employment is therefore a significant issue within the Shire (Helborn 1980) (see Figures 3.6.4 and 3.6.5).

Within the Botany Bay region the restructuring of industry from 1971 to 1981 accounted for a dramatic loss of manufacturing jobs with an associated increase in community services, retail and wholesale employment (DEP 1979). The current economic recession has produced dramatic retrenchments within the existing manufacturing labour force and the viability of some of the major manufacturing enterprises (e.g. Namco) within the Shire is now under question.

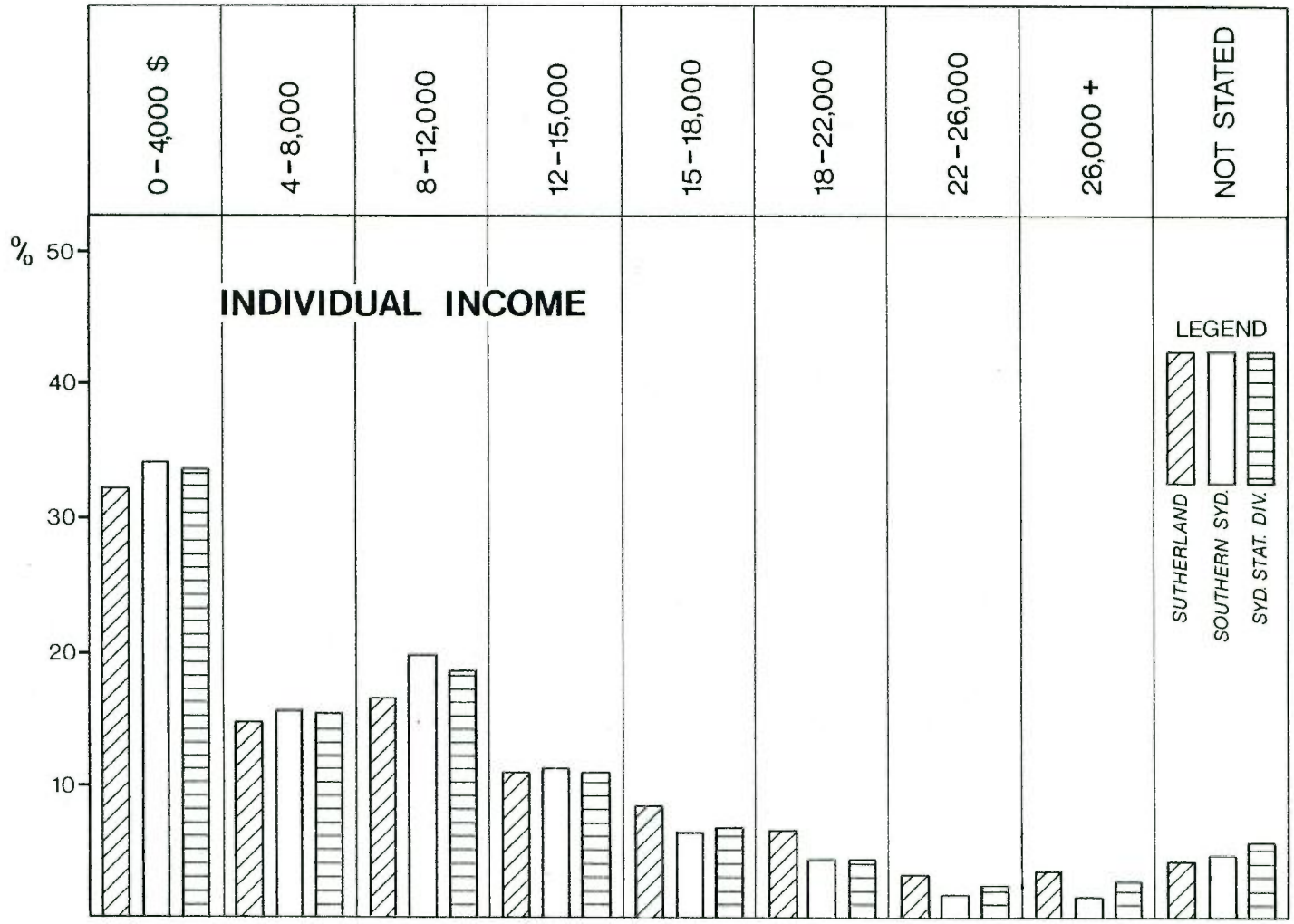
3.7 Housing Market

Sutherland Shire had 54,604 dwellings in 1981 and since 1972 has averaged 792 new dwellings per annum. The rate of housing construction has fluctuated dramatically over this period. However, the 724 new dwelling completions in 1981-82 is about average for the past 10 years. For the same period the Menai district had 1,959 dwellings and between 1980 and 1982 has averaged approximately 500 new dwellings per annum which represents 63% of the Shire's total dwelling completions per annum (see Figure 3.7.1 and Table 3.1)



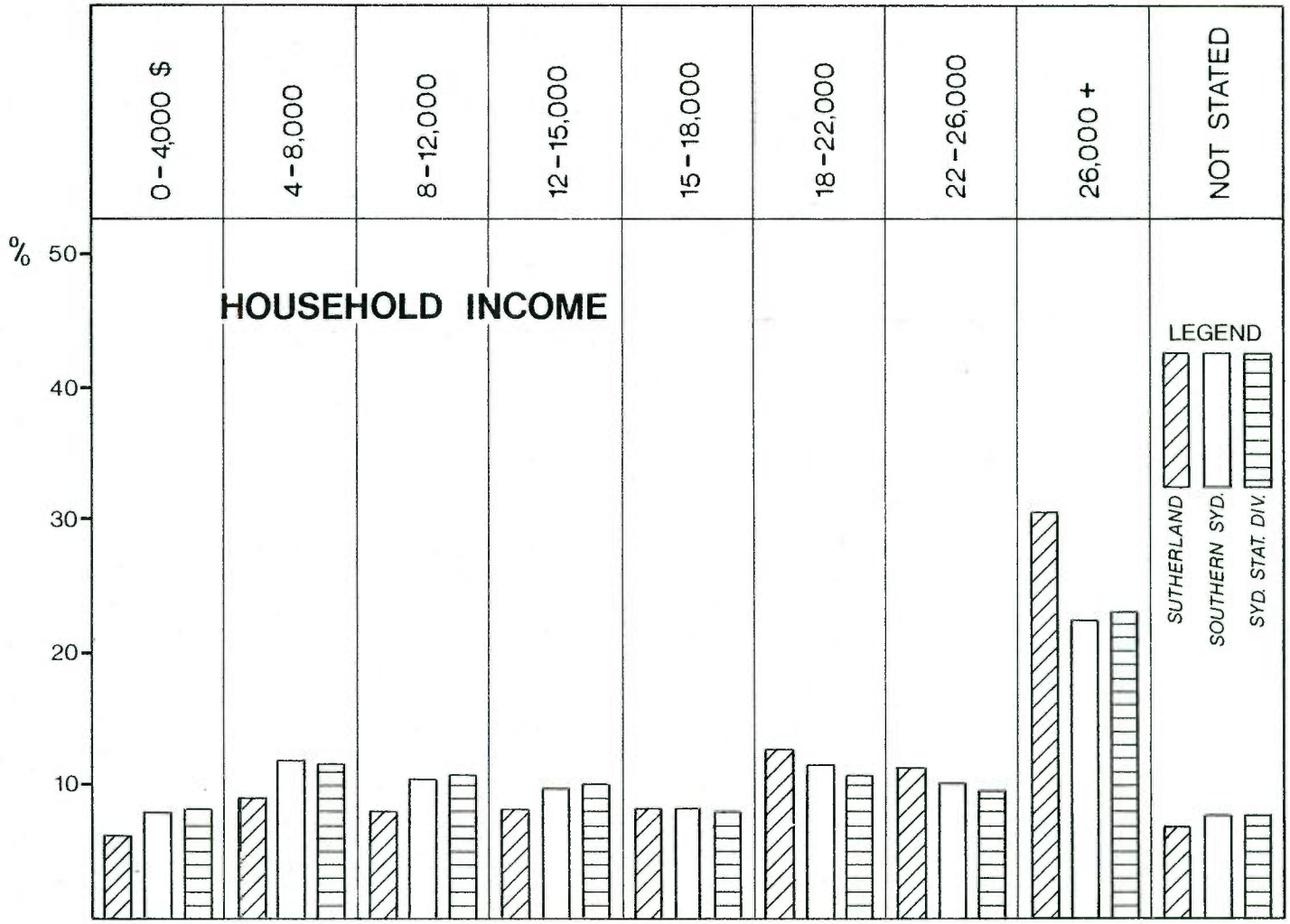
Source: A.B.S.

Figure 3.6.1



Source: A.B.S.

Figure 3.6.2



Source: A.B.S.

Figure 3.6.3

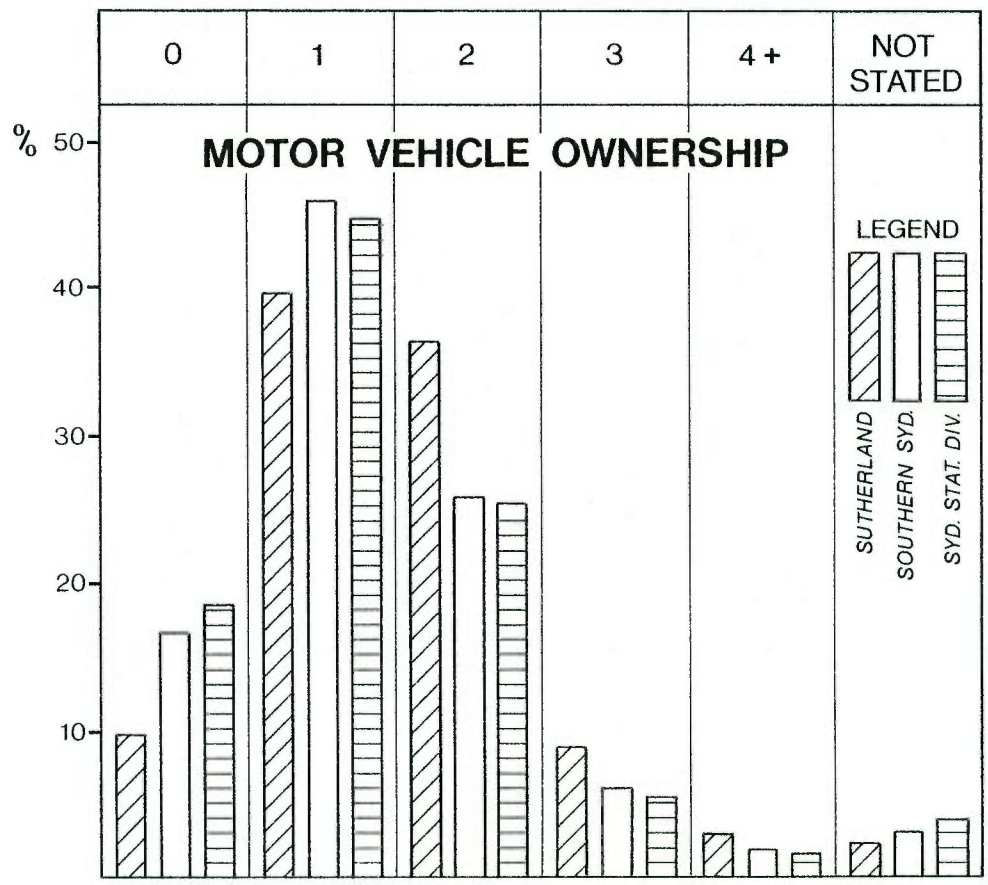


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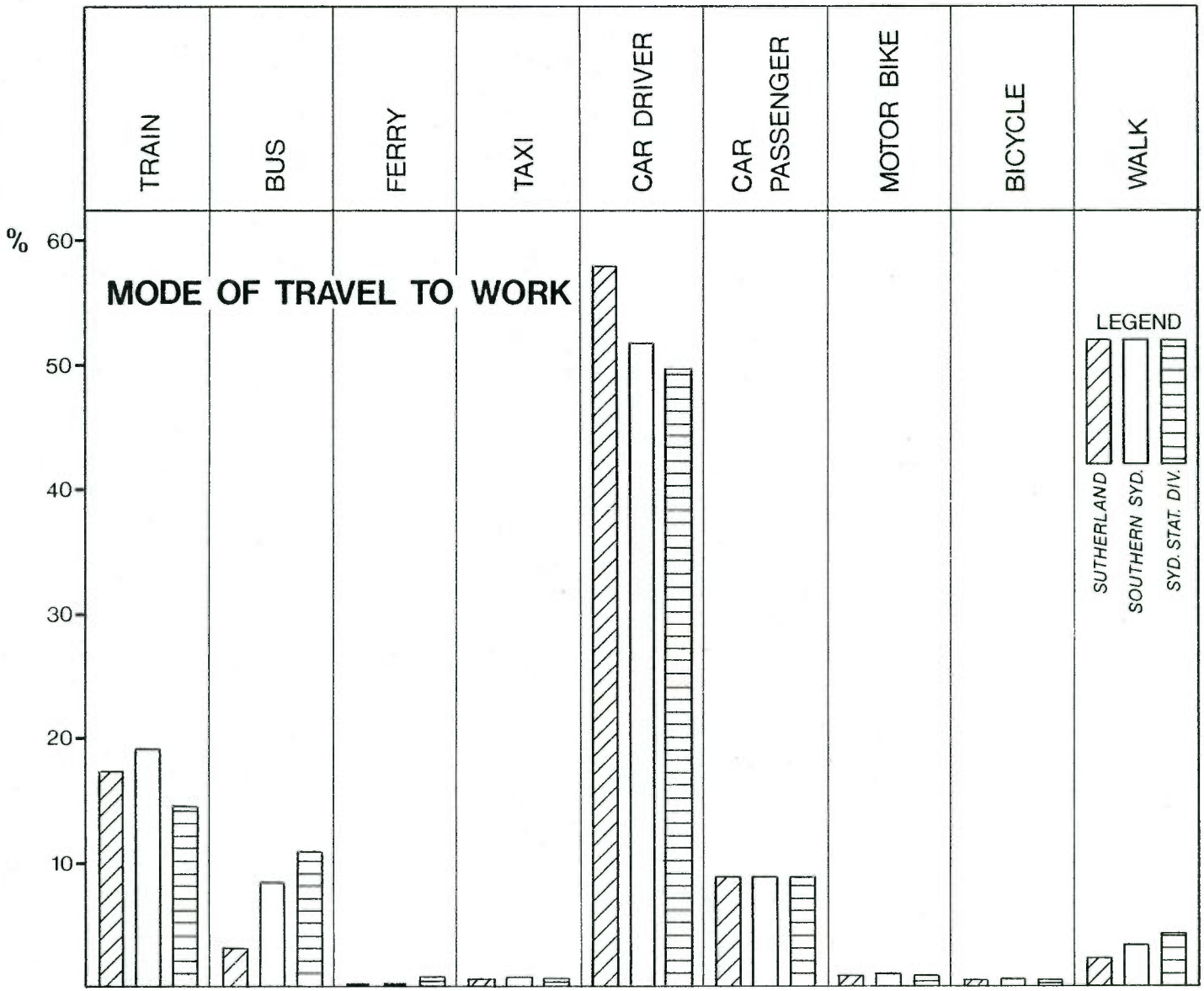
Figure 3.6.4

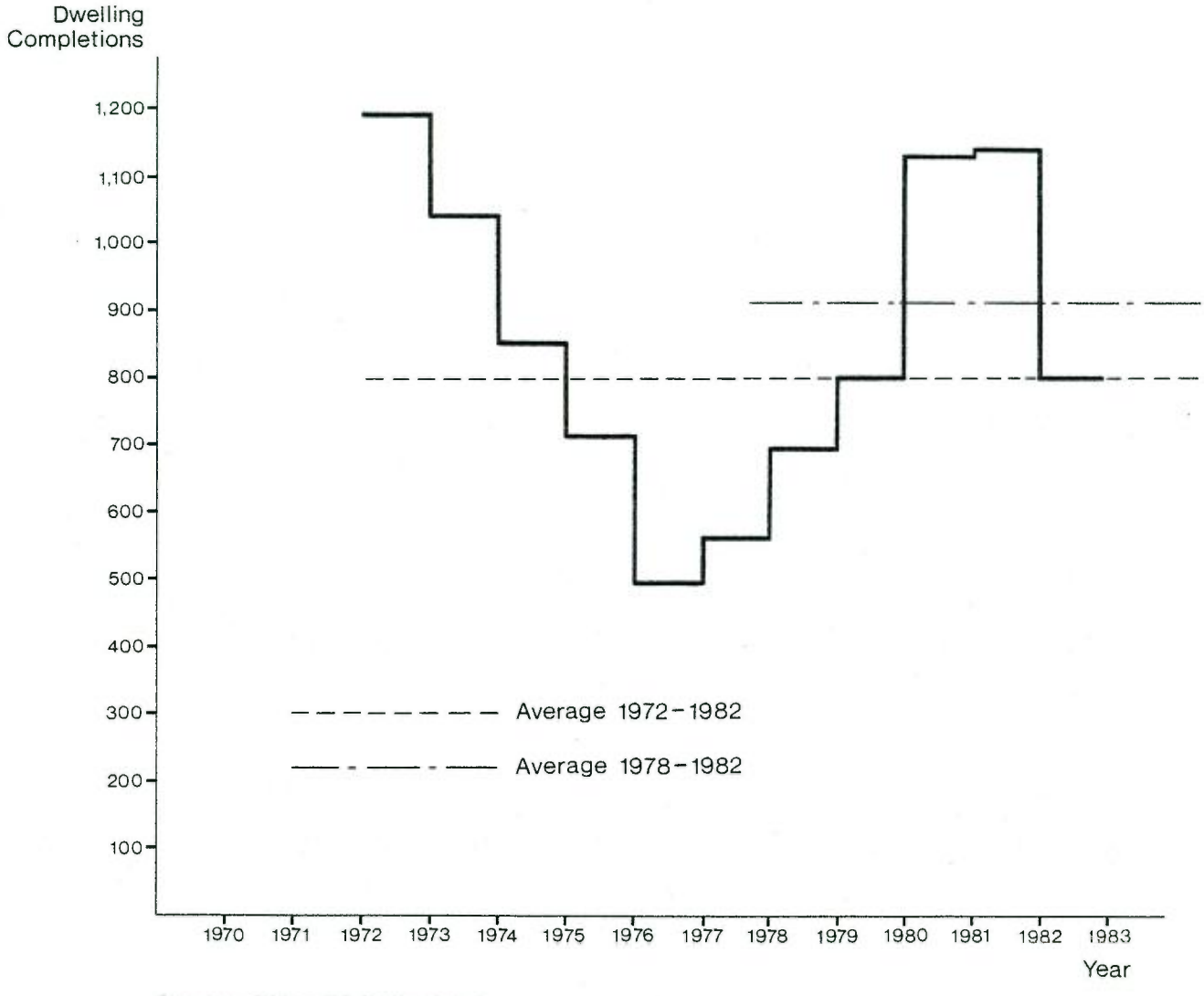


Source: A.B.S.

Figure 3.6.5

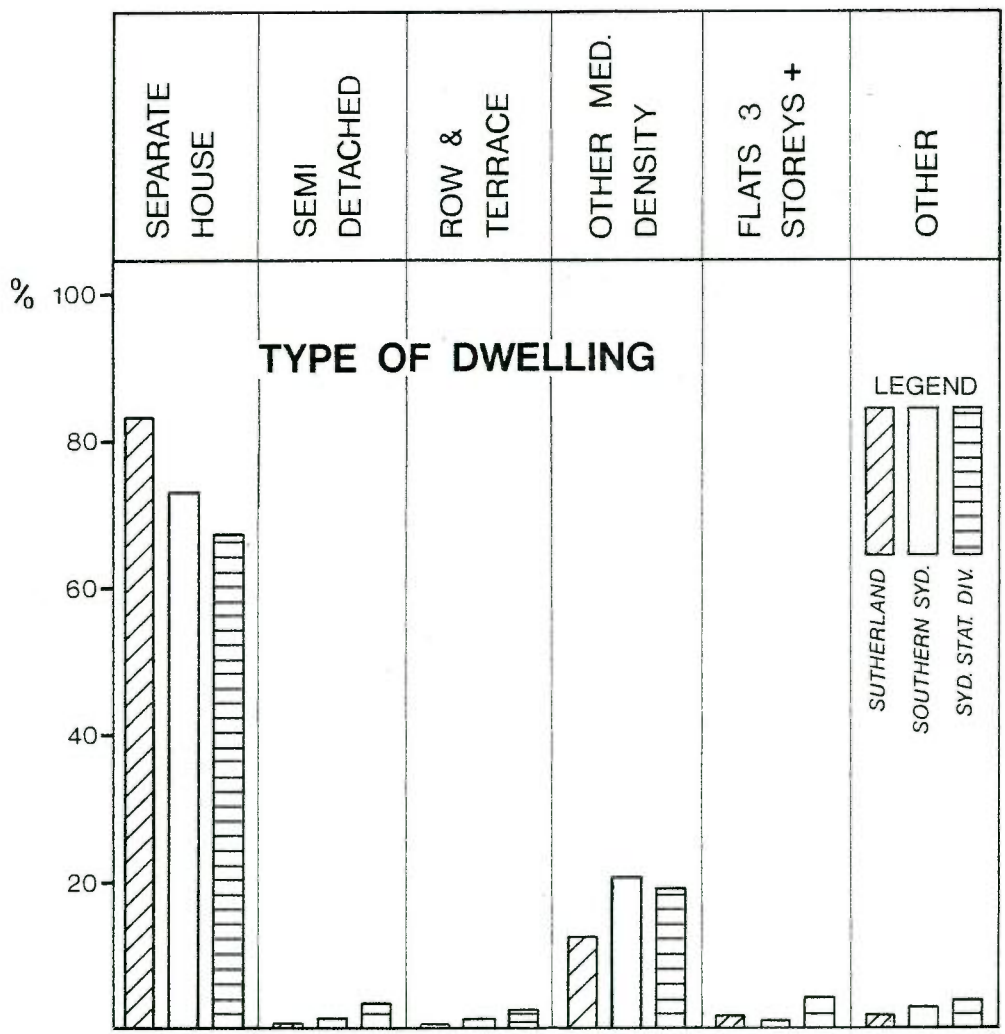
The housing structure within Sutherland is predominantly detached single family dwellings and the vast majority of Sutherland residents either own or are purchasing their homes. These dwellings are generally larger than the Sydney average, with the three bedroom home being the most common and a relatively high proportion of four bedroom homes (see Figures 3.7.2, 3.7.3 and 3.7.4)

NEW DWELLINGS COMPLETED, 1972 -1982
SHIRE OF SUTHERLAND



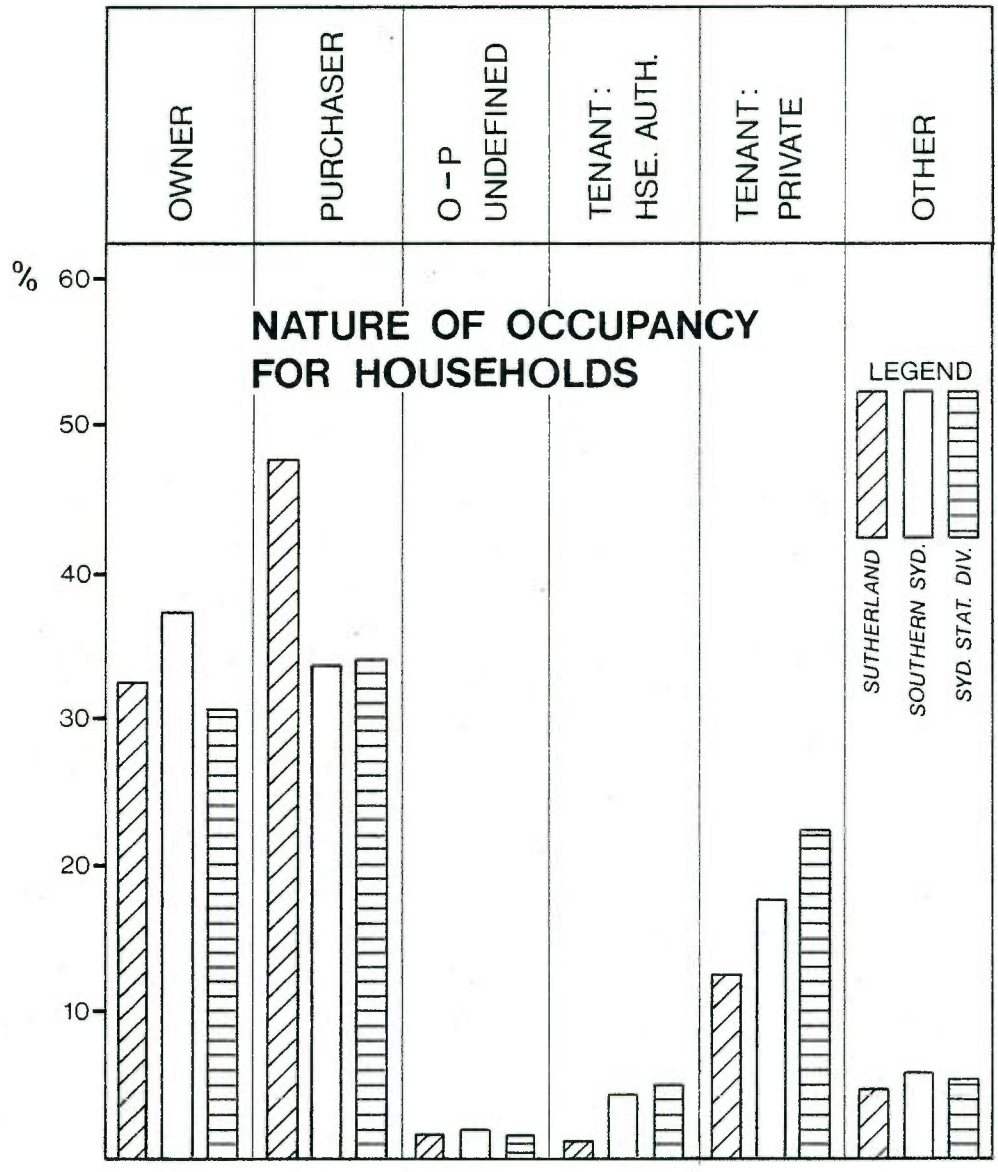
Source: Shire Of Sutherland

Figure 3.7.1



Source: A. B. S.

Figure 3.7.2



Source: A. B. S.

Figure 3.7.3

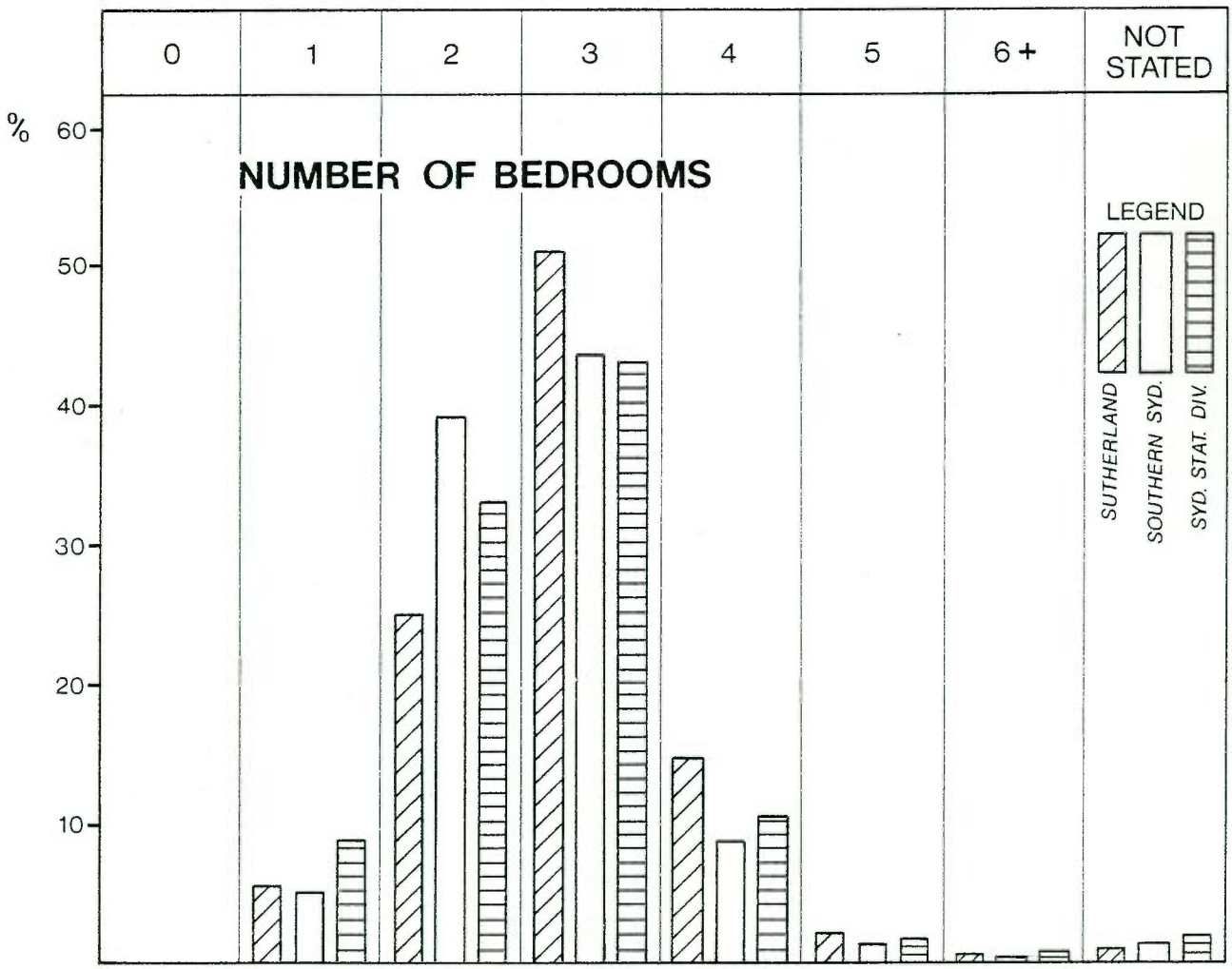

0
1
2
3
4
5
6+
NOT STATED
%
60
50
40
30
20
10
NUMBER OF BEDROOMS
LEGEND
SUTHERLAND
SOUTHERN SYD.
SYD. STAT. DIV.

Figure 3.7.4

TABLE 3.1: SHIRE OF SUTHERLAND BUILDING APPROVALS FOR MENAI STAGE ONE 1980-1982

Year	Location	Building Approvals	Total	Percentage
1980	Illawong	148		27
	Bangor	246		45
	Menai	149		28
	TOTAL		543	
1981	Illawong	147		30
	Bangor	252		51
	Menai	98		19
	TOTAL		497	
1982	Illawong	139		45
	Bangor	110		36
	Menai	57		19
	TOTAL		306	
	Total Building Approvals 1980-82		1,346	
	Average Building Approvals p.a.		450	

Source: Shire of Sutherland

3.8 Water Quality

3.8.1 Possible Sources of Water Pollution

The history of land use in West Menai suggests that groundwater and surface water could be contaminated from a variety of sources. The activities which could contribute to water pollution include:

i) Laterite removal, quarrying and MWDA landfill operations - causing increased turbidity in streams and abnormally high sedimentation in stream channels.

ii) Trail bike riding and other off-road vehicle use - increased turbidity and stream sedimentation.

iii) SSC night soil dumping - causing contamination of water with faecal coliform bacteria and other potential health risk organisms. The following Portions or part Portions have been affected: part of Portion 251, part of Portion 253, all of Portions 252, 121, 254, 255, 122, 152, 256, 272, 273, 274, 277, 278, 295, 276, 279, 280, 281 and 282. A plan showing these Portions is provided as Figure 3.8.1. The area most heavily used in recent years has been Portions 252, 254, 255, and 122. When night soil dumping is complete, all night soil areas will be proclaimed unfit for building purposes under Section 55 of the Public Health Act, 1902, until the Department of Health is convinced that all night soil has been assimilated and/or affected top soil has been removed.

iv) MWDA landfill operations - leachate from solid waste tip; this appears to be primarily a legacy from the period prior to MWDA control, when compaction, covering and compartmentalising techniques were not employed. Also there is some risk from bacterial contamination from the MWDA amenities block and truck cleaning bay. The Portions affected by garbage disposal are 124 (part), 125 and 126 as shown on Figure 3.8.1.

v) Adjacent residential areas on the eastern side of Mill Creek - possible faecal coliform bacteria contamination as a result of sewer or septic tank overflow during high flow conditions.

vi) Disposal of liquid trade waste by Industrial Waste Collection Pty Ltd on a part of Portion 16 leased by the Commonwealth of Australia for that purpose (see Map 8). The disposal operation was terminated in 1980 when the site was filled to capacity. It has been covered with topsoil and proclaimed permanently unfit for any other use by the Department of Health.

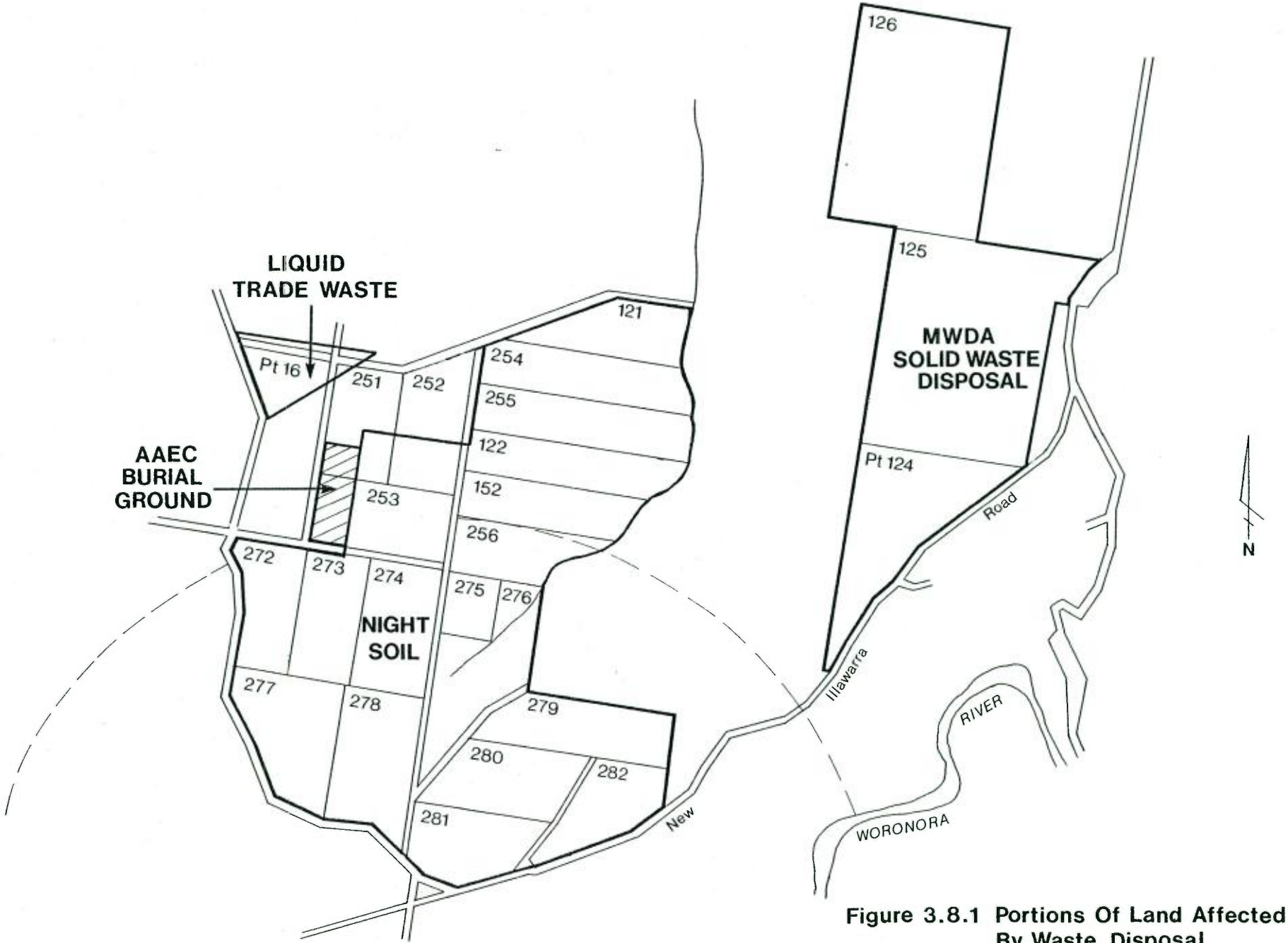


Figure 3.8.1 Portions Of Land Affected By Waste Disposal

vii) Illegal disposal of liquid wastes, particularly oil - contamination by this means has occurred on the western tributary of Mill Creek in the northern end of the study area;

viii) AAEC burial ground for low level radioactive waste - possible radionuclide contamination of groundwater and/or surface water in Bardens Creek. The burial ground occupies part of Portions 251 and 253 shown on Figure 3.8.1.

Our investigations have included both a literature search and water sampling and analysis at various times and locations in the study area.

The principal water sampling programme was conducted on 7 February 1983 during dry weather conditions and no flow in the streams. Samples were collected for faecal coliform organisms on 18 March 1983 just after heavy rains, and a further sample collected on 13 April 1983. The results of the analyses are presented in Table 3.2.

Baumann and Brown (1976) showed that in 1975 the organic loading (in terms of BOD_5) in Mill Creek, associated with discharged leachate from the garbage depot, peaked approximately one month after the maximum observed rainfall, and was roughly proportional to the total monthly rainfall for the area.

Since 1976 the MWDA has assumed control of the garbage depot operation and has introduced modern compaction, soil covering and cell compartmentalising techniques which have made an obvious improvement to the visual, air and water quality of the area. The study team was advised that leachate has virtually stopped flowing from the tip, except after very heavy rains.

The MWDA does take regular samples of leachate evaporation/digestion ponds and in the creek downstream. A set of 1982 results was made available. However the effluent sampling programme does not appear to be related to the important cyclical periods of runoff, nor does the MWDA regularly monitor faecal coliform bacteria, an apparent problem after heavy rains. The latter shortcoming is understandable considering the unlikely discharge of high faecal coliform bacteria from this operation.

The MWDA water quality data shows that ammonia-nitrogen values are very high in the creek which drains their operations. These levels are high enough in this creek to be toxic to most aquatic animal life and are undoubtedly a major nutrient contribution to the luxuriant growth of weeds, lillies, and other exotic plants which have choked this tributary to Mill Creek.

TABLE 3.2: RESULTS OF WATER QUALITY ANALYSES AT WEST MENAI

Parameter	Date Sampled	Recent Rainfall**	Site 1*	Site 2*	Site 3*	Site 4*
pH	7 Feb 83	Nil	6.7	6.9	7.2	-
Specific conductance at 25°C microsiemens/cm	7 Feb 83	Nil	-	573	587	-
Turbidity, NTU	7 Feb 83	Nil	-	4.0	3.2	-
Dissolved oxygen, % of saturation	7 Feb 83	Nil	5	70	77	-
Temperature, °C	7 Feb 83	Nil	23.5	24.0	27.0	-
Non-filtrable residue mg/L	7 Feb 83	Nil	-	4	2	-
Total filtrable residue 180°, mg/L	7 Feb 83	Nil	-	355	393	-
Biochemical oxygen demand, BOD_5 mg/L	7 Feb 83	Nil	-	5	5	-
Chemical oxygen demand, COD mg/L	7 Feb 83	Nil	-	22.0	13.0	-
Total inorganic carbon, C mg/L	7 Feb 83	Nil	4.5	-	5.5	-
Nitrogen ammonia, N mg/L	7 Feb 83	Nil	-	0.002	0.002	-
Nitrogen-nitrate, N mg/L	7 Feb 83	Nil	-	0.21	0.14	-
Total phosphorus, P microgram/L	7 Feb 83	Nil	-	18	18	-
Total Sulphide, S mg/L	7 Feb 83	Nil	0.07	-	0.01	-

TABLE 3.2: RESULTS OF WATER QUALITY ANALYSES AT WEST MENAI
cont'd

Parameter	Date Sampled	Recent Rainfall**	Site 1*	Site 2*	Site 3*	Site 4*
Total Iron, Fe mg/L	7 Feb 83	Nil	-	0.8	1.1	-
Total Zinc, Zn mg/L	7 Feb 83	Nil	-	0.002	0.002	-
Total Copper, Cu mg/L	7 Feb 83	Nil	-	0.003	0.003	-
Total Lead, Pb mg/L	7 Feb 83	Nil	-	0.022	0.015	-
Total Cadmium, Cd mg/L	7 Feb 83	Nil	-	0.002	0.002	-
Total Chromium, Cr mg/L	7 Feb 83	Nil	-	0.01	0.01	-
Total Coliform organisms/100 ml	7 Feb 83	Nil	-	680	42	-
Faecal coliform organisms/100 ml	7 Feb 83	Nil	-	500	2	-
Faecal coliform organisms/100 ml	18 Mar 83	83 mm	83000	unreliable	1400	3400
Faecal coliform organisms/100 ml	13 Apr 83	0.2 mm		54		

* See Map 8 for location of water sampling sites
** Total rainfall recorded from Liverpool for 72 hours prior to sampling

It was planned to sample immediately after (and again about a month following) heavy rains in the area in order to compare present conditions with those recorded by Baumann and Brown (1976). However, rains did not occur and consequently the most detailed survey followed a long drought when only a few ponds of standing water were present.

However, in mid March heavy rains occurred and resampling took place for faecal coliform organisms within 24 hours following the heaviest day of rain. The results of this samping were of concern, so a single additional sample was taken in April to confirm the results. Budget and study timetables did not allow a complete sampling programme about one month following the rain.

3.8.2 Conclusions

Water quality results did not indicate any particular hazard to aquatic life. Dry weather results of ammonia-nitrogen were well below recommended safe limits for aquatic life. None of the other chemical measurements revealed any alarmingly high results. However, the initial faecal coliform bacteria levels on Mill Creek below the junction of the tip drainage creek were .500 colonies/100 ml; this is higher than the recommended level of 200 colonies/100 ml for contact recreation (US EPA, 1976) and certainly higher than the requirements of no faecal coliform/100 ml (Hart, 1974). Therefore, after heavy rain Mill Creek upstream and downstream of its confluence with the tip creek, the tip creek itself and Bardens Creek near the night soil cleaning depot were retested for faecal coliform. The results were alarmingly high, particularly from the tip creek. One site yielded unreliable results and was retested during a later period of low flow in Mill Creek, when the result was within safe limits for bathing.

It appears that there may be a serious health risk to children who play in the creek or drink the water, particularly immediately after heavy rains. It was not practicable to isolate the source of the high faecal coliform, but it is not likely to be attributed to the MWDA landfill operations because, according to the Chief of the MWDA Solid Waste Development, no human waste is disposed in this solid waste depot (except possibly soiled baby napkins). Furthermore, the leachate which does still emanate from the MWDA site, and is treated on site, would be toxic to faecal coliform

organisms. The only significant source would appear to be an illegal sewage/septic discharge upstream of the measuring site, an overflow from the sewerage line which serves the new residential area to the east or from several septic holding tanks (one or two septic tanks would not produce the levels recorded in the survey considering the dilution available from high stream flows).

The source of the high values which were recorded immediately following heavy rain needs to be resolved.

Also the organic load and nutrient load to the stream needs to be checked approximately one month following heavy rain as suggested by Baumann and Brown (1976) to determine the present impact of MWDA operations on the Mill Creek environment. There is certainly evidence of high nutrient loading and iron oxidising bacteria in the tip creek at the present time.

The assimilative capacity of Mill Creek appears to have generally diluted, absorbed or oxidized any BOD_5 or nutrient loads to acceptable levels by the time it reaches the Georges River.

It is not considered that the night soil areas would contribute high faecal coliform bacteria to the watercourses, except where heavy rains fall on very fresh night soil. It is the intention of SSC to phase out night soil dumping as soon as possible, but a termination year cannot yet be confidently given. It would appear to be on the order of about ten years. The Department of Health may then require about 15 years of lying fallow before the land could be used for building purposes.

The IWC liquid trade waste site did not appear to be producing any leachate during dry weather conditions, but a check of the water quality in the drainage creek from that site after saturating rain is recommended. Leachate could be draining into the deeper shale pits immediately adjacent to the disposal site. These pits usually contain water and require regular pumping into the natural drainage system.

Turbidity in the streams has been caused by erosion on the plateaus. In some areas high sedimentation in streams has altered stream profile and riparian vegetation. Further discussion of this problem is given in Appendix A.

The results of illegal oil dumping in the western tributary to Mill Creek have been observed. The impact is visually displeasing but has not been quantified.

The AAEC burial grounds for low level radioactive wastes do not appear to pose a danger or problem to aquatic life or humans. However, the area is not an ideal location for the burial of radioactive waste because of the high water table that exists on that site.

3.9 Noise

This section is a summary of a more detailed discussion of noise assessment which is presented in Appendix E.

The principal sources of noise which may contribute to the annoyance or discomfort felt by residents in West Menai are:

i) artillery noise from the Holsworthy Firing Range;
ii) traffic noise along the Heathcote Road and any new link road(s);
iii) aircraft noise from civilian and military aircraft;
iv) noise generated by quarrying operations and the MWDA waste disposal operation; and
v) noise associated with existing recreational activities including:
    - trail bike riding
    - model aeroplane flying (aero club)
    - skeet shooting (gun club).

Because of the close proximity of the Holsworthy Firing Range, the assessment of the West Menai development proposal requires particular attention to the noise impact of artillery firing.

In the assessment of noise impact for an area, it is important to take into account the cumulative effect of introduced noise on ambient levels.

3.9.1 Artillery Noise

In an effort to better define the artillery noise problem and its extent, the Department of Defence has recently commissioned the National Acoustics Laboratory (NAL) to conduct a noise study of artillery firing at Holsworthy, entitled the "Defence Impulsive Noise Study" (DINS). Although the detailed results were not available at the time of writing this report, fruitful discussions with the researchers have taken place and preliminary estimates of noise exposure levels in West Menai and their perceived impact have been obtained.

It is apparent from both a social survey and noise level monitoring over 12 months, that an Leq level of 40 dB(C) from the artillery firing is likely to cause serious effect to approximately ten percent of people

(Bullen, verbal communication). A description of "seriously affected" and a comparison with surrounding suburbs is provided in Appendix E.

The preliminary noise exposure contours show that the most significant noise impact occurs in the southwestern corner of the study area. The Leq 45 dB (linear) contour has been plotted on Map 10. This contour is approximately equivalent to the Leq 40 dB(C) noise level, which had not been plotted by NAL at the time of writing this report. **It is recommended that residential development not be permitted south of that approximate line until the noise problem is reduced or removed. Alternatively another use migh be identified.**

The Leq 45 dB (linear) isopleth has been plotted in surrounding suburbs for measurements taken during the DINS study. This isopleth is shown on Figure E.1 in Appendix E, and provides a comparison between the existing noise levels experienced by residents and the anticipated levels in the West Menai area.

There may be methods of reducing the average noise level. Some of the possibilities have been discussed with the Army and NAL and it appears that, if it can be clearly demonstrated that certain modifications to firing practice would reduce noise to surrounding residents, there may be an opportunity for cooperation.

It is recommended that discussions be held between the Army and NAL with a view to modifying the firing practice where it can be shown that such action would be effective in reducing noise impact.

It is also recommended that either the Council or the developer be required to advise all potential home owners in West Menai that they will experience artillery noise from time to time which, on occasion, may be intrusive. Refer to Appendix E for the rationale of this recommendation.

3.9.2 Traffic Noise

The likely areas of traffic noise will be:

- adjacent to Heathcote Road;
- adjacent to Illawarra Road;
- adjacent to any east-west link roads which are built; and

- across Mill Creek valley from gaps in the natural (or man-made) noise barriers.

The DEP has recently suggested a noise guideline for new developments: residential developments should not proceed in areas adjacent to major roads (greater than 8,000 vehicles/day) where the day time L_{10} noise level exceeds 65 dB(A) and the night time L_{10} exceed 55 dB(A) at the facade of any dwelling. This guideline has been adopted in planning considerations for Heathcote Road.

However, in the Draft Sydney Regional Environmental Plan (Botany Bay, 1982), the DEP has introduced the concept of a performance standard in Policy No. 21. Under this policy, a new dwelling which could not meet the required criteria of 55 dB(A) at its facade, could be approved if it could be demonstrated that, by taking extraordinary steps in design such as noise insulation and room orientation, the **interior** noise level did not exceed 50 dB(A).

Such a performance standard would be available as an alternative in the development of West Menai.

Field measurements show that at a distance of 30 m from the edge of the nearest traffic lane on Heathcote Road, it is unlikely that traffic noise will be annoying to most people during the day time (including peak hour). However, at night, a buffer zone of 40 m should be maintained between the edge of the nearest traffic lane and the facade of any house (not the property boundary) to achieve the recommended 55 dB(A) level.

Therefore, to account for the most sensitive period, **the nearest facade of all residences should be set back at least 40 m from the edge of the nearest traffic lane on all major roads.** This distance could be reduced if adequate noise barriers existed or were created, to maintain either the 55 dB(A) level at the facade, or 50dB(A) level in the interior with windows and external doors open.

The proposed new link road is likely to require a 30 m noise buffer zone while it is constructed to a 60 km/hr standard; if it is upgraded to 80 km/hr, a 40 m buffer zone would be neccessary as on other major roads. Noise levels will be slightly higher at intersections, and on steep grades (refer to Appendix E for more detail).

The suggested 40 m noise buffer zone along major roads could be utilised to provide a public transport corridor, such as a bus route with frequent stops. It could also provide a wide footpath, a bicycle path or both. This would provide a safe unifying link for residents and their children between the land development units which are strung along Heathcote Road in a linear fashion.

3.9.3 Aircraft Noise

The 20 NEF (Noise Exposure Forecast) 1983 contour has been used to assess the aircraft noise impact on West Menai. Figure E2 (Appendix E) shows the 20 NEF contour for Sydney (Kingsford-Smith) Aiport (KSA). This passes to the northeast of the study area and suggests that aircraft noise from KSA is not a significant noise nuisance to residents.

Bankstown Aerodrome and the Holsworthy military airstrip are discussed in Appendix E. They also are not significant sources of noise annoyance to West Menai.

In summary, aircraft noise is not regarded as a significant noise nuisance.

3.9.4 Extractive Industry and Landfill Operations

While quarrying and/or landfill operations are in progress, it is recommended that at least one kilometre should separate **exposed** plant equipment from the nearest residence. Good barrier attenuation is afforded by rock escarpments, pit walls etc. The closest any residents could be located to such an activity would be approximately 135 m from a barrier which provided the maximum of about 20 dB(A) attenuation. This presently occurs on the southern side of the Readymix-Farley sandstone quarry in the northwest corner of out study area. Refer to Appendix E for a more detailed discussion.

3.9.5 Recreational Activities

The phasing of development will mean that the early residents will co-exist with many of the existing weekend activities.

It is recommended that the aero club be moved during development of Land Unit A, and that trail bike riders be discouraged by all available means from the northern half of the study area. The 1.6 km radius exclusion zone might be an appropriate site for a well-maintained trail bike complex. Refer to Appendix E for further discussion.

3.9.6 Cumulative Noise Impact

The cumulative impact of noticeable (but not annoying) noise from artillery, nearby quarrying or MWDA operations, model aeroplane flying, trail bikes, road traffic, and occasional aircraft may be sufficient to cause significant annoyance to a significant percentage of residents. Therefore, an awareness of potential noise sources should be maintained during detailed planning and development.

3.10 Bush Fire Hazard

The risk of bush fires in the dry heath and sclerophyll forest areas surrounding Sydney is very high. The West Menai area is particularly vulnerable because of its landform and its proximity to the Holsworthy Military Reservation, a large area of high fire risk bushland immediately to the west.

In our considering fire hazard, the guidelines of the Rural Lands Evaluation Manual (RLEM) (DEP, 1981), the NSW Board of Fire Commissioners (NSWBFC) Hazard Reduction Booklet (1982) and the Bush Fire Policy of the Sutherland Shire Council have been followed.

All of the above sources of bush fire information either point out or imply that fire hazard depends primarily on the following factors:

- the size of the adjacent bushland;
- slope;
- vegetation type; and
- fuel accumulation.

In addition, several other secondary factors contribute to the degree of fire risk. These are:

- the amount of flammable material within the inner and outer fire protection zones;[1]
- density of existing development;
- egress; and
- fire fighting facilities available.

3.10.1 Size of Adjacent Bushland

Generally, the larger the adjoining bushland the greater the fire risk because of the increased fuel supply, the greater distance over which fire can spread and grow in intensity, and the reduced capacity of fire fighting forces to contain the fire.

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1. Inner fire protection zone - the area between the property boundary and the house in a typical urban lot. Outer fire protection zone - the bushland outside but adjoining the property boundary.

The West Menai development area is approximately 1,600 ha in area. Even if West Menai was developed to its maximum potential, over 500 ha could not be developed due to other physical constraints, primarily slope. In addition, there would also be considerable open space/bushland contributions on flatter terrain as required by Council and DEP planning instruments.

The Holsworthy Firing Range is a major remote bushland area of approximately 18,700 ha immediately to the west of the West Menai study area. It is this large fire-prone area which creates the most serious threat to homes which might be built in West Menai.

The vegetation in Holsworthy is open forest, scrub and heath, which is highly flammable during mid-summer. Because the most dangerous winds are the hot westerlies, a fire in the Holsworthy Firing Range would pose a great threat to homes downwind. The firing of artillery and small arms adds further risk to the natural fire hazard due to sparks and ordinance explosions.

East Menai is largely undeveloped east of the Old Illawarra Road and along the west side of the Woronora River. This bushland area, about 450 ha, also adds considerable fire risk to West Menai. However this part of Menai is likely to be developed before the study area.

The fire frequency in these areas is about every two years given the fuel, according to the bush fire control officer of Sutherland Shire Council.

3.10.2 Slope

The greater the slope the greater the fire hazard. Compared to the rate of spread on flat terrain a fire is likely to travel twice as fast up a 10 degree slope, and four times as fast up a twenty degree slope (NSWBFC, 1982).

Steep slopes surround all development in West Menai; most of the valley sides are greater than twenty degrees in slope. Structures clad in flammable materials should not be permitted in these areas.

3.10.3 Aspect

The direction a home faces and the direction of the nearest timbered slope are important in assigning risk. During periods of extreme fire danger, winds are most likely to be from the western sector; the NSWBFC Hazard Reduction Booklet ascribes greater risk to the N, NW, W, SW and S winds, rather than the eastern sector winds. Vegetation types on slopes facing north and west are likely to be drier and more flammable than vegetation on slopes facing to the east and south. This is due to direct sun exposure. Therefore, steep slopes facing the western half of the compass and which adjoin houses at the top of the slope, present the greatest fire hazard.

The large potential fire source of Holsworthy Artillery Firing Range is a result of size, vegetation, slope and aspect. The steep valley slopes of Deadmans Creek are immediately to the west of Heathcote Road and would allow a fire in Holsworthy to build up speed and intensity as it moved east toward the West Menai development. Heathcote Road and its associated cleared shoulder would provide adequate buffer to the most intense flames and good access for fire fighters. However, it would do little to prevent spotting.

The total distance between building facade and bush covered steep slopes would be in the order of 75 metres (40 metres east of the road; 12 metres road easement; 15-30 metres variable width west of the road; Army perimeter dirt road just inside the fence: approximately 5 metres). This is double that required by the Sutherland Shire Council Bush Fire Policy for set back from steep slopes. Heathcote Road provides excellent access. This should be sufficient to prevent major fires crossing the road into the urban development.

3.10.4 Vegetation Type and Fuel Accumulation

The RLEM ranks wet and dry sclerophyll forests as the highest risk among vegetation types. Coastal heath and shrubland are rated about half as hazardous.

The study team is of the opinion that heath, scrub and shrubland should be rated higher than depicted in the RLEM. This belief derives from observations of the team and those of experienced fire fighters in scrub/heathland. Although there is less "heavy" or woody fuel than in a forest, the low surface vegetation of heath and scrub provides the main fuel of bush fires. The dead vegetation litter on the ground, and low shrubs with oil-bearing leaves are likely to flare and enhance fire intensity.

The slow burning of heavy fuels after the main front has passed has limited significance for the fire fighter, whose main concern is the finer material which is rapidly consumed and contributes most to the spread of fire. Heath and scrub provide abundant fine fuel, both living and dead. The NSWBFC Hazard Reduction Booklet points out that fuel in excess of 6 mm (pencil thickness) tends to burn after the fire has rushed through the finer material, and can be excluded from a fine fuel sample.

Following from the above discussion, dense heath and scrub (greater than 50% projected foliage cover) has been given a rating equivalent to dry sclerophyll forest.

3.10.5 Fire Hazard Rating

The RLEM fire rating scheme aims to define fire hazard areas within broad rural areas for consideration of adequate planning measures, whereas the NSWBFC Hazard Reduction Booklet and the Sutherland Shire Bush Fire Policy are designed principally for the protection of urban dwellings which already exist adjacent to fire prone bushlands. The two latter policies provide more detailed specifications and on a much smaller scale than the RLEM.

The method of recording fire risk in the NSWBFC booklet requires the estimation of:

i) the Basic Risk Index, which depends on the size, slope and aspect of adjacent bush (in this study area the Basic Risk Index would obviously be very high); and
ii) the Current Hazard Index, which depends on the condition and size of the inner and outer fire protection zones (this cannot be done in an

undeveloped area although consideration should be given to high standards when planning for development).

Since this report is intended as a broad planning instrument, rather than a detailed planning guide, the RLEM method of fire hazard rating was used for initial assessment.

The fire hazard rating for the study area is shown on Map 9. All rateable areas have either a medium or high fire hazard rating. The small pockets of medium fire hazard are on the flat plateaus, as far from the steep valley slopes as possible, and with good access. The unrated areas have been cleared of the original natural vegetation and are excluded from the analysis.

3.10.6 Recommendations

As pointed out in the RLEM, there are two basic options for development of medium and high fire hazard areas:

i) Exclusion of Development. This is a viable option if there are alternative sites available to meet the same demand for development. It is also an option where the provision of risk reduction works are not cost beneficial in terms of either direct financial cost, or environmental costs associated with impact on scenic or ecological amenities.

ii) Develop the area in such a way as to protect it from fire. In this case, careful compliance with such policy specifications as the NSWBFC Hazard Reduction Booklet and the Sutherland Shire Bush Fire Policy is required. It is noted that the NSWBFC booklet is more specific and conservative with respect to a hazard reduction zone.

In view of the fire history of the forest and heathland areas in the Sutherland Shire, and the slope and aspect of bushland adjoining potential development areas, it is considered reasonable to predict that parts of West Menai will burn in the future.

Therefore it is recommended that:

i) **Exclusion of development on the grounds of bush fire hazard should be given serious consideration.** Serious fire risk will always be a part of life in West Menai. Extensive risk-reduction works could seriously impair the attraction of the very thing people would live there to enjoy: a rich and varied bushland setting.

ii) **If it is concluded that on balance, West Menai should be developed, an adequate buffer zone should be maintained along Heathcote Road.** The 40 metre noise buffer on theeastern side of Heathcote Road could be planted with selected trees and shrubs. The nature strip between the western side of the road and the Holsworthy fence would require regular hazard reduction clearing but selected trees and shrubs should remain. The advice of competent botanists with local knowledge should be consulted on ways to protect or transplant **Melaleuca deanei** and other rare or restricted plants which occur in the affected area.

iii) **If development proceeds, the recommendations of the Sutherland Shire Bush Fire Policy and NSWBFC Hazard Reduction Booklet should be followed with regard to:**
   a) **fire protection zones in the detailed planning of lot positions;**
   b) **hazard reduction burning.**

iv) **During the detailed planning of traffic routes and fire breaks, close consultation should be achieved with the Sutherland Shire Fire Control Officer.**

v) **No structures with an external facade/cladding which could burn should be constructed on slopes greater than twenty degrees.**

3.11 References

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4. DEVELOPMENT POTENTIAL

4.1 Constraints

Apart from placing the study area in its environmental context, the main purpose of the background investigations was to identify a series of constraints upon urban development in the West Menai area. These constraints are summarised in this section and their extent has been plotted on Map 10.

4.1.1 Slope/Soil

The steep slopes associated with the deeply incised drainage lines are the major constraint to development. Slopes less than one percent (because they are very difficult to drain) and greater than 25% (major foundation risks and cost penalties) are defined as constraints to development.

The amount of land which is sterilised in the study area by slope constraints is estimated to be about 30% of the total 1,600 ha.

The dominant soil type is loose and skeletal/colluvial. This soil type is very highly erodible, particularly when the vegetation cover is disturbed. Map 4 shows those areas where soil erosion is likely to be a serious problem for development.

Soil erosion has already caused high sedimentation in the creeks draining the disturbed plateaus.

4.1.2 Subsidence

Beneath the southern part of the study area are two known coal seams which, at the present time, are not economical to work. However, technology and economic demand may reach the stage where it is worthwhile extracting the coal. If this resource is not to be sterilised by new development then any construction in the area must be capable of accommodating a calculated amount of surface subsidence which may follow the mining of the seam. The northern-most boundary of the area which could possibly be affected by subsidence is marked on the incompatible

land use map (Map 8), and management techniques to allow for future surface movement are discussed in both Section 5.3 and Appendix A. The only recommended constraint to development is a footing specification in the southern region; concrete slabs are discouraged in this area but cannot be prevented by legislation and controls relating to Mine Subsidence District as West Menai is not classified as such.

4.1.3 Flora and Fauna

Specialist studies have nominated a number of areas which should be preserved in their natural state. Five comparatively rare plant species have been identified, one of which is an endangered plant (see Section 2.4). It has been recommended that where these occur naturally, some stands of vegetation should be preserved to allow them to continue to exist in their natural associations.

Second, many of the vegetated areas are of significant landscape value. The existing vegetation enhances the backdrop of cliffs to the Georges River as well as reducing the impact of any development upon the skyline ridges which may be seen from as far away as Botany Bay. Furthermore, one of the attractions of the area is the extent of vegetation along the valley floors and on the crowns above the sandstone cliffs when observed from local viewpoints.

Finally, it has been recommended that not only should significant areas be set aside to allow animals, particularly birds, to live in their natural habitat, but fauna corridors should be provided to permit animals to cross freely between larger neighbouring natural areas such as the Holsworthy Firing Range and the study area. Areas of vegetation which meet these requirements are shown on the constraints map.

4.1.4 Archaeology

The methodology adopted by the consultant archaeologist in surveying the study area has been outlined in Section 3.1 and sites of archaeological interest have been plotted on Maps 7 and 10. However, it must be remembered that the archaeological survey is not comprehensive for the entire study area, and before major development takes place in certain areas defined in our report (Appendix C) the developer must consult with

officers of the National Parks and Wildlife Service (NPWS) who will decide whether further investigations are required.

4.1.5 Committed Land Use

Although not zoned for urban purposes, there are a number of activities which are firmly established in the study area and which will have both short and medium term, and in some cases continuing, implications for residential development. The location of these is indicated on Map 10.

AAEC Exclusion Zone

The 1.6 km radius zone of influence of the AAEC defines the southern boundary of the study area. However, the AAEC intends to retain its control over Portions 251, 252 and 253 and is to maintain control of part Portion 16. Restrictions to this parcel of land will be similar to the 1.6 km zone and cannot be considered for urban purposes.

A further constraint resulting from the proximity of the AAEC reactor is the State Government policy to limit the permanent population within 4.8 km of the AAEC to 5,000 persons within 20° sector and to prohibit certain land uses such as food manufacturing and hospitals.

Shale/Sandstone Quarries

Quarrying operations in the study area will also continue for some years to come. Although the three shale quarries at Little Forest are virtually worked out, an assessment is being made of the value of the shales in adjacent areas and if they are of a particular type (especially cream-burning clay) it would be good planning to permit their extraction before intensive urban development takes place in this vicinity.

Another proposal for a cream-burning clay quarry adjacent to the Lucas Heights reservoir has apparently been abandoned, since significant sandstone overlies any possible resource, and the quality and extent of cream-burning clay is not known. Therefore this area has been disregarded as a significant geological resource. It would be up to the Department of Mineral Resources and/or the lease applicant to make a case for reservation of this area until extraction could take place.

The sandstone quarry in the northwest corner of the study area has a lease and an appended work programme which envisages operations continuing for perhaps another ten years.

Gosford Quarries have taken over an existing small lease on the ridge above the Metropolitan Waste Disposal Authority (MWDA) operation and wish to renew the extraction of sandstone blocks from this lease or an adjacent area. Ongoing working of this quarry would be appropriate only as long as the MWDA continues operations in the vicinity.

An approach has also been made by a quarry operator to open a new crushed sandstone quarry and a concrete batching plant on the knoll just west of New Illawarra Road and very near the existing concrete batching plant at the southern extremity of the site. This is a proposed land use and is not yet committed but if it should be approved its working life and restoration should be linked to MWDA operations.

Solid Waste Disposal

The MWDA has had a solid waste disposal establishment at Lucas Heights for many years but the existing facility is reaching the limits of its capacity. Present expectations are that the existing design plans will be complete by late 1986. The existing site could be redesigned and filling continued for several more years, although with some cost penalties and adverse effects on adjacent housing. However, approval has been sought to carry out a Stage II waste disposal operations in Bardens Creek, and plans have been prepared to this effect. Another alternative under consideration is the establishment of an MWDA facility at Upper Mill Creek.

The impact of either option could be significant on residential development, the extent of the proposed Stage II site is plotted on the constraints map. The proposed operation at Bardens Creek would be filled to agreed contours and landscaped. It is anticipated that compaction will be sufficient for road construction and possibly lightweight building construction. Similar standards could be expected to apply to any alternative proposal for Upper Mill Creek.

The areas at present used for solid waste disposal are Portions 125, 126 and part Portion 124. It is the intention of the Health Commission to proclaim this land unfit for building construction due to the differential settling which is expected of landfill sites. Modern compaction techniques have eliminated most settling problems but this tip has an earlier history of uncompacted filling before being taken over the by MWDA.

There is also concern by the Health Commission about methane gas generation. It is our understanding that vent pipes quickly remove any methane gas which may be produced. Modern techniques have apparently reduced gas production. This would need to be demonstrated to the satisfaction of the Health Commission.

The Health Commission would probably not object to limited building construction provided:

- it was designed to overcome any engineering problems associated with the poor bearing capacity of the fill;
- precise measures were taken to ensure gases did not enter any building; and
- site surveys were carried out to determine whether gases are generated.

However, while in the long term such sites might be suitable for industrial and other developments, for the purposes of this plan, the general policy for such areas is playing fields and open space.

Liquid Waste Disposal Area

Part of Portion 16 has been utilised as a liquid trade waste disposal area by Industrial Waste Collections Pty Ltd. The site is proclaimed permanently unfit for any other purpose. It has been covered with topsoil and fenced. Fumes emanate from the site and are offensive for up to 100 metres. It is not known whether any toxic liquids or gaseous emissions occur. Investigations by the Health Commission are recommended to verify the safety of adjacent areas. A temporary buffer zone of no development should be maintained for 100 metres around this site until further evidence is collected on any discharges and its safety demonstrated.

Night Soil Dumping Area

The night soil dumping grounds will be proclaimed unfit for building purposes by the Health Commission under Section 55 of the Public Health Act, 1902, as soon as the permissive occupancy arrangement has ceased. The portions affected are 252, 121, 254, 255, 122, 152, 156, 272, 273, 274, 277, 278, 276, 279, 280 and part Portions 251 and 253.

The area will be required to be fallow for 15 years or until it can be proved by soil testing that all waste had been assimilated into the soil. The topsoil will then probably be required to be stripped and all materials satisfactorily dispersed. Night soil areas are not to be used for active sports, i.e. body contact sports, unless the site has been cleared and a fresh sand/soil layer placed over the top. However, passive recreation is acceptable particularly when suitably landscaped.

Holsworthy Artillery Firing Range

The Department of Defence has advised that the Holsworthy Firing Range will continue to be an important facility for the foreseeable future. Although this is outside the study area, it is an incompatible neighbour from points of view and noise and bush fire hazard and should be taken into account in planning.

Other Land Uses

A small lease for the purpose of a concrete batching plant has been approved on New Illawarra Road. This is not considered a significant constraint as the operators can be encouraged to relocate in any industrial area likely to be developed on the site when their lease expires. Similarly, the model aeroplane club and the gun club located off Heathcote Road and the pony club adjacent to the concrete batching plant could also find alternative accommodation fairly readily when their sites are required for urban development.

These would be interim land uses and a condition of continuing operation would be that restoration be carried out at completion.

4.1.6 Noise

Artillery firing creates a significant noise problem on the southwestern plateau (see Map 10) and much of Land Unit 29 is effectively sterilised for residential purposes until the artillery noise is reduced or removed.

Road traffic noise from Heathcote Road, New Illawarra Road and any future link roads across the study area requires that a distance of 40 m separate the edge of the road and the facade of a residence. This buffer zone is needed to comply with the DEP guideline of a night time L_{10} of 55 dB(A) at the facade. This buffer distance could be reduced using noise attenuating barriers, noise insulation, or room orientation techniques. About 30 m of buffer zone would be required on a 60 km/hr road.

Quarry operations and the MWDA landfill operations will generate localised noise impacts which warrant consideration with regard to phasing of residential development. Generally, any exposed machinery should be at least one kilometre from the nearest residence to preclude noise annoyance. The pit wall at the Readymix-Farley sandstone quarry provides sufficient barrier attenuation to recommend development up to 135 m of the pit wall in a southerly direction.

Recreation activities within the development areas such as trail bike riding, model aeroplane flying and skeet shooting will have to be phased out as development proceeds. Short term nuisance may be felt by the early residents in the area. Trail bikes will continue to present a noise problem unless alternative locations are provided for them.

The cumulative effect of a number of relatively minor noise intrusions at West Menai may become significant. For this reason an awareness of noise impact should be maintained throughout the detailed planning process.

4.1.7 Access

Road access into the study area is a primary constraint on development. The location of road corridors is itself constrained by many factors including topography and committed land use. Topography provides the

major constraint partially through its effect on road and bridge construction costs.

Road corridors are also constrained by possible access points onto the adjacent major road network. The current alignment of Old/New Illawarra Road is such that there are very few acceptable access points. The preferred access point at Barden Road is further constrained by proposed future motorway locations. The proposed east-west motorway meets the Old Illawarra Road at Barden Road, and the proposed north-south motorway meets Old Illawarra Road either north of, or south of Barden Road. Access for all link road options on to Old Illawarra Road is preferred at Barden Road, focusing on the future motorway locations. This is discussed in detail in Appendix D, and illustrated on Figure D.9 of that Appendix.

On the western side of the study area the alignment of Heathcote Road provides fewer constraints on access for the east-west link road but alignments and sight distances must still be considered. The development along the eastern side of Heathcote Road is also constrained by its linear nature since the number of access points onto Heathcote Road needs to be controlled. Because traffic speeds on Heathcote Road are generally high, a large number of access points would create an unsafe situation. Traffic on to the road must be channelled into a limited number of points.

Should early development proceed in the northwest parts of the West Menai area, there appears a need to permit a crossing of Mill Creek for use by fire services, cyclists and pedestrians. For development options which do not include a road crossing in this vicinity a lower cost crossing is recommended.

Public transport services to the site at the present time are limited, but given the existing topography, it is unlikely that any future parcel of developed land will be located more than one kilometre from either existing roads or a link road and these should provide a relatively simple bus routing network.

4.1.8 Services

The provision of electricity and telephone services to West Menai presents no obstacles to development. Existing sewerage services could be extended to accommodate new development in the southeast of the study area while plans have been prepared for an aqueduct crossing of Mill Creek in the vicinity of Rosewall Drive to allow for a major sewerage main along the western bank of the valley to service development in from Heathcote Road. The only constraint this places upon development, apart from timing, is a stated inefficiency in any system providing secondary mains up some of the western tributaries of Mill Creek to service only one side of the catchment.

The provision of a water supply to the study area presents the major constraint to the phasing of the development of West Menai. By upgrading the existing reservoirs and utilising the proposed aqueduct near Rosewall Drive, water can be provided to developments in the southeast corner of the study area and to the northern parts of those areas west of the Mill Creek valley. However, on the western side there is a height limit of AHD 100 which will prevent further development to the south along Heathcote Road until such time as an additional main can be constructed along a link road through the middle of the site. Land above AHD 120 generally in the southwest corner of the study area cannot be serviced without the construction of a tank, pumping station and mains estimated at this point in the order of $1 million. An area of some 100 ha is constrained by this factor.

The provision of community facilities does not present difficulties if they are planned for in advance and the areas are developed in viable population units. However, should the development period be prolonged, consideration will have to be given to providing interim accessibility to facilities in neighbouring areas.

4.1.9 Bush Fire Hazard

The risk of bush fire damage in the study area is serious enough to consider a non-development option. However, should development proceed a strictly managed buffer zone must be maintained along Heathcote Road including the western slope down to Deadmans Creek. Also if development

is to proceed the recommendations of the NSWBFC Hazard Reduction Booklet and recently circulated draft State policies on development in areas of bush fire risk should be followed.

4.2 Development Potential

In addition to constraints to development the background studies identified a number of special opportunities which should be taken into account in the planning process. Also any new population locating in the study area will generate its own demand for services and facilities.

4.2.1 Geological Resources

As a general principle it is recommended that new development not sterilise any valuable mineral deposits which have not yet been extracted. It is recommended that existing quarry leases continue to their planned completion and that the potential cream-burning clay areas in Little Forest and south of New Illawarra Road be tested to establish their value as soon as possible. Two new leases are under consideration; one to extract and crush sandstone for roadbase material, and the other to quarry for dimension sandstone. Provided that these leases include a requirement to restore the sites, cannot be seen from New Illawarra Road, and are not allowed to continue beyond the completion of MWDA operations in the vicinity, then they should be permitted. It is also recommended that further consideration be given to construction standards for civil engineering and building works in the southern part of the study area to allow for future subsidence if the coal seam is worked.

4.2.2 Landscape

The natural "wilderness" character of the valley systems is probably the greatest attraction for new residents coming to this area and any development should be sympathetic to that character.

Planned development of the West Menai area provides a number of opportunities to preserve landscape elements which contribute to the visual amenity of the region and local areas. Plans for the area should preserve the ridge lines which, as explained in 2.5, have both regional and local significance as well as the cliffs and vegetation backdrop to the Georges River. Detailed planning of the individual development precincts should also consider the internal views across valleys to adjacent ridges. As much vegetation as possible should be maintained on the shoulders above the sandstone cliffs to screen new housing from view.

Once developed, views within the site will become more important and buildings, roads and other constructions could come to dominate the environment. The existing drainage system (creeks and their valleys) covers ground which is usually too steep for easy development. By utilising this system as a network of vegetated open space, the developed areas would be divided into clearly separate units of more human scale and of lesser visual impact than if all possible areas were built on.

There is also the potential to meet both landscape and environmental objectives concurrently by considering only cluster forms of housing in some areas where good vegetation should be maintained for aesthetic and habitat reasons. Such areas are indicated on Maps 5, 6 and 10 and in the principles diagrams (Figs. 5.4.1 to 5.4.8).

4.2.3 Recreation

The study area at West Menai at present accommodates a number of recreation activities. As well as the model aeroplane club, gun club and pony club which have formal leases, other activities such as trail bike riding, orienteering and boating, operate informally. There are opportunities to provide for four broad categories of recreation in future planning. These are:

i) developed active recreation on a large scale, such as a showground and golf course;
ii) undeveloped passive recreation with paths and trails in the bushland valleys;
iii) preserved wetland areas where the natural environment may be retained for scientific and educational purposes (see section 2.2.4); and
iv) developed riverside passive recreation similar to State Recreation areas on the other side of Georges River.

These opportunities meet both regional and local needs and would be in addition to the smaller facilities which would be associated with development for a new population.

In particular, the Georges River and its foreshores offer an opportunity to become a regional recreation resource, the precedent for which has already been established at the Picnic Point State Recreational Area on

the northern side of the river. The steep tree-covered slopes surrounding the broad waterway and lack of obvious residential development create a valuable visual resource with great recreational potential.

If a "no development" option were to be adopted then there is also an opportunity to formalise to some extent the activities of trail bike riders which are not well catered for in most parts of the Metropolitan region.

4.2.4 Housing

A marketing strategy must rely upon predictions of supply and demand affecting the sub-market in question. In the case of West Menai it is fundamental to consider the sub-market as including both East and West Menai. As both these areas contain Crown land it is imperative that they are considered together in any marketing strategy. The two areas most likely will be developed within overlapping time frames and a marketing gain for one area will almost inevitably be at the expense of the other.

Market Segment

There are three essential market segments in Menai: high quality land, for example the Illawong portion of East Menai which is currently marketed at prices up to $70,000 (water views); medium quality land, for example the Bangor area currently being sold up to $50,000; and poorer quality land, for example some sections of the Menai area which in most instances fetch a lower price than the above mentioned categories.

The marketing approach should be based upon the continuing supply of land in all three categories in order to spread the risk of a market downturn.

Data has not yet been made available to allow analysis of market demand in terms of the three market segments identified above. It is however, important to define demand for the Menai area in order to illustrate the potential constraints which will affect cash flow calculation for East and West Menai as the two areas are intrinsically linked.

Demand

Demand analysis is based on the patterns of housing completions between 1971 and 1981. The following facts are relevant:

Average Total Housing Completion, Sutherland Shire, per annum	792
Average Total Housing Completion, Menai per annum	500
Percent of Total Shire Housing Completion	63

In the absence of any evidence to the contrary, the above figures provide a first estimate of the likely rate of demand in future. DEP projections indicate some increase in population growth in the 1981-2001 period. This increase could result in the need to anticipate a demand rate approximately 20% greater than the 1971-81 rates. Sutherland residential market has featured a range of new release areas over the previous decade, of which East Menai has been the largest. The alternatives are now approaching capacity and Menai is expected to capture a greater market share over the next 20 years. Urban consolidation and residential infill will continue to contribute approximately 25% of the total Sutherland market and Menai will supply the remaining 75%.

Projected Total Housing Completion, Sutherland Shire per annum	950
Menai's Market Share of Total Housing Completion	.75
Projected Total Housing Completions, Menai per annum	713

Housing completion in Menai will therefore probably average about 715 per year.

Supply

Assuming a constant lot yield of nine lots per hectare, the Department of Lands has calculated that East Menai has a total potential of 9,000 lots. While the pressures for urban consolidation may encourage more medium density development, and therefore boost this potential, the more conservative figure will be adopted in this analysis.

At 30 June 1983, 4100 lots in East Menai were either under development or fully developed, with a remaining 4,900 lots available for future development.

Data regarding the rate of supply are limited in the absence of a full land market study. An indication of supply can be gained from records on 1981 lot production.

Total Lots Produced in Sutherland 1981	1,008
Total Lots Produced in Menai 1981	628
Percent of Total Sutherland Lots	62

With these figures in mind, and assuming that the release of West Menai would broaden the potential Menai market by about 10%, it would appear that the demand for lots in the total Menai area will be about 690 lots per annum.

When the alternative release areas in Sutherland reach capacity, Menai's market share is expected to increase by a further 10% and lot demand will average approximately 750 lots per annum.

This extrapolation of lot creation statistics projects a demand in Menai from 690 up to 750 lots per annum. The previous projection of housing statistics provided a demand figure of approximately 715 dwellings per annum which suggests that the average demand will be approximately 720 lots per annum.

East Menai is expected to satisfy the projected demand for a further seven years and it is understood that all three of the market segments previously discussed will be accommodated.

4.2.5 Land Required for Industrial and Other Development

There are two categories of land to be considered:

i) Land for service industry;
ii) Land for other industry and non-local employment.

Land for service industry will primarily serve the needs of the West Menai population. The requirement for this purpose is calculated upon the basis of Appendix I Table I2.

Based upon the analysis obtained in this table, it is recommended that a land allocation of 18.3 ha be made for service industry use within the West Menai Release Area. However, this might have to be increased if insufficient land is set aside in other parts of the Menai district.

Land for other industry and non-local employment could be in demand in the long term. It is obviously impossile to precisely predict this demand and recommendations for an allocation can only be made in broad terms.

The results of Sutherland Shire's 1978 survey of zoned industrial land, excluding Kurnell, showed that some 75 ha was vacant at that time. Council officers advise that there has been considerable land take-up since that time, and that a potential shortage could develop. In the absence of any more precise data, it appears that the 1978-83 industrial land take-up is probably about 50 ha, i.e. 10 ha per annum.

The degree to which West Menai can satisfy Sutherland's future industrial land needs is a matter of surmise. Assuming that West Menai could satisfy half the industrial land need of the Shire, excluding Kurnell, and that to plan for a 20 year supply is acceptable, the industrial land potential is calculated as follows:

Annual take-up: 5 ha
Twenty years' demand: 100 ha

An office park, if established, would require about 30 ha. Assuming satisfactory land can be identified and set aside for development, the total area of land required for long-term, non-service, non-local employment would be 130 ha. If compaction and management techniques at the MWDA site at Bardens Creek prove satisfactory, this could accommodate over half of the potential demand.

Industrial Employment

The present industrial workforce within Sydney implies an average worker density of 50 workers per hectare. Current trends in this sector suggest that such a density is likely to decline due to increased automation, but with limited data available, the present density of 50 workers per hectare will be applied as an indication of the maximum employment generation for

the recommended industrial estate. Given an estate of 18 hectares this equates to a maximum employment potential of 900 service sector workers while if 100 ha were set aside for general industry this could generate employment for up to 5,000.

Office Park Employment

Since the notion of office parks is relatively new to the Australian experience, and its implementation within the estate is limited to the long term, it is impossible to establish precise guidelines for the likely employment generation. American experience suggests that these parks accommodate up to 2,000 workers but with 30 hectares of land designated for this purpose, a figure of 750 would appear more realistic when the office park reaches capacity.

The proximity of AAEC and related CSIRO facilities could create an opportunity for the establishment of a specialist "high technology" base fo this employment area.

Retail Employment

The determination of worker densities in the retail sector is complicated by the preponderance of part-time employees. Experience in the City of Blacktown suggests a density of one equivalent full-time worker per 50 m^2 of retail floorspace. The recommended retail floorspace for the estate is 7,395 m^2 which equates to a workforce generation of approximately 150 employees.

Total Employment

The maximum employment potential for the estate prior to the development of an office park or major industrial estate is approximately 1,000 workers and this could increase to a total of 1,750 workers when an office park reaches capacity. A major industrial estate could provide a further 5,000 jobs when fully developed, if sufficient suitable land could be identified and existing densities were maintained.

4.2.6 Community and Commercial Facilities

A survey of potential institutional land users was carried out and this section sets out needs identified at this stage.

Churches

The Anglican Church requires an area of approximately one hectare for use as a church site within easy access of the proposed public and private transport corridors.

The Catholic Church requires approximately five to six hectares for a church and school complex in the vicinity of the district centre.

The Uniting Church requires approximately 1,000 m^2 for a church site within the district centre but may require up to 2,700 m^2 if provision for on-site parking is required.

The Presbyterian Church requires approximately 3,500 m^2 for a church site along the main road connecting Heathcote and Illawarra Road, preferably equidistant between the Menai town centre and the estate's district centre.

Service Institutions

The Scout Association and the Girl Guides will each require two sites of approximately 600 m^2 for the development of halls within the neighbourhood centres.

Emergency Services

The Police Department require approximately 3,000 m^2 for a single storey sub-station near the district centre with privacy at the rear of the lot for the handling of prisoners.

The Health Department will require a shop in the district centre of approximately 80-100 m^2 for a baby/neighbourhood health centre. This facility combined with the proposed Community Health Centre in the Menai Town Centre will provide sufficient service for the estate.

Child Care Facilities

The Department of Youth and Community Services recommended that multi-purpose child care facilities be provided on the basis of one classroom unit (20 children) for each 500 lots, which they approximate as one space per 12 children. Assuming that West Menai will attract a similar age structure to the existing East Menai population the estate will require nine child care units.

It is recommended that a two-unit centre be developed adjacent to each of the two neighbourhood centres, a three- unit centre be developed adjacent to the district centre and a further two-unit centre be developed within the business park. These nine centres would each require lots of approximately 700 m^2 with a total land requirement of 2,800 m^2.

Community Amenities and Services Provision

The Council's attitude to the use of Section 94 is generally in line with guidelines set down by the Department of Environment and Planning in Circular 42. In this regard there will be a need to prepare a Social Plan. Until this is done it is difficult to determine the land requirements and precise level of monetary contribution. It would, however, appear that council aims to develop multi-purpose community centres at a neighbourhood level suggesting that two such centres may be required in the estate. These centres require a lot size of approximately 5,000 m^2 each and should be located in the proposed neighbourhood centres.

Should these centre be developed, there is an obvious need to coordinate their provision with the Scout and Girl Guide organisations and other users of local halls.

Primary School Facilities

Based on the Education Department's "pupil generation index" (PG1) technique (see Appendix G) the estate will eventually require **three** primary schools if its population exceeds say 17,500.

High School Facilities

The Education Department designs its high schools for approximately 1,000 pupils on a site of six hectares, with one high school provided for a community containing 4,000 dwellings. According to this standard of provision the estate will require one high school which should be located adjacent to the district centre and bordering on to a major road for optimal access to public transport. Localities west of Mill Creek will generate 65% of the demand for the high school and the site should favour these western areas of the estate.

The Education Department is currently building a new high school at Holsworthy and this may cater for some of the demand generated by the northwestern portion of the study area as well as Sandy Point. A high school is also proposed for the Menai town centre and this may meet the demand generated by localities nearer Illawarra Road.

Other Institutional Facilities

While no major institutional land users were identified in the study and State policy prohibits a number of them within 4.8 km of the AAEC, planning for some areas (e.g. areas 28.8 and 27.6) should be flexible enough to accommodate such facilities if a need arises in the longer term.

4.2.7 Land Required for Retail Areas

The analysis of retail demand (see Appendix H) shows a requirement for a supermarket-dominated centre of some 7,040 m^2 and a need for additional neighbourhood centre space in other locations totalling 2,350 m^2 for the preferred option.

In view of the dispersed nature of residential development in the area, it is likely that two neighbourhood centres of approximately 1,180 m^2 each would be appropriate. Using this assumption, the land areas required for each centre are in the following order of 1.3 ha for the supermarket-dominated centre and 0.3 ha for each of the neighbourhood centres. (see Appendix H, Table H2).

4.3 Land Development Units

After plotting constraints to development of the West Menai area the study identified 58 separate land units each with sufficiently similar internal characteristics to be regarded as a contiguous homogeneous area. These units ranged in size from 410 ha (the bulk of the valley floor) to 1 or 2 ha (usually areas isolated from a similar unit by a man-made discontinuity such as the study boundary or a road). Generally, the land units ranged from 5 ha to 40 ha.

Earlier Menai planning studies identified 37 broad development areas with Areas 25 to 36 applying to the West Menai area. For comparison purposes this numbering system has been maintained and along with the areas of valleys and slopes generally unsuitable for urban development (X) have been subdivided into the 58 land units. Table 4.1 sets out for each unit its area, its suitability for various land uses and its potential residential yield while Map 11 establishes the boundary for each unit.

An assessment of various types of land use which could be accommodated on each land development unit and the arranging of these in various combinations provide the basis for a number of options which were evaluated later in the study.

TABLE 4.1: DEVELOPMENT POTENTIAL

LAND UNITS	AREA (ha)	DEVELOPMENT SUITABILITY						COMMENTS	RESIDENTIAL POTENTIAL (lots)
		R	C	I	SU	AR	PR		
(i)	(ii)			(iii)				(iv)	(v)
25.1	29	H	S	U	S	S	U	Subject to application for quarrying	275
2	3	H	S	U	S	S	U		25
TOTAL	32							Potential population 2,850	300
26.1	21	S	U	U	U	U	S	Some steep slopes	125*
2	10	U	U	U	U	U	S	Adjacent to MWDA	-
3	51	U	U	S	S	S	U	Existing MWDA available 1985-6 borrow areas suitable for construction	-
TOTAL	82							Potential population 500	0 - 125
27.1	30	S	U	S	S	U	U	Borrow area for MWDA, suitability will depend on restoration, some steep slopes	285*
2	10	S	U	S	S	U	U	Transmission lines, proximity to MWDA, some slopes and erosion potential	95*
3	2	U	U	U	U	U	S	Steep slopes	-
4	9	S	U	S	S	U	S	Subject to soil conservation techniques	85*
5	10	S	U	S	S	S	U	Potential quarry, contiguous with MWDA, subject to design controls	95
6	83	U	U	U	S	S	S	Assumed MWDA land unsuitable for development in foreseeable future	-
TOTAL	144							Potential population 2,000	0 - 560
28.1	11	S	U	U	S	S	U	Could be expensive to service	105*
2	3	S	U	U	U	U	S	Some steep slopes	25*
3	29	S	S	S	S	S	U	Proximity to AAEC, MWDA, etc	275*
4	10	S	U	U	U	S	S	Head of tributary valley	95
5	2	U	U	U	U	U	S	Steep slopes	-
6	26	H	S	U	S	S	S	Well-treed	250
7	32	S	S	S	S	S	U	Subject to quarry restoration and liquid wastes	300*
8	22	S	S	S	S	S	U	As for 28.3	210*
9	2	U	U	U	U	U	S	Steep slopes	-
10	41	U	U	U	U	U	U	Excluded from transfer	-
TOTAL	178							Potential population 1,250-4,500	345-1,260
29.1	15	S	U	U	U	U	H	Steep slopes along creek lines	90*
2	7	H	S	U	U	U	U		65
3	7	H	S	S	S	S	U		65
4	17	S	S	S	S	S	U	Subject to quarry resoration	160*
5	8	S	U	U	U	U	S	Subject to soil conservation techniques	75*

TABLE 4.1: DEVELOPMENT POTENTIAL (cont'd)

LAND UNITS (i)	AREA (ha) (ii)	DEVELOPMENT SUITABILITY (iii) R	C	I	SU	AR	PR	COMMENTS (iv)	RESIDENTIAL POTENTIAL (lots) (v)
6	18	S	S	U	U	U	S	Will sterilise shale deposits	170*
7	8	S	U	U	U	U	U	As for 29.5	75*
8	122	H	S	U	U	S	U	Expensive to service	1,160
TOTAL	202							Potential population 4,600-6,700	1,290-1,860
30.1	5	S	U	U	U	U	S	Well-treed, transmission lines	50*
2	25	H	U	U	S	U	S		240
3	6	S	U	S	S	S	U	Proposed sandstone block quarrying	55*
TOTAL	36							Potential population 900-1,250	240-345
31.1	5	S	U	U	U	U	S	Spectacular views to north	30*
2	15	H	U	U	U	S	S		140
3	2	S	U	U	U	U	S	Some broken rock and erosive soils	10*
TOTAL	22							Potential Population 500-650	140-180
32.1	39	H	S	S	S	S	U	Servicing after road link	370
2	7	S	U	U	U	U	S	Well treed along escarpment	40*
3	3	S	U	U	U	U	S	Area of good trees	20*
TOTAL	49							Potential population 1,350-1,550	370-430
33.1	22	H	S	U	S	U	U		210
2	8	S	U	U	U	U	S	Well treed along escarpment	50*
TOTAL	30							Potential population 750-950	210-265
34.1	10	S	U	U	U	S	S	Potential faunal corridor	60*
2	38	H	S	U	S	U	U		360
3	11	S	U	U	U	U	S	Well treed along escarpment	65*
TOTAL	59							Potential population 1,300-1,750	360-485
35.1	47	S	U	U	S	U	S	Some erosive soils, transmission line	450
2	76	H	S	U	S	S	U		720
3	5	S	U	U	U	S	S	Well treed along escarpment	30*
TOTAL	128							Potential population 4,200-4,300	1,170-1,200
36.1	40	S	U	U	U	U	S	Transmission line preserve ridgeline	380*
2	38	H	S	S	S	U	U	Subject to quarry restoration	360
TOTAL	78							Potential population 1,300-2,650	360-740

TABLE 4.1: DEVELOPMENT POTENTIAL (cont'd)

LAND UNITS (i)	AREA (ha) (ii)	DEVELOPMENT SUITABILITY (iii) R	C	I	SU	AR	PR	COMMENTS (iv)	RESIDENTIAL POTENTIAL (lots) (v)
X1	410	U	U	U	U	S	H	Main slopes & valley of Mill Ck	-
2	3	S	U	U	U	S	S	Lookout over Georges River	20*
3	1	S	U	U	U	U	S	Lookout over Georges River	5*
4	17	S	U	U	U	S	S	Spur overlooking Georges River	100*
5	4	S	U	U	S	S	S	Spur	25*
6	3	U	U	U	U	U	S	Flat part of valley floor	-
7	6	S	U	U	U	U	S	Ledge separated from main plateau	35*
8	4	S	U	U	U	U	S	Low spur at confluence of creeks	25*
9	20	U	U	U	U	U	S	Steep slopes along creek	-
10	34	U	U	U	U	U	S	Very steep slopes to Woronora River	-
TOTAL	502							Potential population 750	0 - 210
ROAD	4							Illawarra Road	-
TOTAL AREA	1,546							POTENTIAL POPULATION 17,500 - 28,500	YIELD 4,785 - 7,960

NOTES:

(i) Land Unit — Derived from opportunities and constraints Map and labelled to approximate earlier Crown Lands Office preliminary structure plan.

(ii) Area — To nearest ha.

(iii) Development — Each unit has been assessed as highly suitable (HS), Suitability suitable (S) or unsuitable (U) for each use below:

Residential (R), commercial (C), industrial (I), special uses (SU), active recreation (AR), passive recreation (PR)

(iv) Comments — A record of any aspects which either affected suitability for development or will affect yield.

(v) Residential Development Potential — An assessment of the likely number of residential lots to be obtained from the land unit. The range expressed in the total assumes complete development of all suitable land on the one hand and development of only highly suitable land on the other (excluding provision for essential services in each case).

5. DEVELOPMENT OPTIONS

5.1 Options for Development

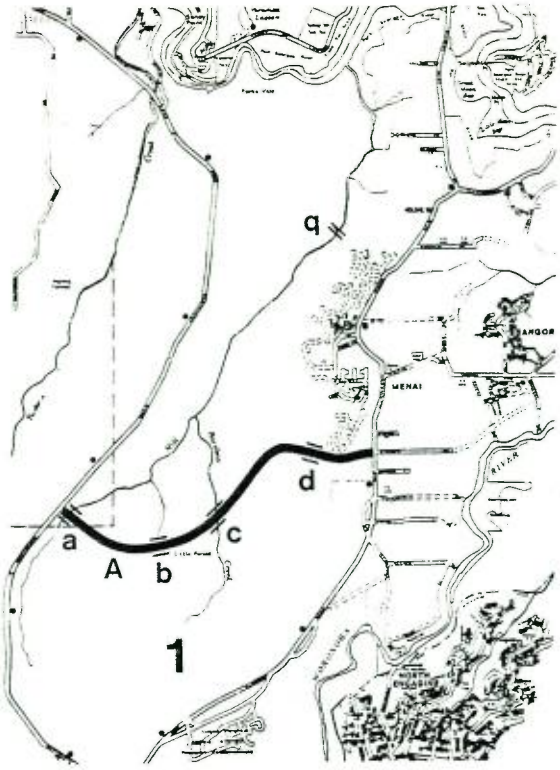
Many different aspects must be considered before a programme of development for West Menai can be formulated. Land use patterns, access and movement, servicing, staging and financial considerations are among the matters which require attention. Within each category, a range of options presents itself.

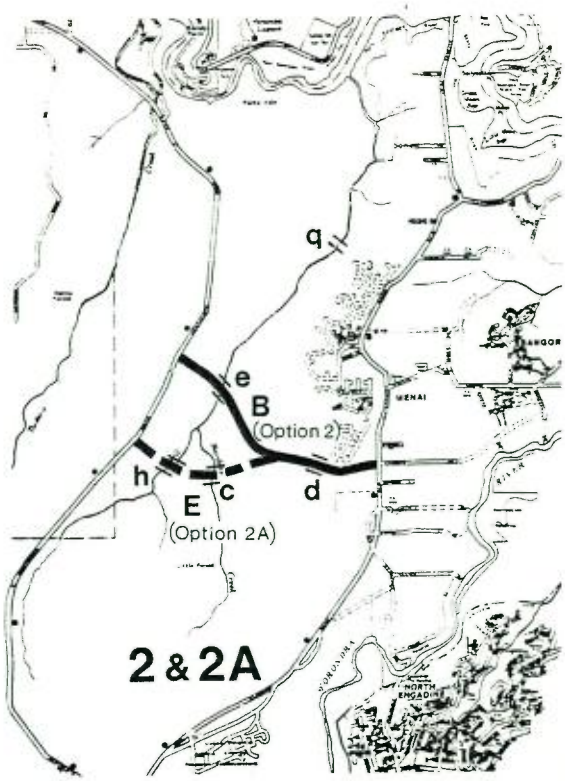
In assessing a preferred strategy for West Menai, only broad land use arrangements and alternative road links have been evaluated in detail. Servicing, staging and financial criteria have been introduced in this evaluation but alternative approaches have only been applied to the preferred strategy and structure plan, and are discussed in later parts of this Chapter. It should also be noted that within each strategy there are a number of further options for detailed locational choices, e.g. school sites, which would not affect the broad implications of any of the overall land use or access options.

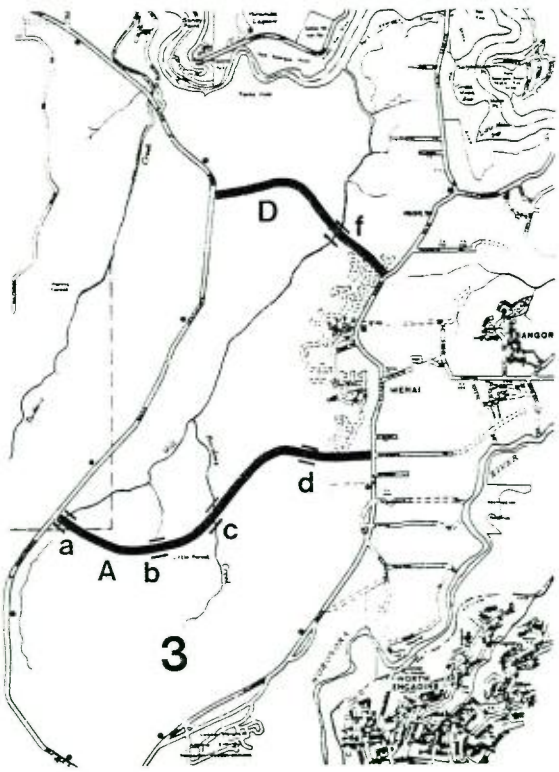
5.1.1 Road Link Options

There are three major areas of the site suitable for development, namely the northern part, west of the Mill Creek valley (Areas 32 to 36), the southwest corner at the head of Mill and Bardens Creeks (Areas 28 and 29), and the central and southeast parts of the study area (Areas 26, 27, 30 and 31) (refer to map 11). Future residents of these areas will seek access to the proposed Menai town centre to the east, as well as work locations to the north, west and southeast. Five road alignments were identified which individually, or in combination, would provide a degree of access for the residents of West Menai. These alignments are (refer to Figure 5.1.1 and Appendix D):

a) a link from the intersection of Old Illawarra Road and Bardens Road, across the southwest of the study area, to Heathcote Road, about 4.5 kilometres north of the intersection of New Illawarra Road and Heathcote Road;
b) a link which shares the alignment with (a) from Bardens Road across to Area 30, then turns north and crosses Mill Creek north of its







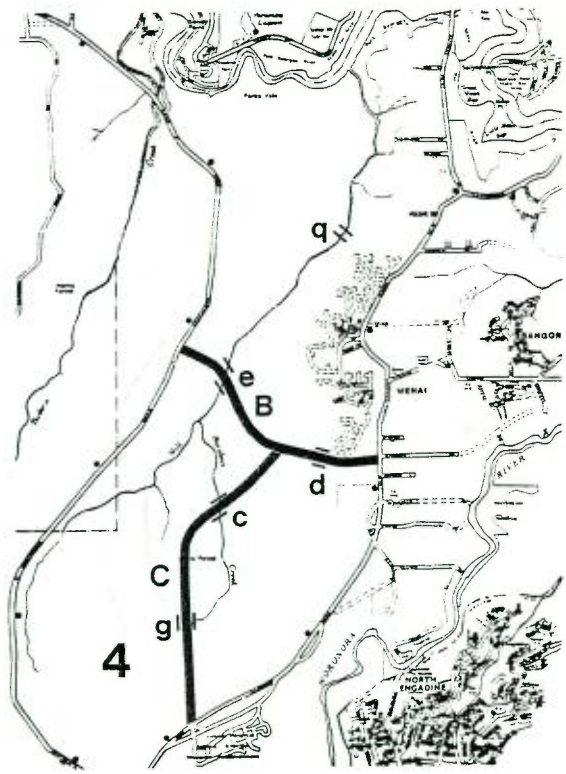


Figure 5.1.1
Road Options

confluence with Bardens Creek to link with Heathcote Road a further 2.5 kilometres north of the proposed junction with alignment (a);

c) a link proposed to give access from either alignment (a) or (b) south to New Illawarra Road in the vicinity of AAEC;

d) a direct link for the northern parts of the site across the deep Mill Creek valley just downstream of the tidal limit; and

e) an alternative route to (b) through the middle of the study area joining Heathcote Road between the (a) and (b) options, while

q) indicates a possible low level crossing for temporary access to early stages and for service vehicles such as fire trucks and ambulances.

In various configurations, these alignments have been evaluated as Road Options 1, 2 and 2A, 3 and 4 (see Figure 5.1.1). While it has generally been assumed that the road link will be needed to serve the new population and to meet marketing criteria, a comparison with a "no link" option has been made. The road link is placed in the wider context in Section 3.5 and discussed in more detail in Appendix D.

Table 5.1 summarises the matters which were considered in assessing the five options. It may be seen that development choices range from an expenditure of $5.3 million (Option 1) to $10.7 million (Option 3) yet Option 3 is about 40% more efficient than Option 1 in terms of reducing the average length of journey for West Menai residents to the proposed Menai town centre. The "no link" option which incurs costs only for upgrading Heathcote Road, conceptually provides two-thirds the accessibility for half the cost of Option 1. Options 2 and 2A tend to lie in the middle of the range in cost and accessibility, but in terms of cost effectiveness, perform well. All the options, apart from 2, are dependent upon the MWDA filling Bardens Creek, or constructing another bridge across Bardens Creek valley for a cost in the vicinity of $2.9 million, before the link can be completed. These alternatives are subscripted 'a' in the tables.

Based on an unweighted ranking system which takes into account environmental considerations, Option 2A with or without the Bardens Creek bridge is the preferred road option (see Table 5.2). However a decision on the location, design standard and number of east-west links can only be made after a more detailed assessment of feasibility and need.

TABLE 5.1: COMPARISON OF ROAD LINK OPTIONS

Option (i)	Cost $M	Accessibility Index (ii)	Transport Advantages	Transport Disadvantages	Environmental & Development Issues
1	5.3	147	. lowest cost link	. poor accessibility to northern areas	. least environmentally sensitive . does not serve early stages
1*	8.9	147	. as for 1 without dependence on MWDA	. as for 1 no dependence on MWDA	. does not serve early stages
2	7.2	159	. most direct route from centre of study area	. no access to southern areas	. major environmental & visual impact at Mill Creek crossing
2A	7.5	175	. accessibility better than most direct route		. less impact than 2 . depends on MWDA
2*	10.4	175	. as for 2A without dependence on MWDA		. as for 2A without dependence on MWDA
3	10.7	208	. best accessibility	. highest cost with dependence on MWDA	. high environmental impact for northern crossing . best servicing for early stages
3*	14.3	208	. as for 3 without dependence on MWDA	. highest cost	. as for 3 without dependence on MWDA
4	10.2	196	. good accessibility to central & southern areas	. cost relative to 2A	. southern link passes through AAEC exclusion zone
4*	13.8	196	. as for 4 without dependence on MWDA	. as for 4	. as for 4 without dependence on MWDA
No Link	2.0	99	. least cost	. poor accessibility . no access to central areas	. no environmental issues . major constraint to services

Notes: (i) options marked '*' allow for bridge over Bardens Creek and are not dependent on MWDA programme
(ii) inverse of average trip length per household multiplied by 1000 (refer Table D.1 in Appendix D)

TABLE 5.2: RANKING OF ROAD LINK OPTIONS

Option	Least Cost	Highest Access	Least E.I	Highest Staging etc	With Bardens Ck Fill Score	With Bardens Ck Fill Ranking	Independent of MWDA Score	Independent of MWDA Ranking
1	2	8=	2	9	21	4	-	-
1*	5	8=	3	8	24	10	24	6
2	3	7	6	4	20	3	20	2
2A	4	5=	4	6	19	1=	-	-
2*	7	5=	5	2	19	1=	19	1
3	8	1=	9	5	23	7	-	-
3*	10	1=	10	1	22	5=	22	3=
4	6	3=	7	7	23	7=	-	-
4*	9	3=	8	3	23	7=	23	5
No Link	1	10	1	10	22	5=	22	3=

Note: Options marked * allow for bridge over Bardens Creek and are not dependent on MWDA program.

5.1.2 Land Development Options

Preliminary assessment of the study area, the constraints upon development, and opportunities to meet market demands have suggested five broad development options for West Menai.

Option 1: "Maximum" Residential Development

This option proposes that, taking into account the major environmental and other constraints, as much of the site as is practicable should be given over to residential uses and support services for the new population.

Option 2: Balanced Residential/Employment Generation Option

As well as taking into consideration some additional environmental issues, this option seeks to provide a balance between the demand for housing in the Menai area and an opportunity to provide for the need for additional industrial and commercial land in Sutherland Shire.

Option 3: "Save Bardens Creek" Option

This option takes those environmental issues considered in Option 2 a step further and assessses the impact on development of a decision not to proceed with the MWDA filling of Bardens Creek valley.

Option 4: Deferral of Land Unit 29

This option is, in many respects, similar to Option 2, but recognises that the activities of Holsworthy Firing Range and the additional costs of servicing the southwest corner of the study area could mean that a decision to develop Land Unit 29 is deferred indefinitely.

Option 5: No Development Option

Given the high bush fire risk in the study area, the costs of development in sandstone terrain, and the complexity of a number of other environmental issues, the option of development not proceeding is one which has received serious consideration.

The four development options are illustrated diagrammatically in Figure 5.1.2 and an assessment of the extent of development for each is described in Table 5.3.

Analysis suggests that Option 1 could yield approximately 6,600 lots as well as about 30 hectares of non-residential development. At the other end of the spectrum, Option 4 creates only about 3,800 lots (although Area 29 is kept in reserve) while Option 2 sets aside about 80 hectares for non-residential development including around 60 hectares for industry.

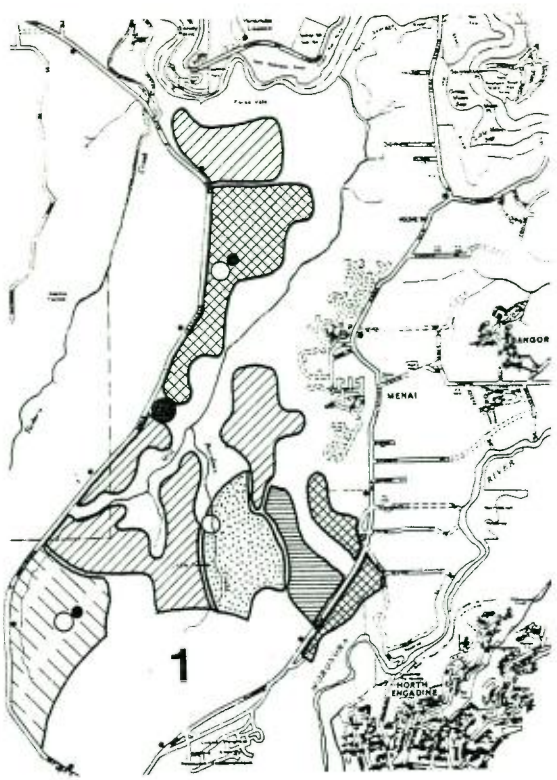
5.1.3 Evaluation

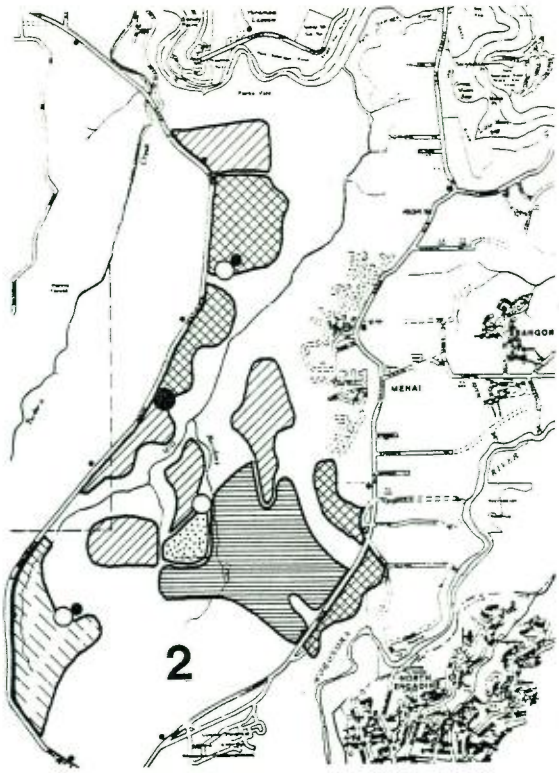
To compare the costs and benefits of the four development options along with a "no development" option the following criteria have been reviewed:

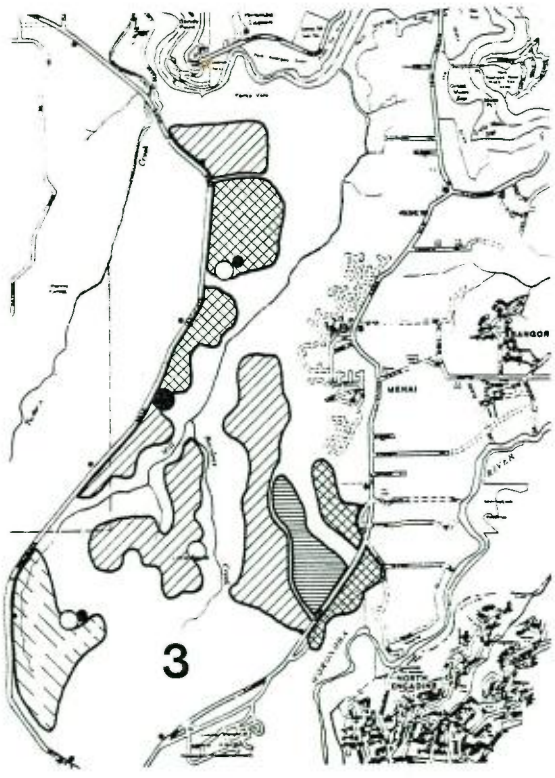
a) residential lot yield;
b) non-residential development;
c) an estimate of market value of developed land;
d) development costs;
e) a notional return (or residual land value) for each option and a notional cost per lot;
f) environmental considerations including vegetation and habitat, landscape, recreation, and noise;
g) bushfire hazards; and
h) development issues such as geological resources, services and access, the residential market and employment generation.

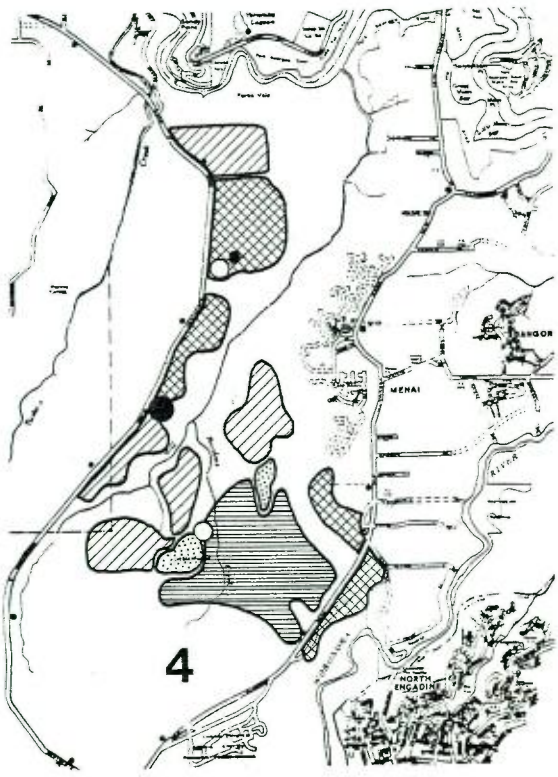
It should be noted that notional returns in the West Menai case will in fact return to public coffers as the area is all Crown Land.

This comparison is set out in Tables 5.4 and 5.5. It may be seen that financially, Option 1 is the best performer both in terms of notional residual land value and development cost per lot. There is an obvious cost penalty to meet the objectives which constrained Options 2, 3 and 4. The "no development" option would generate income only from continuing lease activities (this income is not included in the assessment) as well as in the longer term any benefits which may be attained from developing the MWDA areas after refuse disposal operations are completed.









LEGEND

- Residential – Stage 1
- Residential – Stage 2
- Residential – Stage 3
- Residential – Stage 4
- Centres
- Schools
- Non-Residential Development

Figure 5.1.2
Land Development Options

TABLE 5.3: LAND DEVELOPMENT OPTIONS

Land Unit	DEVELOPMENT OPTION															
	1. Max. Residential				2. Balanced Residential & Employment Generation				3. "Save Bardens Ck"				4. Deferred Area 29			
	Res. Area	Lots	Non-Res. Area	Use	Res. Area	Lots	Non-Res Area	Use	Res. Area	Lots	Non-Res. Area	Use	Res. Area	Lots	Non-Res Area	Use
25.1	29	276	-	-	29	276	-	-	29	276	-	-	29	276	-	-
2	3	28	-	-	3	28	-	-	3	28	-	-	3	28	-	-
TOTAL	32	304	-	-	32	304	-	-	32	304	-	-	32	304	-	-
26.1	21	126	-	-	21	126	-	-	21	126	-	-	21	126	-	-
2	-	-	10	R(10)	-	-	10	R(10)	-	-	10	R(10)	-	-	10	R(10)
3	-	-	51	R(51)	-	-	51	R(44) I(7)	-	-	51	R(51)	-	-	51	R(51)
TOTAL	21	126	61		21	126	61		21	126	61		21	126	61	
27.1	30	285	-	-	-	-	30	I(25) R(5)	30	285	-	-	-	-	30	I(25) R(5)
2	10	60	-	-	-	-	10	I(5) R(5)	-	-	10	I(5) R(5)	-	-	10	R(10)
3	-	-	2	R(2)	-	-	2	R(2)	-	-	2	R(2)	-	-	2	R(2)
4	9	85	-	-	-	-	9	I(9)	-	-	9	R(9)	-	-	9	R(9)
5	10	95	-	-	-	-	10	I(8) R(2)	-	-	10	I(8) R(2)	-	-	10	I(8) R(2)
6	-	-	83	C(3) R(80)	-	-	83	R(83)	-	-	83	R(83)	-	-	83	R(83)
TOTAL	59	525	85		-	-	144		30	285	114		-	-	144	
28.1	11	66	-	-	11	66	-	-	11	66	-	-	11	66	-	-
2	3	18	-	-	3	18	-	-	3	18	-	-	3	18	-	-
3	18	171	11	R(11)	18	171	11	R(8) C(3)	18	171	11	R(8) C(3)	18	171	11	R(11)
4	10	60	-	-	-	-	10	R(10)	-	-	10	R(10)	-	-	10	R(10)
5	-	-	2	R(2)	-	-	2	R(2)	-	-	2	R(2)	-	-	2	R(2)

TABLE 5.3: LAND DEVELOPMENT OPTIONS cont'd

Land Unit	DEVELOPMENT OPTION 1. Max. Residential				2. Balanced Residential & Employment Generation				3. "Save Bardens Ck"				4. Deferred Area 29			
	Res. Area	Lots	Non-Res. Area	Use	Res. Area	Lots	Non-Res Area	Use	Res. Area	Lots	Non-Res. Area	Use	Res. Area	Lots	Non-Res Area	Use
6	16	152	10	R(10)	16	152	10	R(10)	16	152	10	R(10)	16	152	10	R(10)
7	32	304	-	-	32	304	-	-	32	304	-	-	32	304	-	-
8	22	209	-	-	22	209	-	-	22	209	-	-	22	209	-	-
9	-	-	2	R(2)	_	_	2	R(2)	-	-	2	R(2)	-	-	2	R(2)
TOTAL	112	980	25		102	920	35		102	920	35		102	920	35	
29.1	15	90	-	-	-	-	15	R(15)	-	-	15	R(15)	-	-	15	R(16)
2	7	66	-	-	3	28	4	R(4)	3	28	4	R(4)	-	-	-	-
3	7	66	-	-	-	-	7	R(7)	-	-	7	R(7)	-	-	-	_
4	17	161	-	-	17	161	-	-	17	161	-	-	-	-	-	_
5	7	42	1	R(1)	4	24	4	R(4)	4	24	4	R(4)	-	-	-	-
6	15	90	3	C(3)	15	90	3	C(3)	15	90	3	C(3)	-	-	-	-
7	8	48	-	-	8	48	-	-	8	48	-	-	-	-	-	-
8	120	1140	2	C(2)	109	1035	13	C(1) R(12)	109	1035	13	C(1) R(12)	-	-	-	-
TOTAL	196	1703	6		156	1386	46		156	1386	46				15	
30.1	4	24	1	R(1)	-	-	5	R(5)	-	-	5	R(5)	-	-	5	R(5)
2	25	237	-	-	25	237	-	-	25	237	-	-	25	237	-	-
3	6	57	-	-	-	-	6	I(6)	6	57	-	-	-	-	6	I(6)
TOTAL	35	318	1		25	237	11		31	294	5		25	237	11	
31.1	5	30	-	-	-	-	5	R(5)	-	-	5	R(5)	-	-	5	R(5)
2	15	142	-	-	15	142	-	-	15	142	-	-	15	142	-	-
3	2	12	-	-	2	12	-	-	2	12	-	-	2	12	-	-
TOTAL	82	184	-	-	17	154	5		17	154	5		17	154	5	

TABLE 5.3: LAND DEVELOPMENT OPTIONS cont'd

Land Unit	DEVELOPMENT OPTION 1. Max. Residential				2. Balanced Residential & Employment Generation				3. "Save Bardens Ck"				4. Deferred Area 29			
	Res. Area	Lots	Non-Res. Area	Use	Res. Area	Lots	Non-Res Area	Use	Res. Area	Lots	Non-Res. Area	Use	Res. Area	Lots	Non-Res Area	Use
32.1	25	237	14	I(6) C(8)	25	237	14	I(6) C(8)	25	237	14	I(6) C(8)	25	237	14	I(6) C(8)
2	7	42			4	24	3	R(3)	4	24	3	R(3)	4	24	3	R(3)
3	3	18	-	-	3	18	-	-	3	18	-	-	3	18	-	-
TOTAL	35	297	14		32	279	17		32	279	17		32	279	17	
33.1	22	209	-	-	22	209	-	-	22	209	-	-	22	209	-	-
2	8	48	-	-	-	-	8	R(8)	-	-	8	R(8)	-	-	8	R(8)
TOTAL	30	257	-	-	22	209	8	-	22	209	8		22	209	8	
34.1	10	60	-	-	-	-	10	R(10)	-	-	10	R(10)	-	-	10	R(10)
2	33	313	5	R(5)	33	313	5	R(5)	33	313	5	R(5)	33	313	5	R(5)
3	11	66	-	-	-	-	11	R(11)	-	-	11	R(11)	-	-	11	R(11)
TOTAL	54	439	5		33	313	26		33	313	26		33	313	26	
35.1	30	180	17	R(17)	25	150	22	R(22)	25	150	22	R(22)	25	150	22	R(22)
2	70	665	6	C(6)	70	665	6	C(6)	70	665	6	C(6)	70	665	6	C(6)
3	5	30	-		-	-	5	R(5)	-	-	5	R(5)	-	-	5	R(5)
TOTAL	105	875	23		95	815	33		95	815	33		95	815	33	
36.1	40	240	-	-	20	120	20	R(20)	20	120	20	R(20)	20	120	20	R(20)
2	38	361	-	-	38	361	-	-	38	361	-	-	38	361	-	-
TOTAL	78	601	-	-	58	481	20		58	481	20		58	481	20	-
GRAND TOTAL	779	6601	220		593	5224	428		629	5550	375		437	3822	375	Plus Area 29 (187 ha)

TABLE 5.3: LAND DEVELOPMENT OPTIONScont'd

Land Unit	DEVELOPMENT OPTION 1. Max. Residential	2. Balanced Residential & Employment Generation	3. "Save Bardens Ck"	4. Deferred Area 29
SUMMARY				
POPULATION	23,750	18,800	19,950	13,750
LOTS	6,601	5,224	5,550	3,822
AV. RESIDENTIAL DENSITY	8.47 dwgs/ha	8.81 dwgs/ha	8.82 dwgs/ha	8.75 dwgs/ha
RESIDENTIAL	779 ha	593 ha	629 ha	437 ha
INDUSTRIAL/ COMMERCIAL	6 ha	57 ha	21 ha	52 ha
COMMUNITY FACILITIES	22 ha	21 ha	21 ha	14 ha
RECREATION & OPEN SPACE	192 ha	328 ha	328 ha	309 ha (ii)
	plus 502 ha along valleys	plus 502 ha along valleys	plus 502 ha along valleys	plus 502 ha along valleys

NOTE: (i) Non-residential uses indicated in this table are Industrial and Commercial (I), Community Facilities including shopping (C) and Recreation and Open Space (R).

(ii) A further 187 ha is not designated to any use in this option.

TABLE 5.4: COMPARISON OF LAND DEVELOPMENT OPTIONS

Evaluation Criteria	LAND DEVELOPMENT OPTION 1. Maximum Residential	2. Balanced Residential & Employment Generation	3. "Save Bardens Creek	4. Deferred Area 29	5. No Development
A. Residential					
Lot yield (i)	6,600	5,225	5,550	3,820	Nil
B. Non-residential Development (ha) (i)					
. Industrial/commercial	6	57	21	52	-
. Community facil.	22	21	21	14	-
Total	28	78	42	66	-
C. Estimate Value ($M) (ii)					
. Residential	231.00	182.88	194.25	133.70	-
. Industrial/commercial	1.21	8.55	4.46	19.68	-
Total	232.21	191.43	198.71	153.33	-
D. Development Costs ($M) (iii)					
. Residential	112.20	88.83	94.35	64.94	
. Industrial/commercial	1.44	4.56	3.20	10.48	-
. Other	2.24	2.70	2.59	2.56	1.79
Sub-total	115.88	96.09	100.14	77.98	1.79
. Main Roads (iv)	7.50	7.50	10.40	7.50	-
. Headworks (v)	14.75	14.75	14.75	13.75	0.50
Total	138.13	118.34	125.29	99.15	2.29

TABLE 5.4: COMPARISON OF LAND DEVELOPMENT OPTIONS cont'd

Evaluation Criteria	LAND DEVELOPMENT OPTION 1. Maximum Residential	2. Balanced Residential & Employment Generation	3."Save Bardens Creek	4. Deferred Area 29	5. No Development
E. Financial Performance					
. Nominal Return ($M) (vi)	94.08	73.09	73.42	54.18	2.29
. Cost per Lot (vii)	20,250	20,850	20,900	20,800	-
F. Environmental Considerations					
. vegetation & habitat	minimises natural vegetation and does not provide faunal corridor	retains vegetation above scarps and provides faunal corridor	as for (2) and preserves Bardens Ck	as for (2)	loses Bardens Ck but retains rest of site in existing state
. landscape	reduces value of internal views but regional features maintained	meets most landscape objectives	markedly improves landscape for land units 27, 28 & 30	as for (2)	preserves landscape if ongoing management provided
. recreation	provides adequately for active/ passive/local requirements	as for (1) with the addition of passive recreation along Upper Mill Creek	as for (2) with benefit of Bardens Ck	as for (2)	as for (2)

TABLE 5.4: COMPARISON OF LAND DEVELOPMENT OPTIONS cont'd

Evaluation Criteria	LAND DEVELOPMENT OPTION 1. Maximum Residential	2. Balanced Residential & Employment Generation	3. "Save Bardens Creek	4. Deferred Area 29	5. No Development
. noise	depends on staging of SW area and detailed design	as for (1)	as for (1)	no develop- in S-W area	no residential development
G. Bush Fire Hazard	high risk area requires attention at design level	as for (1)	as for (1)	as for (1)	remains threat to adjoining development of Menai Stage I
H. Development Issues					
. geological resources	does not sterilise known res-ources if phasing and other rec-ommendations followed	as for (1)	as for (1)	as for (1)	quarrying could be permitted to continue
. services and access	minimises service costs per lot apart from S-W area	less efficient than (1)	additional cost of bridging Bardens Creek	does not develop S-W corner but less effic-ient	needs services only only if future development of MWDA sites warrant

TABLE 5.4: COMPARISON OF LAND DEVELOPMENT OPTIONS cont'd

Evaluation Criteria	LAND DEVELOPMENT OPTION				
	1. Maximum Residential	2. Balanced Residential & Employment Generation	3."Save Bardens Creek	4. Deferred Area 29	5. No Development
. residential market	can be phased to meet demand for approx 4250 lots but remainder constrained by MWDA operations	as for (1) except only 3000 lots could be provided in early stages	as for (1) except no constraint by MWDA and about 3500 lots could be provided in early stages	of total yield of yield of 375 lots approx 350 constrained by MWDA operations	does not attempt to meet demand
. employment generation	only by services to new population	land allocated for industry etc but only about 80 ha available before year 2000	loss of potential development of MWDA site at Bardens Creek	as for (2) but only 60 ha available before year 2000	Bardens Creek site might be developed after year 2000
. phasing	accommodated but delays to development 27, 28 & 30	accommodated, but delays development of 27, 28 & 30	allow early development of 27, 28 & 30	indefinite deferral of unit 29	no development
. environmental constraints	reduces value of area as viable faunal habitat. Some arch. sites threatened	maintains adequate vegetation. Arch. sites are protected	provides max. natural open space. 7 arch. sites are saved, 5 others are lost The arch. trade-off requires further consideration.	assume that artillery noise will continue to indefinitely	does not provide for protection of environment as a result of good land management. Continued exploitation of area

NOTES:

i Refer to Table 5.3 for estimates of yield

ii) Estimated value of residential land was $35,000 per lot, industrial/commercial land $150,000 per ha and district and neighbourhood shopping sites $750,000 and $280,000 respectively. For industrial land and shopping centre sites, there are very great difficulties in estimating the sale price of land. With regard to the retail and commercial components of district and neighbourhood centres, factors contributing to this difficulty include uncertainty of market factors at time of sale, stage of development at which commercial sites are marketed, and identity of neighbourhood land uses. This opinion regarding likely retail/commercial land prices is based broadly on recent experience with centres in the City of Penrith.

iii) Estimated land development costs were $17,000 per residential lot and $80,000 per ha and $35,000 per ha for industrial commercial land and recreation/community facilities respectively.

iv) Based on road option 2A - See Tables 5.1 and 5.2

v) based on preliminary estimates provided by MWSDB and SCC but does not include costs for water supply (apart from $1m for tanks and pumping station for service to southwest corner) or electricity mains.

vi) Based only on costs included in this table. No attempt has been made to assess the effect of staging on nominal return.

vii) Based on residential development costs and proportion of roads and headworks cost (allocated by relative area).

All prices are assumed 1983 values.

TABLE 5.5: RANKING OF LAND DEVELOPMENT OPTIONS

Option (i)	Preliminary Ranking					Final Ranking	
	Highest Lot Yield	Highest Employment Generation (ii)	Best Financial Performance (iii)	Least Environmental Impact	Servicing Staging, etc	Score	Rank
1	1	4	1	4=	2=	12	2=
2	3	1	2=	3	2=	11	1
3	2	3	2=	1	4	12	2=
	4	2	3	4=	1	14	4
5	5	5	4	2	5	21	5

Notes: (i) See Table 5.4
(ii) Based on total area of industrial and commercial land.
(iii) Based on nominal return - see Table 5.4, Item F.

Generally the case for development is much stronger than that for "no development". Most of the development options make adequate provision for open space and recreation and no unique habitats or significant features are threatened by proposals. Paradoxically bushfires, soil erosion, litter, and off-road and recreation vehicles will be better controlled if development takes place. The development options can meet both regional housing and recreation objectives while the "no development" option can meet regional recreation objectives only partlyand housing objectives not at all.

Although the environmental considerations and development issues cannot readily be quantified, on balance it would seem that Option 2 meets more objectives than the other four (see Table 5.5). It is this Option which is examined in more detail in the remainder of the study. Additionally, if the MWDA Stage II site did prove suitable for medium to long term industrial uses then the "balanced" options would provide even greater financial and social benefits.

5.2 Preferred Strategy and Structure Plan

The preferred strategy which combines land use Option 2 with road link Option 2A has the advantage of remaining flexible enough to increase residential yield while keeping open the opportunities for employment generation. It can also respond to changes in the use of the artillery range and bring forward or delay the development of the southwest corner. The only major decision implied in adopting this strategy is the necessity for the MWDA to proceed with their Bardens Creek operation following a timetable which permits the construction of the link road when development of Areas 28, 32 and 33 are required to meet demand. Alternatively, a bridge will have to be constructed over Bardens Creek.

Proceeding from the adoption of a preferred strategy to the preparation of a structure plan to implement this strategy required further elaboration upon the constraints considered earlier. The criteria listed for the following land uses have been defined to ensure that each activity can be established with appropriate access, siting and freedom from conflicting neighbouring uses. These criteria represent the optimum situation and in some instances compromises will be necessary because of site development cost factors. These criteria have been incorporated in the principles diagrams and implementation guidelines discussed in the next section.

5.2.1 Residential Locational Criteria

- Location on undulating land slopes between 5-15%, and in some instances special housing on land with slopes up to 25% subject to more detailed site investigations.
- Site size to be large enough to form viable residential neighbourhood units.
- Location in areas capable of being serviced at reasonable cost without incurring major additional headworks costs.
- Freedom from site hazards including landslip and uncompacted fill areas.
- Avoidance of areas with existing or potential noise problems.
- Avoidance of neighbouring existing or potential pollution sources, either visual or environmental.
- Avoidance of areas with inherent high cost development features.
- Restriction on the maximum population in any 20° sector within 4.8 km of AAEC.

5.2.2 Industrial Locational Criteria

- Location with direct access to the arterial road system.
- Land slope generally between 1-10 percent.
- Avoidance of prime residential land.
- Opportunity for buffer zones to separate and screen major industrial sites from residential areas and other sensitive land uses.
- Avoidance of site hazards such as bush fire, consolidated fill and landslip.
- Site size to be sufficient for economic industrial estate development (generally larger than 10 hectares) and preferably capable of accommodating an office part concept (30 hectares).
- Service industry sites to be located near commercial centres.
- Prohibition of certain uses within 4.8 km of AAEC.

5.2.3 Commercial Locational Criteria

- High level of road accessibility to associated residential areas.
- Site size to be sufficient for projected needs at full development.

- Locations to be selected as close to primary and high school sites as appropriate.
- Potential for direct pedestrian linkage with residential areas to be ensured.
- High level of visibility to collector road systems.
- Commercial locations to respect retail catchment criteria based on service to residential neighbourhood units.
- Integration of commercial sites with proposed or potentially viable public transport system.

5.2.4 Community Facilities Locational Criteria

- Location within or beside retail areas.
- Where possible, community facilities to be grouped in the interests of service, accessibility and mutual support.

5.2.5 Schools Locational Criteria

- Integrated with key locations on the access system in association with retail centres and community facilities.
- Sited with potential for shared use of schools and community playing fields and passive recreation areas.
- Sited with potential for direct pedestrian and bicycle access from surrounding residential neighbourhoods.

5.2.6 Open Space Locational Criteria

- Active open space to be sited for dual use by schools and the community.
- Local natural drainage system to be assessed for potential enhancement to the open space system.
- The principal network of open space to provide continuous lengths between residential areas and the schools/commercial/ community facilities areas.
- Pedestrian access through public open space to the creek system to be established.
- Uncompacted fill areas to be set aside to create attractive open space areas where possible.

- Active open space provision to be based on a hierarchy of regional district and local facilities to ensure good access for all residential areas.
- Regional active recreational facilities to be well located relative to main roads.
- Regional passive open space to incorporate areas of regional landscape significance such as unspoiled valleys, major escarpments and river foreshores.

5.2.7 Preferred Structure Plan

Because of topographical constraints and the location of main access roads the West Menai development will be primarily a series of development precincts along the western part of the site between Heathcote Road and the Mill Creek Valley and other pockets of development on the smaller plateaus around the middle of the study area. Generally, the development units are well articulated by the open space network except where MWDA operations might intrude between Areas 28 and 30 at the northern end.

Residential

Apart from the existing MWDA operations and areas on and around the proposed Bardens Creek fill, most of the large parcels of land suitable for development have been allocated for residential purposes. These range in size from over 150 hectares in Areas 35 and 36 to 15 hectares on the ridge between Mill and Bardens Creek forming the eastern part of Area 28.1.

Centres

The proposed district centre containing a supermarket-based shopping facility, community services, high school and at least half of the required service industry area, has been sited at the preferred junction of the link road and Heathcote Road. This allows a reasonable level of convenience for most residents of the West Menai area. It has not proven practical to concentrate residential development in the vicinity of the centre because of the topographical constraints. Nevertheless, the relatively flat terrain along the Heathcote Road ridge and the potential to have a good pedestrian and cyclists movement network should contribute to the serviceability and viability of the centre.

Two other centres are proposed and these are intended to be located in the two main population areas, namely Areas 33 to 36 and Areas 29 and 32. A preferred location has been indicated for the northern centre along with a school in the vicinity but plans for the restoration of the quarry in Unit 36.2 include a proposal for a school site and local shops. These latter sites are not considered appropriate as they will not be available for development for some eight to ten years after the first residents have moved into this part of the study area. The neighbourhood centre and school sites in Area 29 are proposed adjacent to the parts of the upper reaches of Mill Creek which have been recommended for retention for development of passive recreation facilities. A third school is proposed either in Area 28.3 or preferably on the edge of the MWDA fill (Area 27.6) and it would be appropriate to associate with this site some of the institutional facilities which have been sought.

Industry

Apart from perhaps eight or nine hectares of land set aside for service industries in the district centre, sites for this purpose of approximately 50 hectares are concentrated around the Bardens Creek area. The MWDA programme could constrain the phasing of the industrial area but it is anticipated that alternative access to eastern parts of Area 27 will be available before the completion of the proposed waste disposal operations.

Recreation

The creek valleys and other areas of retained vegetation will accommodate the passive recreation needs for not only the local population, but the region as well. Facilities for active recreational pursuits for the 18,000 residents of the study area will be met by development at three locations namely on parks associated with the centre and school in Area 35, in parks associated with the centre and school in Area 29.8 and in conjunction with larger regional facilities on the land at present being filled by the MWDA. Consideration should also be given to the needs of sporting and recreational clubs for other sites in the study area which do not conflict with the broad objectives of the preferred strategy.

During the investigation, a field studies centre and an aboriginal culture centre were proposed and these could be accommodated on either of the spurs leading to the northeast of Area 35.

The general disposition of land uses is shown on Map 12 and summarised in Table 5.6.

TABLE 5.6: LAND BUDGET

Land Use	Site Area (ha)	Total Area (ha)	% of Site	Notes
1. RESIDENTIAL				
a. Conventional subdivision	477.0			approx 4,500 lots
b. Lower density housing	116.0			approx 700 dwgs in sensitive areas
	593.0	593.0	38.3	
2. INDUSTRIAL/COMMERCIAL				
a. General Industry	38.7			incl. office park
b. Service Industry	18.3			partly associated with district centre
	57.0	57.0	3.7	
3. COMMUNITY FACILITIES				
a. District Shopping	1.3			supermarket-based centre
b. Neighbourhood shopping	0.6			two
c. Primary schools	9.0			three
d. Secondary school	6.0			adjacent to district centre
e. Child minding centres etc	0.3			including community health
f. Religious institutions	7.1			based on survey response
g. Police	0.3			
h. Scouts & guides	0.1			
	24.7	24.7	1.6	incl. 3.7 ha in areas shown (R) in Table 5.3
4. RECREATION				
a. Local parks	53.2			active (1.21 ha/1,000) and passive (1.62 ha/1,000)
b. Major facilities	46.0			9 hole golf course, showgrounds etc
c. Clubs, etc	45.0			pony clubs, sports clubs etc
d. Regional open space	674.6			including SRA and field
	818.8	818.8	53.0	studies centre
5. ROADS				
a. New Illawarra Rd (part)	4.0			within study area
b. New link Road (part)	7.5			within study area
	11.5	11.5	0.7	
6. SPECIAL USES				
a. AAEC	41.0	41.0	2.7	
		1,546.0	100.0	

5.3 Assessment of Impact of the Preferred Alternative

This section summarises the impact of the preferred strategy on the natural environment and on a future population. The degree to which the preferred strategy solves any potential problems or reduces risks is also discussed.

Essentially, the preferred strategy is to develop West Menai to a moderate and balanced degree, providing an east-west link road through the middle of the study area (Road Option 2A), and using Bardens Creek as the long term MWDA solid waste disposal area. Development of the southwest corner is delayed until artillery noise has been eliminated and water storage can be provided for this higher terrain. The strategy also permits a northern local access link across Mill Creek to service the early development.

5.3.1 Regional and State Significance

The West Menai area has been identified for urban purposes for many years and strategy planning for Menai in the late 1960's and early 1970's anticipated a significant population resident in the 14 precincts around the Mill Creek catchment.

This study puts forward a preferred strategy which will accommodate in the order of 18,000 residents without major effects on environmentally sensitive areas in the valleys. (This compares with the 1981 population of Sutherland Shire of over 165,000).

As well as minimising the impact on the existing environment as described in the remainder of 5.3, the preferred strategy has had regard for all State Environmental Planning Policies and Ministerial Directions under S.111 of the Act in force at the time of the study. In addition it has ensured that development complies with stated policy for lands in the vicinity of the AAEC facility at Lucas Heights (see 3.3 and 4.1.5).

The general land use arrangement of the preferred strategy is, subject to major topographical constraints, based upon the premise that the Menai Town Centre will eventually be the focal point of the district and that strong east-west linkages to the Town Centre and beyond to Sutherland are not only desirable, but in the longer term, essential. This is discussed in greater detail in Appendix D.

During the study, the Draft Sydney Regional Environmental Plan (Botany Bay) was published and proposals for West Menai in general comply with the recommendations of the regional plan. Two matters require particular comment in this context. First, to meet a requirement that residential development should be prohibited adjacent to major roads where night time noise exceeds certain levels, landscaped buffers and "no build" strips along such roads have been included in the principles diagrams supporting the preferred strategy (see 3.9.2 and 5.4.1). However the alternative of special building standards for dwellings in the vicinity of major roads could be adopted by Council (see 4.1.6).

Second, the regional plan seeks a variety of housing types and nominates minimum lot sizes a little less than those at present adopted by most local authorities. More importantly, a minimum average lot size for a subdivision is suggested to ensure that overall densities are not too great. In general this principle is accepted but in the West Menai case where environmental considerations ensure much of the land will not be developed, and where most of the land is Crown Land and control is vested in one agency, the concept of a density control for each planning precinct, expressed in dwellings per hectare, would seem more appropriate than a minimum average lot size for each subdivision. The preferred strategy and accompanying guidelines nominate 9.5 dwellings per hectare as an appropriate maximum density for most residential areas at West Menai and six dwellings per hectare for certain environmentally sensitive land units. An estimated gross residential density[1] of 8.8 dwellings per hectare for residential areas would have a lesser impact than the proposed minimum average lot size of 500 m^2 for each subidivision.

Metropolitan region, West Menai is one of the few remaining areas capable of meeting demand. If development were not to proceed, demand could not be met and potential purchasers would have to seek alternatives in the southwest and west or outside the region.

West Menai, if developed along the lines of the preferred strategy could be relatively self-contained with regards to shopping, education,

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1. "Gross Residential Density" in this context means the average number of dwellings per hectare of land set aside for residential purposes and includes residential streets, walkways, local open space and services easements.

recreation and perhaps some institutional activities. However, while some land suitable for industrial and commercial uses has been identified and set aside for non-residential development, it is unrealistic to expect to generate employment opportunities in the vicinity for the 7,000 or so residents who will be seeking a place in the workforce (see 3.6.4 and 4.2.5). The preferred strategy could be expected to generate employment for 900 in service industry, 2,000 in general industry and 150 in retailng.

Finally, the banks and escarpments of the Georges River and the lower reaches of Mill Creek are landscapes of regional significance and the preferred strategy plan will permit their development as part of the Georges River State Recreation Area while providing suitable linkages to local recreation areas in upper Mill Creek and on the plateaus (see 4.2.2, 4.2.3 and principles diagrams, Figure 5.4).

5.3.2 Slope and Soils

Generally steep slopes (greater than 25%) and poorly drained areas (less than one percent) have been excluded from development, but precise definition of development area boundaries will depend upon later more detailed investigation.

Erosion in West Menai would be markedly reduced and natural drainage lines improved by the development proposal. All high risk areas in terms of slope and soil erosion potential have been avoided, but the generally sensitive nature of the site will require appropriate management techniques (see 5.4.4).

Landscaped development will also reduce soil erosion; storm water drains will aid in flushing drainage lines of clogged sediment. However, great care must be taken during construction to minimise surface erosion. Silt traps should be strategically placed by the developer.

5.3.3 Geological Resources

Quarry operations are allowed to complete the extraction of their resources. This prevents sterilisation of valuable clay and sandstone deposits. However, rehabilitation to a high standard will be required. Noise, dust and visual intrusion have been largely avoided by careful phasing of development.

If an economic deposit of cream-burning clay is confirmed under the former night soil dumping ground, then a mutual benefit will result. The Health Commission requirement for a 15 year assimilation period for all the night soil land will postpone urban development in that area long enough for the clay to be extracted. Additionally, the extraction of near surface deposits of clay will necessitate the removal of much of the surface soil which is contaminated. This is also a requirement for urban development. It is recommended that the conditions of a lease to extract cream-burning clay include the removal from the site of all contaminated topsoil within the lease. This would enable urban development to proceed as soon as rehabilitation was complete. The phasing of development in this area has been scheduled for 2001.

All quarries must be rehabilitated to a standard suitable for the intended ultimate use. In the case of residential or industrial development, grading, contouring and compacting would be required such that no slopes greater than 20% or less than one percent occur, and all fill is sufficiently compacted to enable concrete slab and strip footings to be formed directly on the surface without risk of subsidence. A surface stabilising cover of native grasses and shrubs must be planted. Mine subsidence should be allowed for in footing design controls for the southern sector so that the coal seams under this part of the site are not sterilised.

5.3.4 Other Committed Land Uses

Dwellings which have direct line of sight to the MWDA Stage II fill site and the borrow area, particularly those on the plateaus in Areas 33 and 34, may experience a moderate visual impact. Noise from the landfill operation should not be intrusive because adequate distance will separate working equipment from the dwellings although it is recommended that

development of Areas 28.1 and 28.3 in part be deferred until the MWDA operation is finished. The Stage I area will be grassed before development proceeds and open space vistas from the new development at East Menai will be provided.

A landscaped buffer zone of about 100 metres around the former liquid trade waste depot (see Figure 5.4.3) should provide adequate visual screening from the depot as well as enable adequate dispersion of unpleasant fumes which emanate from the site. Continual monitoring of liquid runoff from that catchment by the SPCC would be needed to ensure that no toxic substances are creating an unknown risk to downstream users of the creek system.

The AAEC burial ground should have a 50 m landsaped buffer zone at its northern boundary (all other boundaries are excluded from future development). This would consist of a slope of less than 20% planted with tall Acacias and other native shrubs.

These planted buffer zones provide a good opportunity to plant seedlings of some of the rare plants which occur in the study area and which may be subject to development. Advice should be sought from the Society for Growing Australian Plants.

The Army training facility will continue to be an incompatible neighbour in terms of noise and bush fire risk. A high fence may be required along the western boundary of Heathcote Road to exclude children from the military reservation. The noise impact may well be reduced by adopting slight modifications to firing times and a change in firing direction, if it can be shown that this would make an appreciable difference to the noise felt by residents. This would be a matter for discussion between the Army and the National Acoustics Laboratory.

Improved access to services and facilities will benefit the Sandy Point community. The primary school planned for Area 36 and the high school adjacent to the district centre will provide for the children of the village and both convenient and supermarket shopping will be available at the centre. (Because of road patterns, it is unlikely that the Area 36 neighbourhood shops will serve Sandy Point except as incidental to school trips). Access to Menai Centre and Sutherland will be greatly improved by

the east-west road link. Provided the Georges River banks and escarpment within the study area are not developed, the visual amenity enjoyed by Sandy Point residents should not be impaired by proposals for West Menai.

The preferred structure plan complies with the State policy for limiting permanent population and certain manufacturing and institutional uses within 4.8 km of the AAEC.

5.3.5 Air, Water and Noise

No activities are envisaged which will cause significant air pollution. Dust nuisance from quarries and other interim land uses must be mitigated by management techniques.

There is a risk that the water quality of Mill Creek may, on occasion, be poor enough to be a health risk. High faecal coliform organisms in the creek after saturating rains have been identified (see 3.8). The liquid trade waste depot may produce leachate following saturating rains. If such a leachate were found to be toxic or a health risk, appropriate signposting of a warning would be necessary. Suburban subdivision will preclude any further illegal dumping and night soil areas must be cleared by the Health Department as fit for use.

The AAEC burial ground for low and medium level radioactive waste, whilst no longer used for this purpose, is permanently unfit for other use and has been excluded from the development area.

Because of noise form the nearby Holsworthy Firing Range, residential development in the southwest corner of the Study Area should be deferred until Army activities are relocated.

Adequate allowance has been made for traffic noise generated on Heathcote Road and the new link road when it is built. A 40 m buffer zone will be maintained from the edge of the road to the facade of the dwelling. This should maintain noise levels within the DEP guidelines for major roads, without resorting to extraordinary design modifications.

5.3.6 Bush Fire Hazard

Bush fire risk will continue to be high after ultimate development. It will, of course, be reduced by the clearing of heath and scrub on the plateaus (see Map 9). The most significant improvement will be access roads for fire fighting. A peripheral accessway or public road around all development units, and water availability as per the Sutherland Bush Fire Policy is recommended although lot yield will be reduced and road costs per lot will be increased relative to other developments. Hazard reduction burning, building setbacks, recommended building materials, and other perimeter developments, similar to those described in the Hawkesbury Council draft policy, will further reduce fire risk to dwellings. Assuming all of these guidelines are strictly followed, it is considered that the fire hazard will be sufficiently reduced in developed areas to recommend that development proceed.

However, the occurrence of fire in the Holsworthy training area and the Mill Creek valley will not be reduced. The fire risk on the West Menai plateaus is therefore reduced but not eliminated. Also there is likely to be a frequent inconvenience and loss of amenity due to smoke and haze from nearby fires, and the view of burnt bushland nearby.

5.3.7 Access

Access could be provided to the initial development areas (Areas 34 and 35) by means of a two lane, low level crossing of Mill Creek. Through traffic will prefer to use the high speed peripheral roads, and ultimately the new link road, because principal destinations are in that direction. Liverpool-Bankstown journeys would use Milperra Road.

Access will be provided for east-west traffic by means of the 60 km/hr link road (option 2A). The ranking analysis has demonstrated it to be the best option, disregarding the low cost of the "no link road" options. The link road will be designed for upgrading to 80 km/hr for through traffic if the DMR chooses to do so. Discussion of the impact on the population of the preferred road option 2A is given in Section 4 of Appendix D.

5.3.8 Landscape

The most significant stands of vegetation, including rare or endangered plants, will be preserved and enhanced and will continue to provide adequate fauna habitat.

The major landscape features have been preserved. Of particular importance is the lower Mill Creek valley, and the spectacular backdrop of steep cliffs and tall open forest. While other road options would have intruded into this "remote bushland" setting, the preferred option minimises this intrusion by crossing uptream of a sharp bend in Mill Creek. Below that bend the valley is deep and views are more spectacular. Above the bend the valley floor rises quickly and the bend also reduces the visual and noise impact of a high level bridge from downstream.

A low-capacity link across the northern sector would not be used by through traffic and could ultimately act as a fire trail, pedestrian access and local service road if constructed where shown would not be visible on the creek for long distances from either side. However, this northern access road will significantly reduce the aesthetic value of the important overlook on the southeastern peninsula of Land Unit 35. This is a suitable location of regional recreational facilities but it would be possible to reposition these facilities further out on the northeast knoll between the junction of Mill Creek and its western tributary. This would lessen the impact of the road crossing on the bushland setting and outlook of the public areas. However, without sympathetic treatment of the winding approaches to the low-level road crossing, the valuable outlook from the southeastern peninsula of Area 35 will be seriously degraded.

5.3.9 Recreation and Open Space

The ultimate development will require the moving of existing active recreational activities which have lease arrangements. Unless the Commonwealth Government accedes to suggestions to permit active recreation on land within its control, some of these activities will not be accommodated in future urbanisation programmes. Possibly the pony club and aero club could be relocated to the open space of MWDA Stage I (Area 26.1) subject to environmental matters such as noise and traffic being considered.

The 1.6 km exclusion zone around Lucas Heights Research Establishment along with the area excluded around the AAEC burial ground (Area 28.10) cannot be developed with any permanent buildings. It is currently Commonwealth Government policy to discourage all activities within this zone and not to allow permanent buildings of any kind. It has been suggested that the area north of Illawarra Road be used for recreational activities, subject to conditions imposed by the Commonwealth. However, this does not appear acceptable at the present time so consequently trail bike riding and skeet shooting may eventually be forced to relocate.

The transmission line easements provide logical, if not natural, boundaries to development in the northern end of the study area. The east-west easement above the Georges River provides the northern limit to development, with SRA control north of that easement. The north-south easement crossing the large northern plateau suggests that development east of the easement should be community oriented. This is proposed because of scenic lookouts on the cliff edge and good forest trees which should be kept as open space and in public ownership. Regional recreation facilities could include a field studies/cultural centre which would provide information on walking tracks, vegetation, fauna (particularly birds), estuarine ecology, and archaeology. Picnic amenities, parking and a meeting hall for the local community could also be provided.

All archaeological sites will be protected; a few sites will be positively treated to ensure protection from earthmoving equipment as well as vandals.

Boating on Mill Creek to its tidal limit will be a valuable attraction for residents. Any bridge over lower Mill Creek must be high enough to permit boats to pass underneath.

Jogging will continue to be popular in open space areas, including the 1.6 km radius exclusion zone.

A system of walking trails along Mill Creek and some of its tributaries and out to scenic lookouts will be important unifying features of West Menai. Parking, toilets and trail information could be made available from the upper Mill Creek/Little Forest reserve as well as adjacent to Area 35 and along the Georges River foreshores.

Should the MWDA proposal for Bardens Creek proceed and prove unsuitable for industrial and commercial development, this area will provide a suitable location for major regional recreation facilities such as golf courses, playing fields and showgrounds as long as care is taken in the structure and siting of ancillary buildings.

5.4 Implementation Guidelines

5.4.1 Principles Diagrams

Principles diagrams have been prepared for each development precinct showing broad land uses, linkages, access points and other matters for consideration such as alternative land uses and noise buffers. These are set out in Figures 5.4.1 to 5.4.8. These principles diagrams will provide a basis for the definition of zones in the Local Environmental Plan (LEP) and any Development Control Plans which may be prepared for a particular precinct.

5.4.2 Proposed Zoning

An objective of the assignment is to prepare a local environmental plan for the West Menai area which will permit future development without requiring prolonged consultations between the Crown Lands Office and Sutherland Shire Council as each development precinct is proposed. Any zoning will therefore have to be satisfactorily precise yet retain a degree of flexibility to permit the developer to meet changes in demand for different types of housing and other land uses.

A ministerial direction issued under Section 117 of the Environmental Planning and Assessment Act (refer DEP Circular No. 47) requires the aims and objectives of an LEP to relate to the land use zones expressed in the plan. The following aims and objectives are therefore proposed for statutory land use zones covering the West Menai site.

i) Residential Zones

Aim: To provide the opportunity for attractive and economic residential use of land.

Objectives:

a) to provide for a variety of housing styles in residential zones;
b) to provide for a range of residential densities within residential zones subject to overall performance standards regarding residential density;
c) to facilitate the achievement of suburban consolidation policy;
d) to provide housing forms suitable to the accommodation of the aged;

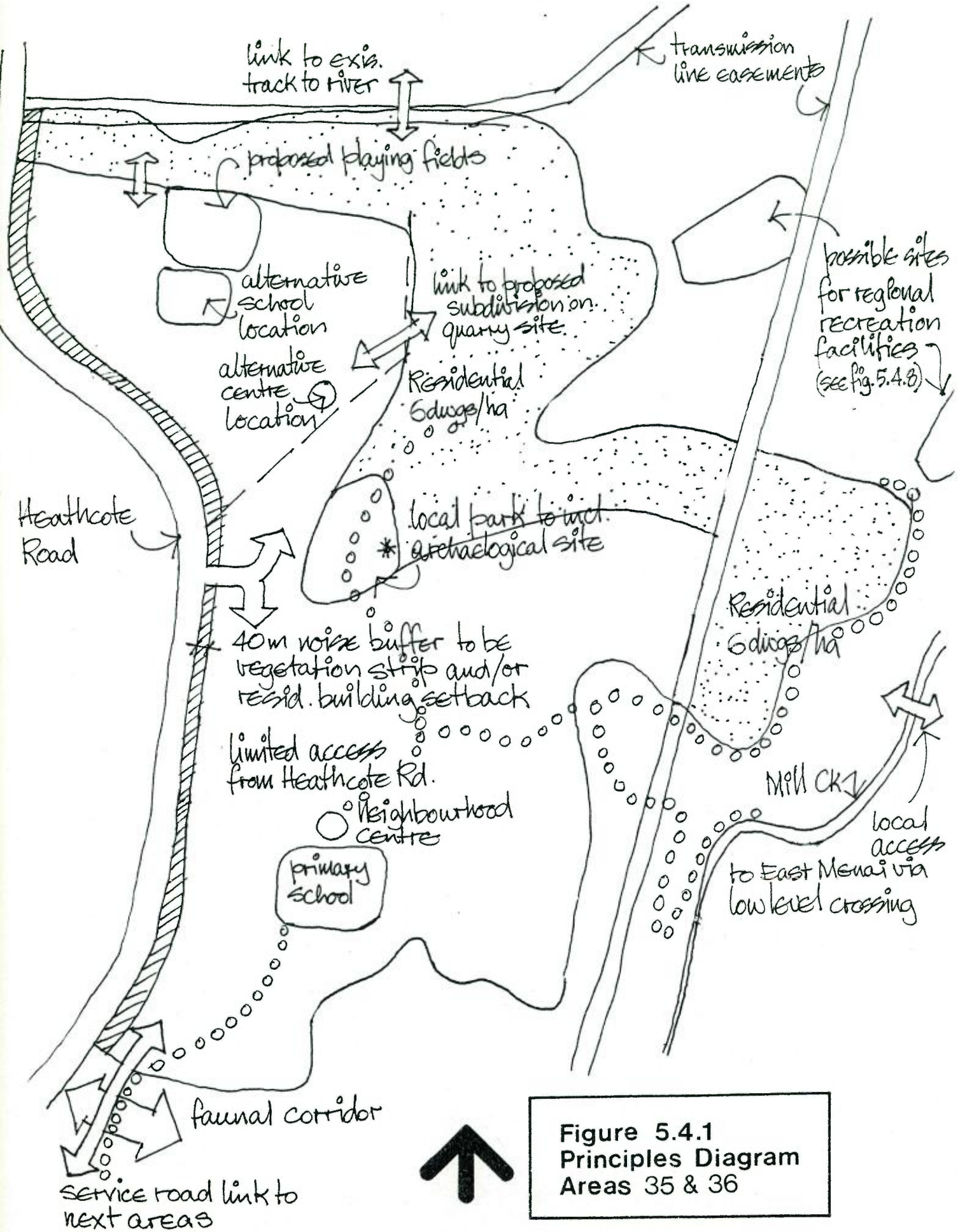


Figure 5.4.1
Principles Diagram
Areas 35 & 36

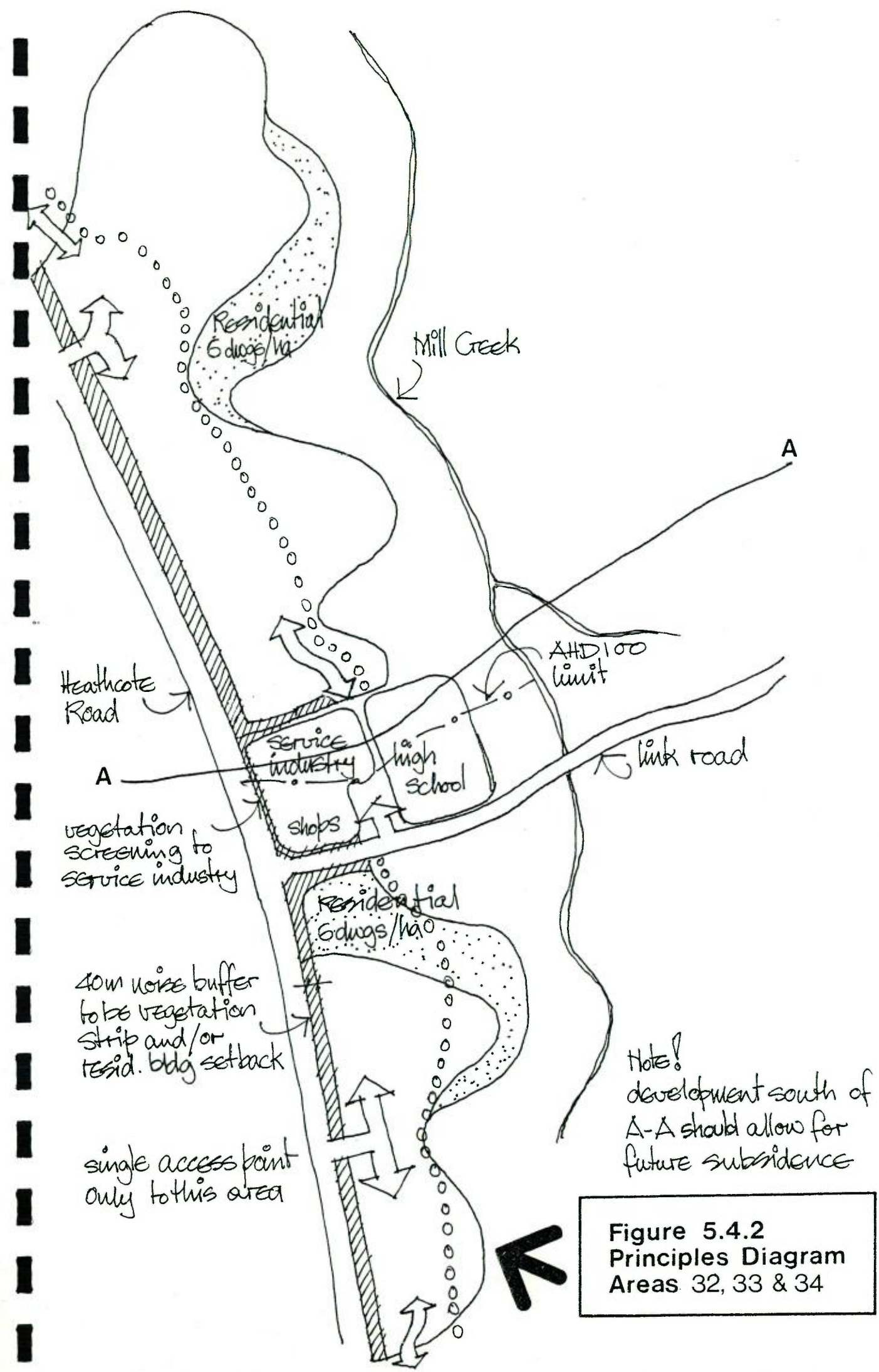


Figure 5.4.2
Principles Diagram
Areas 32, 33 & 34

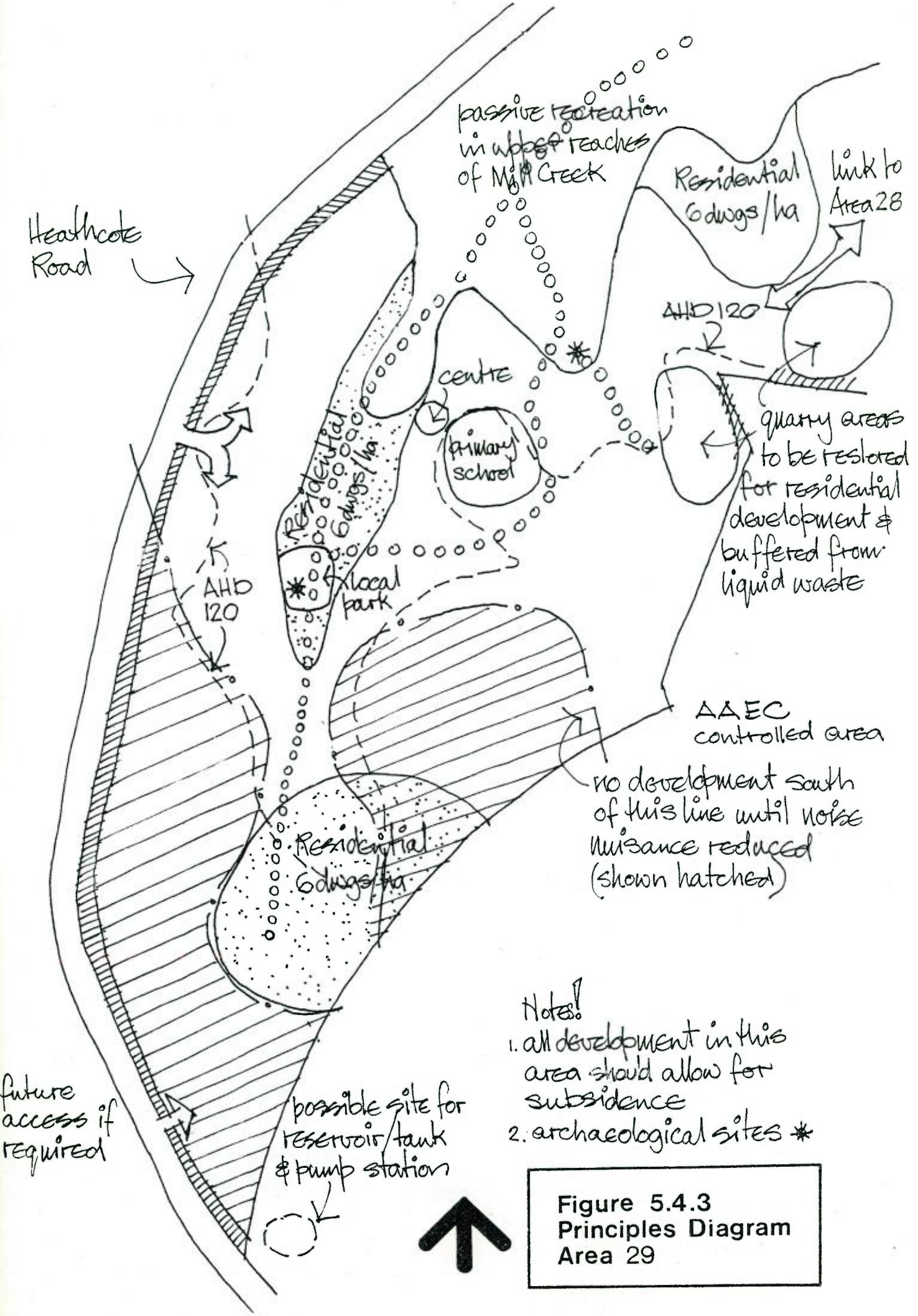
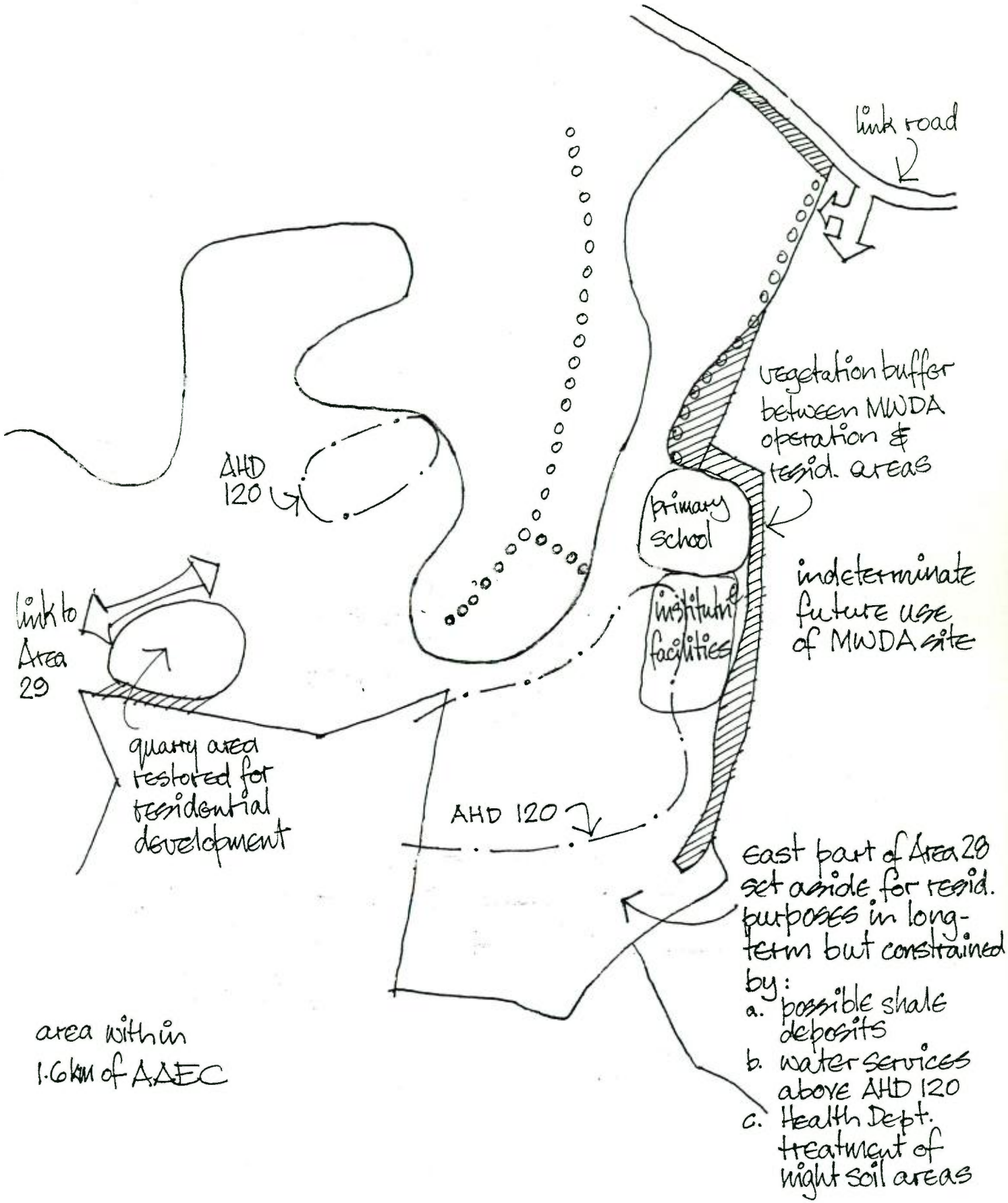


Figure 5.4.3
Principles Diagram
Area 29



Note!
all development in this area should allow for subsidence

Figure 5.4.4
Principles Diagram
Area 28

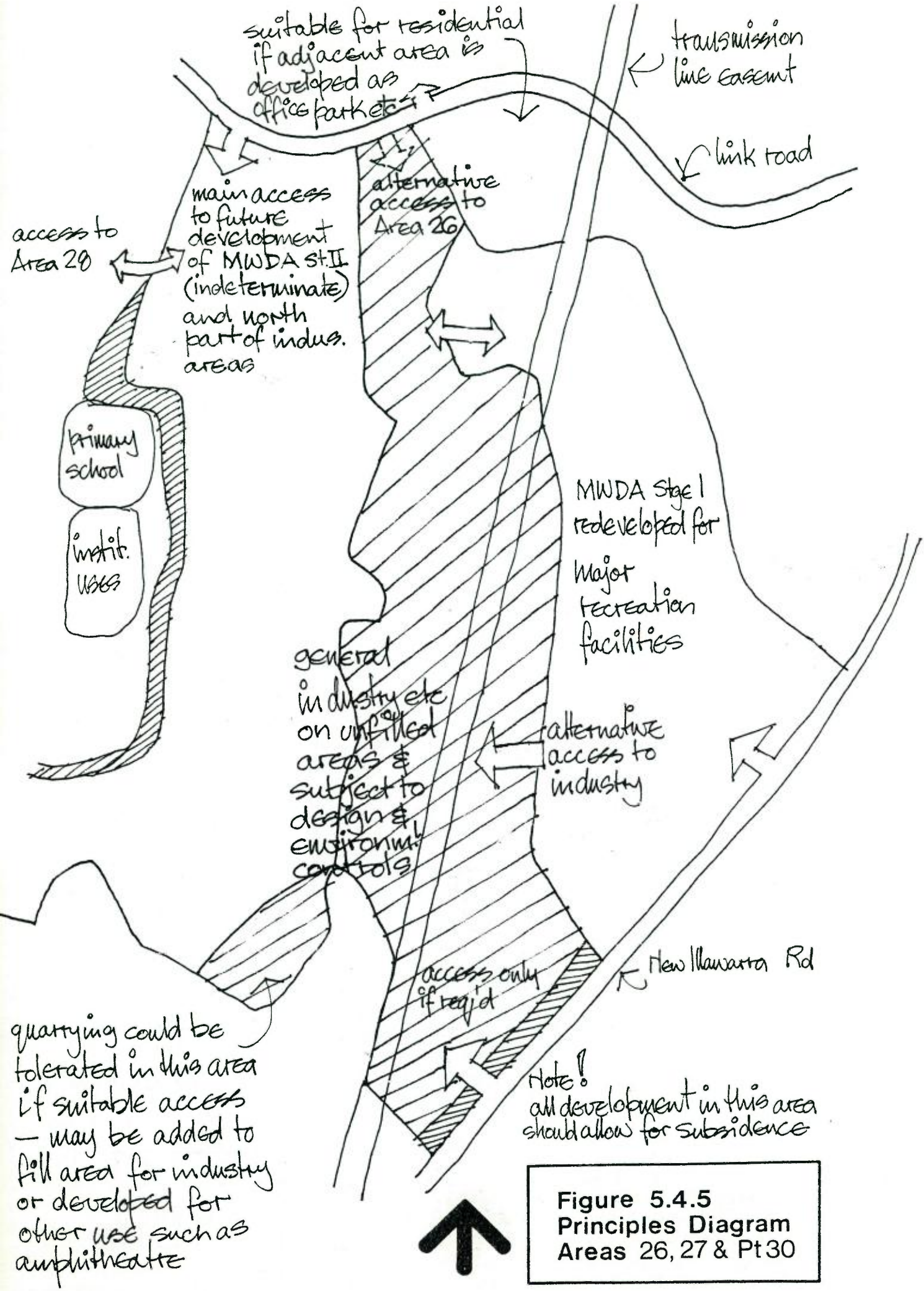
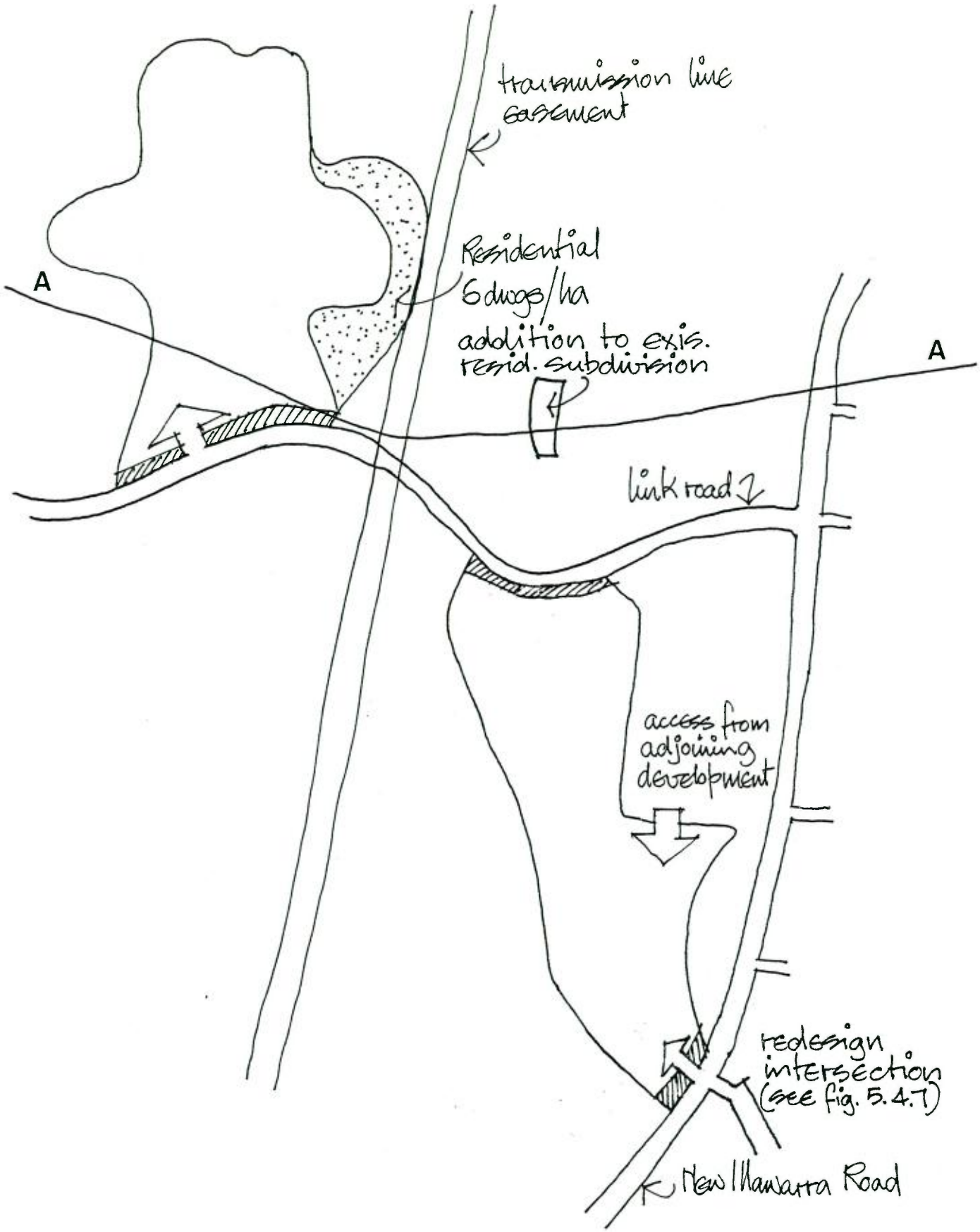
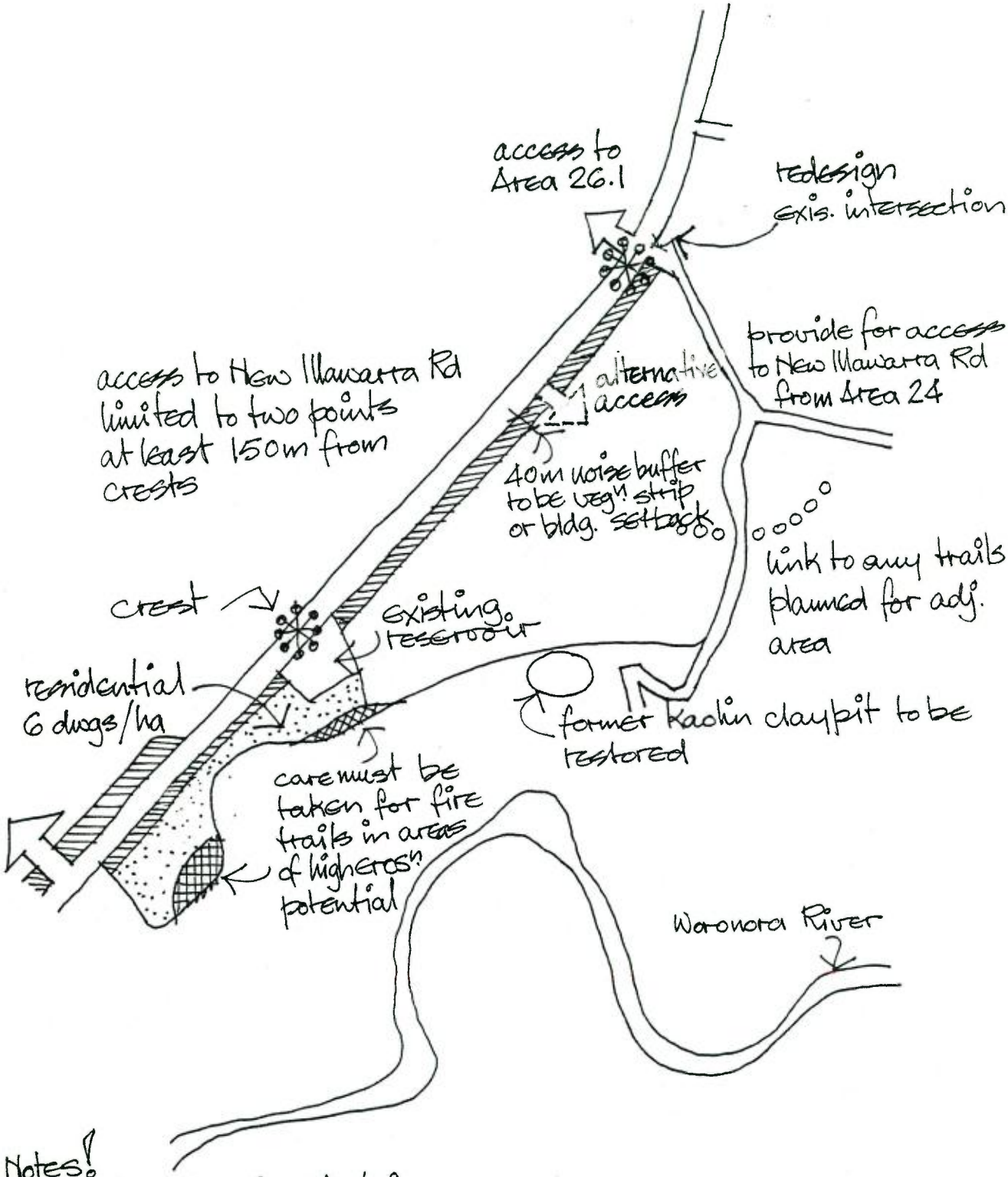


Figure 5.4.5
Principles Diagram
Areas 26, 27 & Pt 30



Note!
development south of A-A should allow for subsidence

Figure 5.4.6
Principles Diagram
Areas 26·1, 30 & 31



Notes!

1. extent & value of underlying shale deposits to be established before res. zone confirmed
2. all development in this area to allow for subsidence if underlying coal deposits to be mined

Figure 5.4.7
Principles Diagram
Area 25

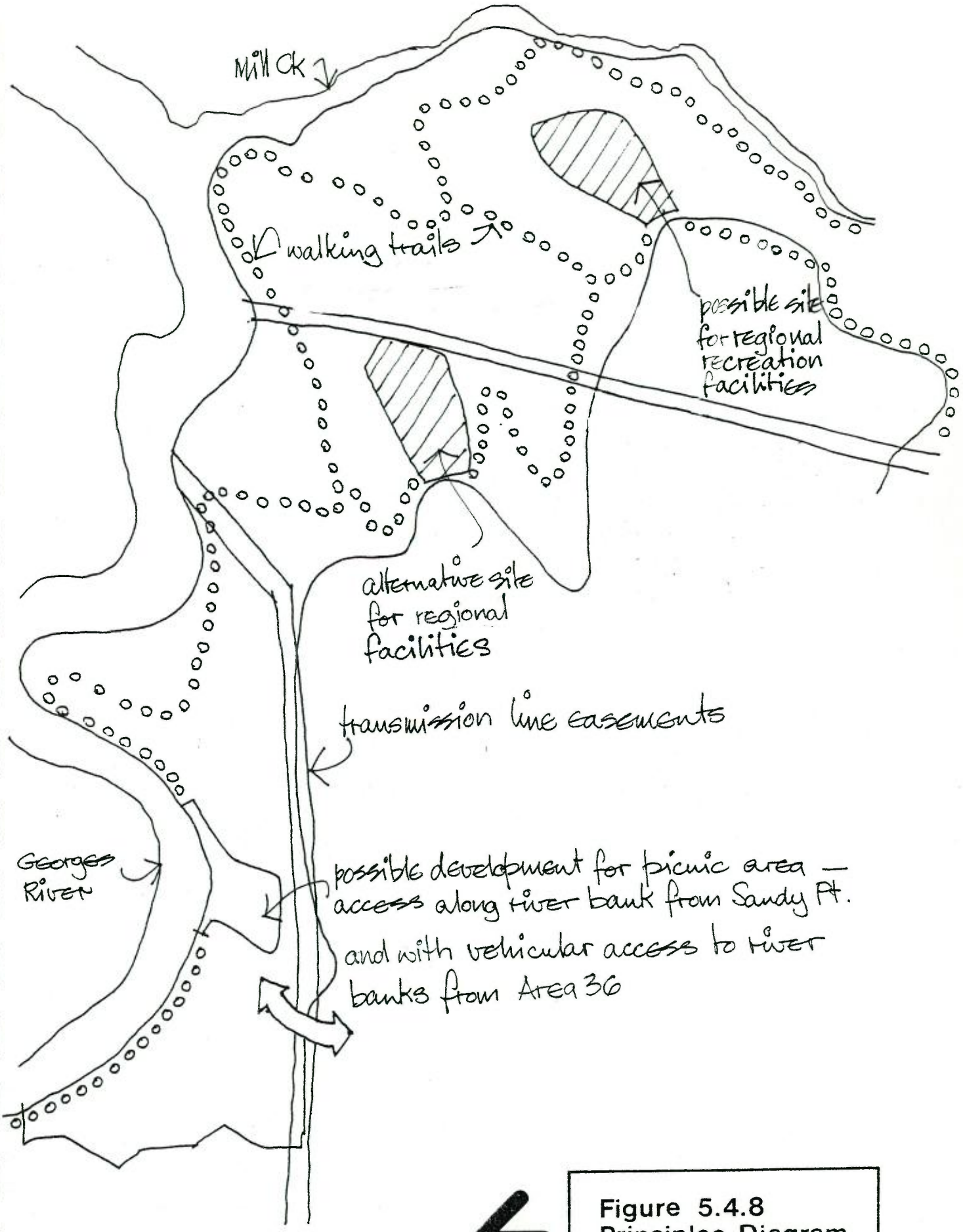


Figure 5.4.8
Principles Diagram
Area X (north)

e) to protect the residential environment from detrimental intrusion by industrial, extractive or commercial activity; and

f) to provide for the establishment within residential zones of those light industry and small shop facilities which will result in local employment and shopping convenience for the residents.

ii) Commercial Zones

Aim: To provide for, and encourage the establishment of retail, commercial and community facilities to serve the population of West Menai.

Objectives:

a) to create a "general business" zone in which retail, commercial, community and service industry activities can be established on proper planning principles;

b) to provide in one location sufficient land zoned "general business" to accommodate the uses identified in (a) above to serve the needs of the West Menai population;

c) to provide "neighbourhood business" zones in sufficient number and area to serve the needs of the population for convenience shopping, local business and community services; and

d) to allow, within "neighbourhood business" zones, a range of shops and business services which serve neighbourhood needs while restricting shops and business services which serve district needs to the "general business" zone;

iii) Industrial Zones

Aim: To provide the opportunity for industrial uses to establish and operate without undue restriction.

Objectives:

a) to exclude from the "general industrial" zones only those activities which conflict with the concept of an "employment" zone offering land for a wide range of employment activities; thus exclude from this zone residential, large retail shops not associated with an on-site manufacturing activity, offensive and hazardous industry;

b) to establish a "general industrial" zone with appropriate provision for the needs of modern industrial activity;

c) to provide for industries to establish appropriate levels of office space to service the needs of their modern operation; and

d) to provide within the "general industrial" zone for the establishment of free-standing office uses within clearly defined areas established on proper planning principles.

iv) Special Uses

Aim: To provide the opportunity for special uses to establish and operate without undue restriction where necessary.

Objectives: To allow the necessary activities of service authorities, education, health and community services to be carried out on specific sites.

v) Open Space

Aim: To provide for the active and passive recreational needs of the population of West Menai and surrounding areas and to preserve areas not suitable for urban use.

Objectives:

a) to allocate land of sufficient area and in appropriate locations to meet the needs for establishment of sporting facilities;

b) to preserve existing areas of good vegetation to meet the passive recreation needs of the community and to link with an open space network; and

c) to prohibit establishment of intensive residential development which will be subject to fire hazards.

vi) Environmental Protection

Aim: To preserve areas with intrinsic environmental qualities for the purposes of scientific and educational interest and for the enhancement of the visual amenity of the area.

Objectives:

a) to prohibit development on those slopes and other physical features which are visually of regional significance;

b) to set aside land along the Georges River for the purposes of a State Recreation Area;

c) to preserve for the purposes of scientific study, watercourses, slopes, and wetlands at the northeast corner of the West Menai planning area; and

d) to preserve those sites of significance which have been identified in the archaeological survey.

5.4.3 Existing Committed Land Uses

There are a number of interim land uses such as waste disposal land fill operations and quarrying which will require a special use zoning that does not necessarily reflect the ultimate land use. In the explanatory notes accompanying the draft LEP proposed ultimate land uses should be clearly described so that restoration works and eventual re-zoning can proceed with a minimum of further consultation.

5.4.4 Special Management Considerations

Noise

It is proposed that a 40 metre vegetation buffer and/or residential building setback be maintained along each of the main roads including the east-west link in order to reduce noise levels in dwellings to approximately 55 dB(A) L_{10}. In addition, it is generally recommended that development be staged so that no new residences are constructed within one kilometre of exposed plant and equipment at the MWDA and quarry sites. However, where the equipment is located within the quarry and there is a pit wall between it and proposed development, this distance could be reduced perhaps to 150 metres or after assessment, as little as 135 metres.

No residential development should take place in the southern parts of Area 29 that are defined by the 45 Leq contour until operations at the Holsworthy artillery range change significantly and have been reassessed.

Subsidence

All building south of the limits of the coal seam discussed earlier should be capable of accommodating predicted subsidence. The guideline suggested

by the Mine Subsidence Board is for cavity brick structures to have a strip footing at least 550mm wide x 300mm deep with ten C12 reinforcing bars. Brick veneer structures should have strip footings at least 450mm wide x 300mm deep with eight C12 reinforcing bars.

In assessing the final location of major bridge crossings of Mill Creek and, if necessary, Bardens Creek, the limits of possible subsidence should also be taken into account.

Bush Fire Hazard Reduction

The detailed design of subdivisions should comply with the requirements of the bush fire policy of Sutherland Shire Council. The actual limit of residential lots and the location of fire trails would have to be assessed in a detailed site inspection prior to the final lot design.

Erosion Reduction

Because of the relatively fragile nature of the topsoils throughout the site, all development should be required to meet design and management criteria set down by the NSW Soils Conservation Service (Section 6, BBS 15).

Performance Zoning

To permit the development to respond to changes in the marketplace, consideration should be given to zoning residential areas according to density and lot yield in conjunction with the stated objectives for the zone. Calculations for this study have been based upon an average yield of 9.5 lots per hectare for most development areas and six lots per hectare for those areas which are either on steep slopes or subject to a vegetation preservation objective. This makes adequate provision for other land uses which have to be provided within local subdivisions such as local roads, services easements, pedestrian and bicycle links, and minor open space provision.

Generally, it is recommended that the minimum residential lot size be 450 m^2 with the minimum average lot size for any residential subdivision being not less than 500 m^2. However market and environmental

considerations may require smaller lots, provided the overall density of a development does not exceed that achievable under these guidelines.

It land zoned for general industry is sufficiently large, it should also be capable of permitting the establishment of an office park, areas for container breakdown and any other use which might fit in with the concept of an "employment generation" zone.

5.5 Phasing and Financial Considerations

5.5.1 Utility Services and Land Release

Of the three major constraints to phasing development at West Menai (services, MWDA operations and artillery noise) the most significant is the provision of services to the development areas. While those areas in the vicinity of Illawarra Road may be serviced from the existing Lucas Heights reservoir, land to the west of Mill Creek may not be developed until an aqueduct is built across the valley near the tidal limit. This is not anticipated to be completed until 1986 and because of the distance from the reservoir, water pressure will limit development to a contour approximating AHD 100. In effect, this means that only those areas north of the district centre may be serviced in the initial stages (Areas 33, 34, 35 and 36).

Once a link road is constructed - this is expected to be around 1993 - water supply can be provided to Areas 28, 30, 31 and 32 but will be limited to a height of approximately AHD 120. Water services to the remaining development areas cannot take place until a new tank and pumping station are constructed at the highest part of the site in the southwest corner. While this could be at any time, it may not be worthwhile until the noise nuisance from Holsworthy artillery range is resolved. For the purposes of financial assessment, this has been assumed to be satisfactory at around the year 2000.

Another significant constraint is the operation of the MWDA facility at Bardens Creek. This must be programmed first to provide sufficient fill to construct the link road by 1993 to then allow the Bardens Creek carrier to be constructed sometime before the year 2000 so that the areas adjacent to this operation may be used for industrial purposes. If this timetable cannot be guaranteed by the MWDA, consideration may have to be given to bridging Bardens Creek.

Studies have shown that Holsworthy artillery range will cause noise nuisance to the extent that it constrains development of perhaps 90 hectares of land in the southwest corner. Whether the remainder of Area 29 proceeds prior to a resolution of the operations of the range is a decision which will have to be made on marketing and financial grounds.

Quarrying provides another constraint in terms of the use of the land and the noise nuisance it creates. The northern-most part of the study area, Area 36, will not be able to be developed until the Readymix-Farley quarry completes operations about 1994. In addition, a buffer of at least 135 m south of the pit face must be retained to reduce the impact of noise nuisance on residential development. Area 25 adjacent to the Lucas Heights reservoir may contain valuable shale deposits and this must be assessed as a matter of urgency before this land can be released for subdivisional purposes.

5.5.2 Market Demand and Land Release

Residential lot yield for the West Menai estate has been calculated at approximately 8.8 lots per hectare for all land suitable for development and lot creation is proposed over six stages (constrained mainly by servicing criteria) as shown in Table 5.7.

While this generalised phasing of development has been conceived in relation to the physical servicing of the site it may be necessary to modify these proposals according to perceived market demand.

Market Approach

West Menai has the potential to continue to accommodate demand in the three market segments, as an extension of the residential land supply currently provided in East Menai. A market strategy which adopts this approach can minimise undue conflict between the two areas.

It is unlikely that the release of West Menai in a programme which is uncoordinated with East Menai will produce any real advantage to the Crown as it seems the market share is fixed fairly firmly. Uncoordinated release of the two areas would only split the potential market and could disadvantage the overall cash flow position.

In total, 9,730 lots remain to be marketed in the combined East and West Menai areas. Marketing at a rate of 630 lots per annum for the next three years and an average of 720 lots per annum thereafter, the total Menai landstock equates to a 14 year supply.

TABLE 5.7: SERVICES & DEVELOPMENT OF STAGING

Stage	Development Period	Development Areas	Totals	Potential Population	Comments
I	1985-1990	25,26	430	1,550	serviced by extension of existing mains
II	1986-1992	35	815	2,950	adjacent to services aqueduct over Mill Creek
III	1991-1995	32,33,34	800	2,900	extension of services south from 35
IV	1993-1998	27(part), 28(part), 29(part), 30,31	990	3,550	require bridging of Bardens Creek for services
V	1998-2000	36	480	1,750	after completion of quarry operations
VI	after 2000	remainder	1,710	6,100	dependent upon new reservoir and relocation of artillery range for full development
		TOTAL	5,225	18,800	

With an estimated 4,900 lots still to be released in East Menai, it is expected that 3,000 lots will remain by 1986 when West Menai comes on to the market. From that date, it is expected that East Menai will continue to market 630 lots per annum and West Menai will capture the residual Menai market of only 90 lots per annum until East Menai reaches full development in March 1991. From April 1991 it is assumed that West Menai will capture the full Menai market potential of 720 lots per annum.

Figure 5.5.1 illustrates West Menai's annual lot stock assuming that the full market potential is realised each year. This rapid marketing of land after 1991 will enhance the project's initial cash flow but is likely to result in a shortage of lot supply between each stage of development. The logistics of land marketing require, wherever possible, that a constant supply of land is maintained over the full period of the project. Since the stages of development are fixed by servicing constraints, it is recommended that Stage IV is marketed to maintain a constant land supply until the year 1998 when Stage V commences.

Stage V of the project should be marketed to capture the full market potential since there is no way of realistically maintaining a constant land supply over the long period before Stage VI is released. However, if the Holsworthy firing range noise issue is resolved before 2001, the commencement of Stage VI could be brought forward accordingly.

The marketing approach recommended for the early stages illustrated in Figure 5.5.1 and would involve the release of 445 lots per annum from 1994 to 1998.

Further Analysis

In order to refine the marketing strategy, staging of areas in West Menai should be undertaken with a view to segmented market demand as well as servicing programmes. In order to move in this direction there is a need to identify data on the following items:

- current rate of sale in high, medium and low quality residential areas in East Menai;
- future lot potential of these areas;
- planned release dates for these areas; and

MARKETING STRATEGY FOR WEST MENAI

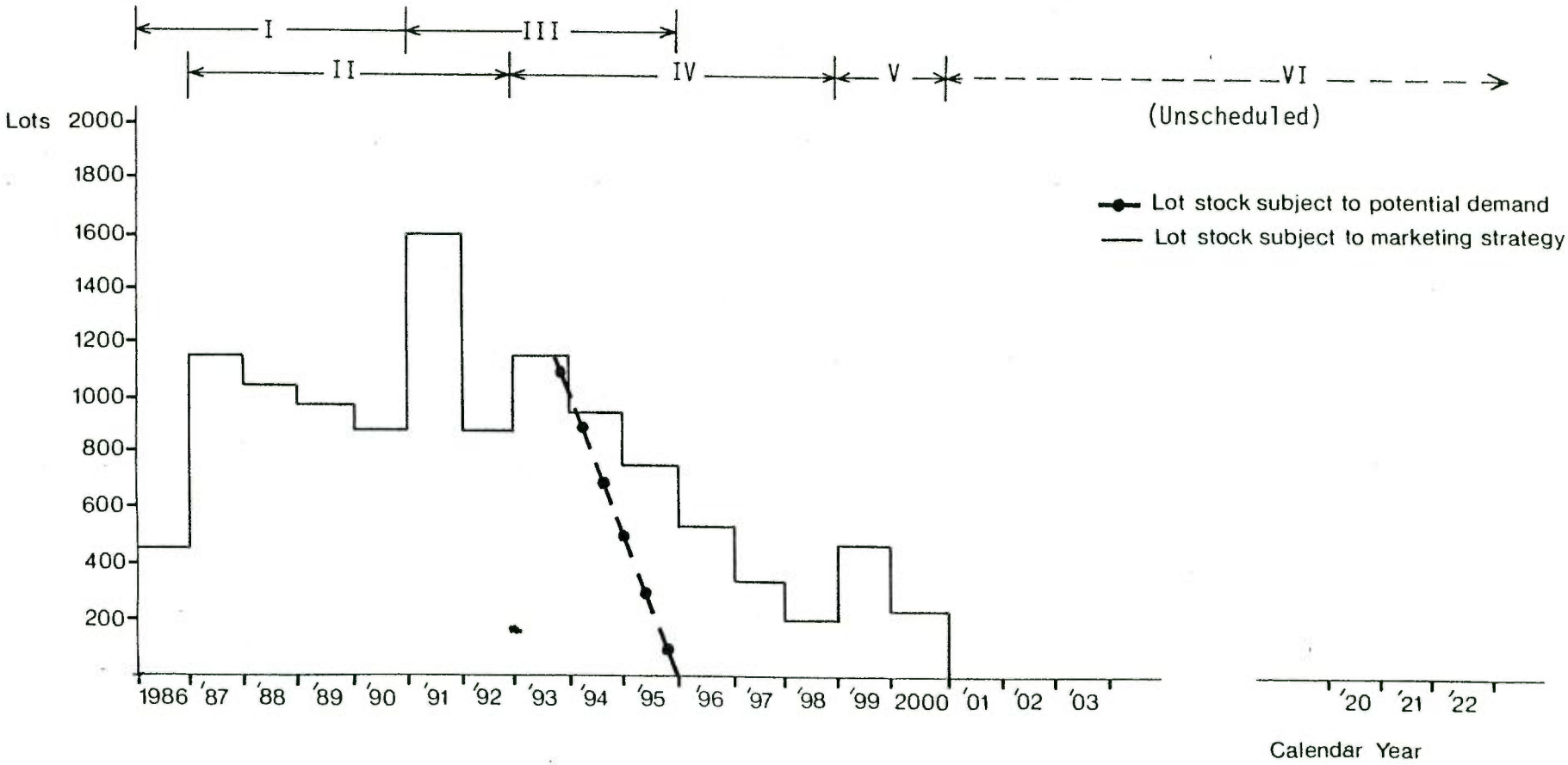


Figure 5·5·1

- feasibility of change to the planned release dates of these areas.

5.5.3 Phasing and Financial Commitments

As well as the assumptions apparent in the previous table, a number of other assumptions were made in preparing Table 5.8 which calculates an accumulated cash flow over a period of 40 years in 1983 values. These additional assumptions are:

i) sales will be as set out in Figure 5.5.1;
ii) the neighbourhood centre in Area 35 will be developed before 1991;
iii) the district centre including service industry will be developed before 1996;
iv) the southern neighbourhood centre will be developed between 2001-2005;
v) the main sales of industrial land will be between 1996-2000; and
vi) estimated property values will be as set out in Table 5.4.

Based on development costs which have been set out in earlier sections, maximum cash exposure in the first five years would be in the order of $18 million. This would reduce quickly as the break even point would be reached during the sixth or seventh year and from then on returns from development would exceed costs identified in this study.

It is clear that there will be one or two major gaps in the development programme (depending on when Area 29 is able to be marketed). The developing authority will have to make a number of decisions relating to the timing of Stages V and VI and these will have significant impacts on any more detailed discounted cash flow analyses.

TABLE 5.8: STAGING AND FINANCIAL CONSIDERATIONS

STAGE	I	II	III	IV	V	VI (hypothetical)			
Five-year Periods	1986-90		1991-95		1996-2000	2001-2005	2006-2110	2011-2015	2016-2020	2021-2025
1. ASSUMPTIONS										
. Lot Production	1245		1790		480	1000				710
. Residential Sales	450		2035		1030	1000				710
	. Centre A		. District . Service Industry 8 ha . Other 9 ha		Industry 40 ha	Centre B	Institutional			
2. SALES ($M)										
. Residential	15.75		71.22		36.05	35.00				24.85
. Non-residential	0.28		3.30		6.00	0.28	1.38			-
TOTAL	16.03		74.52		42.05	35.28	1.38			24.85
3. DEVELOPMENT COSTS ($M)										
. Residential	21.16		30.43		8.16	17.00				12.07
. Non-residential	0.03		1.46		3.20	0.03	0.89			-
Sub-Total	21.19		31.89		11.36	17.03	0.89			12.07

TABLE 5.8: STAGING AND FINANCIAL CONSIDERATIONS cont'd

STAGE	I	II	III	IV	V	VI (hypothetical)				
Five-year Periods	1986-90		1991-95		1996-2000	2001-2005	2006-2110	2011-2015	2016-2020	2021-2025
. Main Roads	2.50		5.00		4.00					
. Headworks	10.75									
TOTAL	34.44		36.89		15.36	17.03	0.89			12.07
CASH FLOW ($M)	(18.41)		37.63		26.69	18.25	0.49			12.78
ACCUMULATED CASH FLOW ($M)	(18.41)		19.22		45.91	64.16	64.65	64.65	64.65	77.43

CROWN LANDS OFFICE

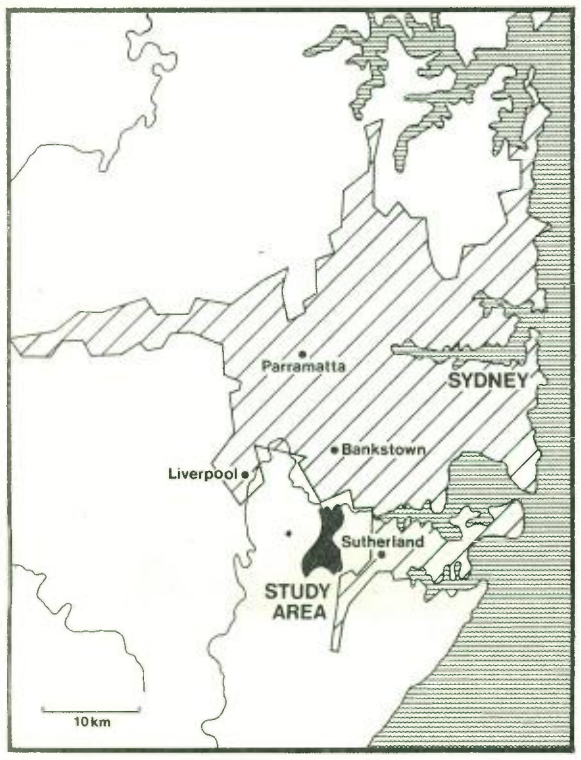
WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant: Neil Bird & Associated Consultants Pty Ltd	**Environmental & Traffic Consultants:** R Travers Morgan Pty Ltd
Socio-Economic Studies: Hirst Consulting Services	**Geology & Extractive Industry:** Hollingsworth Consultants

0 200 400 600 m
Scale

Contour Interval 2m **Aug 1983**

STUDY AREA



MAP 1

CROWN LANDS OFFICE

WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant: Neil Bird & Associated Consultants Pty Ltd

Environmental & Traffic Consultants: R Travers Morgan Pty Ltd

Socio-Economic Studies: Hirst Consulting Services

Base data supplied by S.C.S. (BBS-15: 1979)

0 200 400 600 m
Scale

Contour Interval 10m

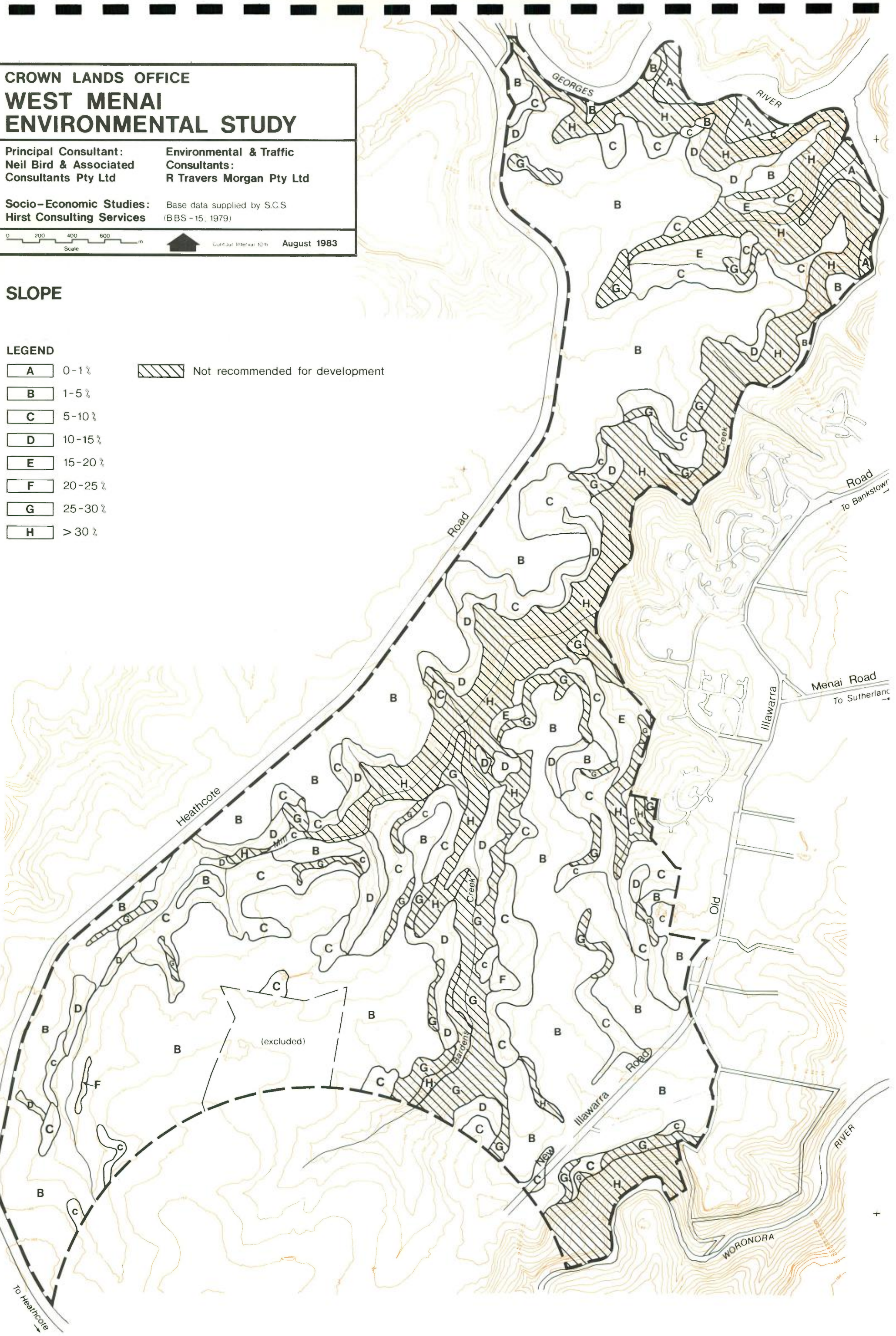
August 1983

SLOPE

LEGEND

- A 0-1%
- B 1-5%
- C 5-10%
- D 10-15%
- E 15-20%
- F 20-25%
- G 25-30%
- H >30%

Not recommended for development



MAP 2

CROWN LANDS OFFICE

WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant: Neil Bird & Associated Consultants Pty Ltd

Environmental & Traffic Consultants: R Travers Morgan Pty Ltd

Socio-Economic Studies: Hirst Consulting Services

Base data supplied by S.C.S. (BBS - 15; 1979)

0 200 400 600 m
Scale

Contour Interval 10m

August 1983

SOILS

LEGEND

- **A** Skeletal/colluvial
- **B** Shallow sands
- **C** Sand alluvial soils
- **D** Swamp soils
- **E** Duplex soils
- **F** Gleyed soils
- **G** Podzolised laterites
- **H** Skeletal podzolised laterites

Night soil / humus deposits

GEORGES RIVER
Road
Heathcote
Creek
Mill
Road To Bankstown
Menai Road To Sutherland
Illawarra
Old
New Illawarra Road
WORONORA RIVER
To Heathcote
(excluded)

MAP 3

CROWN LANDS OFFICE

WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant:
Neil Bird & Associated Consultants Pty Ltd

Environmental & Traffic Consultants:
R Travers Morgan Pty Ltd

Socio-Economic Studies:
Hirst Consulting Services

Base data supplied by S.C.S.
(BBS-15, 1979)

0 200 400 600 m
Scale

Contour Interval 1 m

August 1983

SOIL EROSION POTENTIAL

LEGEND

- Suitable for development
- Intensive geotechnical investigation and design input prior to development
- No development due to severe erosion potential
- Night soil / humus deposits

GEORGES RIVER
Creek
Road
To Bankstown
Heathcote Road
Mill Creek
Illawarra Road
Menai Road
To Sutherland
Old Illawarra Road
(excluded)
New Illawarra Road
WORONORA RIVER
To Heathcote

MAP 4

CROWN LANDS OFFICE

WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant: Neil Bird & Associated Consultants Pty Ltd	Environmental & Traffic Consultants: R Travers Morgan Pty Ltd
Socio-Economic Studies: Hirst Consulting Services	Geology & Extractive Industry: Hollingsworth Consultants

Scale 0 200 400 600 m — Contour Interval 10m — August 1983

VEGETATION

LEGEND

W	Woodland
DW	Disturbed woodland
LW	Low woodland
ILW	Induced low woodland
OF_1	Open-forest (Hawkesbury Sandstone flora)
OF_2	Open-forest (Wianamatta Shale flora)
OF_3	Open-forest (saline/alluvial complex)
OF_4	Open-forest (low salinity/alluvial complex)
OH	Open-heath
IOH	Induced open heath
DOH	Disturbed open heath
OS	Open-scrub
MWDA	Metropolitan Waste Disposal Authority

Areas recommended for preservation

Present vegetation induced for transmission line maintenance

OH/OS/LW Complex

(excluded)

Single specimen of endangered plant Melaleuca deanei

Georges River

Heathcote Road

To Heathcote

Mill Creek

Barrens Creek

Old Illawarra Road

Illawarra Road

Menai Road To Sutherland

New Illawarra Road

Road To Bankstown

Quarry

Grazing land

MWDA

WORONORA RIVER

MAP 5

CROWN LANDS OFFICE

WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant: Neil Bird & Associated Consultants Pty Ltd	**Environmental & Traffic Consultants:** R Travers Morgan Pty Ltd
Socio-Economic Studies: Hirst Consulting Services	**Ecological Consultant:** Glenn Holmes

0 200 400 600 m
Scale

Contour Interval 10m

August 1983

FAUNA
RELATIVE CONSERVATION VALUE

LEGEND

- High - To be disturbed minimally
- Medium - Preferred low density development (eg. recreation areas, low density housing)
- Low - Suitable for high density development
- ● M8 Archaeological sites of significance

GEORGES RIVER
M8
M1
Faunal Corridor
Road To Bankstown
Head of navigation & tidal limit
Creek
Road
Heathcote
Faunal Corridor
Mill
Creek
Illawarra
Menai Road To Sutherland
Old
M10
(excluded)
M9
Bardens
10
New Illawarra Road
WORONORA RIVER
To Heathcote

MAP 6

CROWN LANDS OFFICE

WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant: Neil Bird & Associated Consultants Pty Ltd	Environmental & Traffic Consultants: R Travers Morgan Pty Ltd
Socio-Economic Studies: Hirst Consulting Services	Archaeological Consultant: Dr Helen Brayshaw

Scale 0 200 400 600 m

Contour Interval 10m

August 1983

ARCHAEOLOGY

LEGEND **SURVEYS**

- 1 — Bardens Creek survey area (Silcox 1980)
- Survey areas investigated on foot
- 9 — Survey area with disturbed ridge component Investigated by vehicle and on foot
- 2 — Survey areas not investigated

SITES

- M 2 — Sites located during current survey
- MPO 2 — Potential occupation sites located during current survey
- 2 — Bardens Creek sites

GEORGES RIVER
M8
M7
MPO 10
7
M6
M5
MPO 8
M4
MPO 7
M3
MPO 9
MPO 456
M2
2
MPO 3
6
10
MPO 1
M1
9
Creek
Road To Bankstown
5
MPO 12
Heathcote Road
Illawarra
Menai Road To Sutherland
9
Mill
1
3
9
Creek
2
8
2
1
Old
MPO 13
M10
7
Bardens
3
(excluded)
4
M9
13
6
5
10
4
11
12
11
New
Illawarra Road
8
MPO 11
RIVER
WORONORA
To Heathcote

MAP 7

CROWN LANDS OFFICE

WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant: Neil Bird & Associated Consultants Pty Ltd	Environmental & Traffic Consultants: R Travers Morgan Pty Ltd
Socio-Economic Studies: Hirst Consulting Services	Geology & Extractive Industry: Hollingsworth Consultants

0 200 400 600 m
Scale

Contour Interval 10m

August 1983

INCOMPATIBLE LAND USES

LEGEND

- **S** Solid waste disposal
- **L** Liquid waste disposal
- **N** Night soil disposal
- **A** Nuclear waste disposal
- **M** Military manoeuvres
- **Q** Quarrying
- **R** Recreation
- **C** Concrete batching plants

Current operations

Proposed operations

Operations completed

Approximate northern edge of workable coal seams (>1·5m)

Extent of Ashfield Shale (Wianamatta Group)

Commonwealth land to be transferred to State Crown Land

Approx. location of bore holes for coal gas

$\bullet_2$ Water sampling sites

GEORGES RIVER

Readymix - Farley

Q

M

Creek

Road To Bankstown

Model Aero Club

R

1 2 3

Illawarra

Menai Road To Sutherland

Heathcote Road

Mill

Gosford Quarries P/L

Public Works Dept

IWC P/L

J & E Burke

A R Harrington

SSC

N

A

Bardens Creek

MWDA

S

Old Illawarra Road

Pony Club

R

Q+C

4

New

Adams

WORONORA RIVER

Gun Club

R

A.A.E.C. Exclusion Zone

MAP 8

To Heathcote

CROWN LANDS OFFICE

WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant: Neil Bird & Associated Consultants Pty Ltd	Environmental & Traffic Consultants: R Travers Morgan Pty Ltd
Socio-Economic Studies: Hirst Consulting Services	Geology & Extractive Industry: Hollingsworth Consultants

Scale 0 200 400 600 m — Contour Interval 10m — August 1983

BUSH FIRE HAZARD

LEGEND Hazard Rating Prior To Development

- High
- Medium

Hazard Rating After Development

- **L** Low
- **M** Medium

GEORGES RIVER
Cleared Area
Road
To Bankstown
Menai Road
To Sutherland
Illawarra
Heathcote
Mill Creek
Old
Bardens Creek
Cleared Area (excluded)
CA
New Illawarra Road
WORONORA RIVER
To Heathcote

MAP 9

CROWN LANDS OFFICE

WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant: Neil Bird & Associated Consultants Pty Ltd	**Environmental & Traffic Consultants:** R Travers Morgan Pty Ltd
Socio-Economic Studies: Hirst Consulting Services	**Geology & Extractive Industry:** Hollingsworth Consultants

0 200 400 600 m — Scale

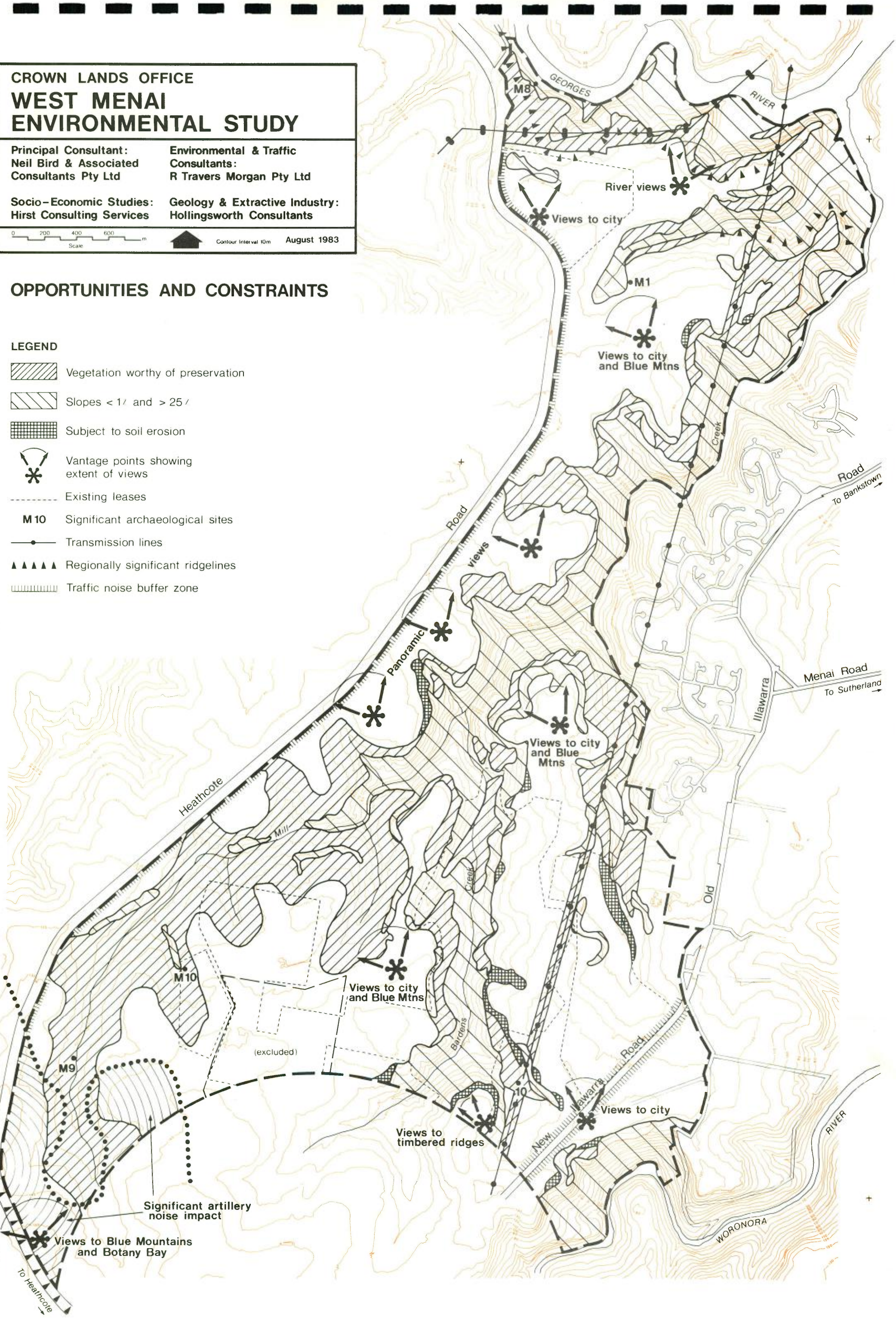
Contour Interval 10m

August 1983

OPPORTUNITIES AND CONSTRAINTS

LEGEND

- Vegetation worthy of preservation
- Slopes < 1/ and > 25/
- Subject to soil erosion
- Vantage points showing extent of views
- Existing leases
- M 10 Significant archaeological sites
- Transmission lines
- Regionally significant ridgelines
- Traffic noise buffer zone



MAP 10

CROWN LANDS OFFICE

WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant: Neil Bird & Associated Consultants Pty Ltd	**Environmental & Traffic Consultants:** R Travers Morgan Pty Ltd
Socio-Economic Studies: Hirst Consulting Services	**Geology & Extractive Industry:** Hollingsworth Consultants

0 200 400 600 m — Scale

Contour Interval 10m

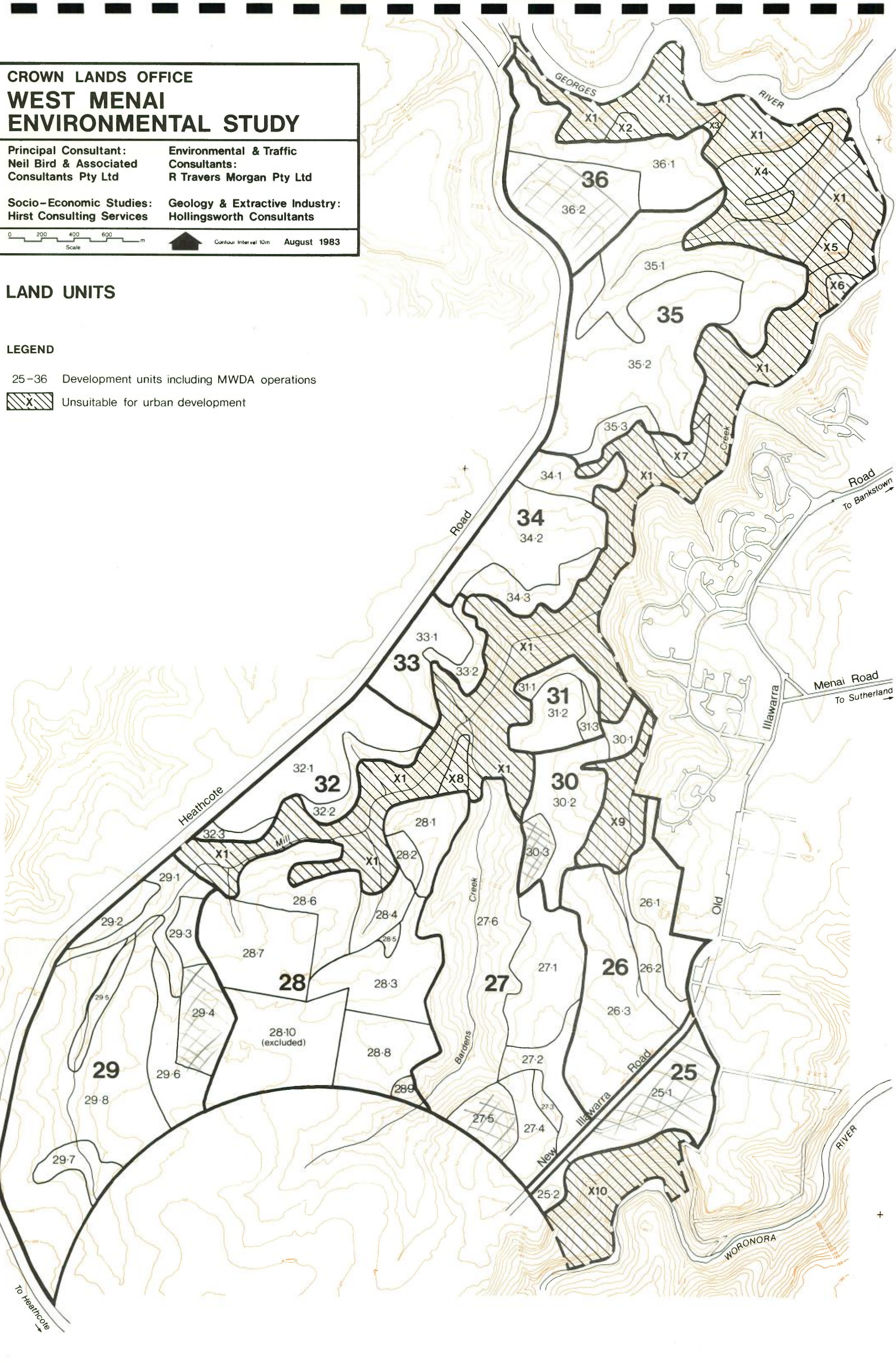
August 1983

LAND UNITS

LEGEND

25–36 Development units including MWDA operations

X Unsuitable for urban development



MAP 11

CROWN LANDS OFFICE

WEST MENAI ENVIRONMENTAL STUDY

Principal Consultant: Neil Bird & Associated Consultants Pty Ltd	Environmental & Traffic Consultants: R Travers Morgan Pty Ltd
Socio-Economic Studies: Hirst Consulting Services	Geology & Extractive Industry: Hollingsworth Consultants

0 200 400 600 m
Scale

Contour Interval 10m

August 1983

STRUCTURE PLAN

LEGEND

- Conventional residential subdivision
- Lower density residential
- District centre
- Neighbourhood centre
- Neighbourhood centre – alternative location
- General industry
- PS — Primary school
- HS — Secondary school
- PS — Primary school – alternative location
- AAEC — Australian Atomic Energy Commission
- Regional open space
- R — Recreation facilities
- Main road link

GEORGES RIVER
PS
R
R
PS
Road
To Bankstown
Creek
District Centre
HS
Illawarra
Mehai Road
To Sutherland
Heathcote
Mill
Creek
PS
R
Old
PS
AAEC
Bardens
R
Road
Illawarra
New
Reservoir
RIVER
WORONORA
To Heathcote

MAP 12

SHIRE OF SUTHERLAND

West Menai release area environmental study

EIS
767
Vol 1

Borrower's name	Date	Ex.

RAECO

EIS 767 Vol 1

SHIRE OF SUTHERLAND

West Menai release area
environmental study

EIS
767
Vol 1