PROPOSED COLLIE POWER STATION

Environmental Review and Management Programme

SECWA

Report No. BD 90/12

March 1990

COLLIE POWER STATION

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

APRIL 1990

STATE ENERGY COMMISSION

OF WESTERN AUSTRALIA

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME PROPOSED COLLIE POWER STATION

prepared by

the State Energy Commission of Western Australia

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

The Environmental Review and Management Programme (ERMP) for the proposed Collie Power Station has been prepared by the State Energy Commission of Western Australia in accordance with Western Australian Government procedures. The report will be available for comment for 10 weeks, beginning on Monday 30th April, 1990 and finishing on Friday 6th July, 1990.

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

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

WHY WRITE A SUBMISSION?

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

All submissions received will be acknowledged.

DEVELOPING A SUBMISSION

You may agree or disagree with, or comment on, the general issues discussed in the ERMP or specific proposals made by the proponent. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more acceptable.

When making comments on specific proposals in the ERMP:

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

POINTS TO KEEP IN MIND

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

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

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

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

REMEMBER TO INCLUDE:

Your name, address, date.
The closing date for submission is Friday 6th July 1990.
Submissions should be addressed to:

The Chairman
Environmental Protection Authority
1 Mount Street
PERTH WA 6000

Attention: Mr D. Michaelsen

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Acknowledgement: SECWA wishes to acknowledge the work conducted towards preparation of this document by Dames and Moore in 1985 and by Bowman Bishaw Gorham during 1988/90.

AERIAL VIEW OF SITE

SUMMARY

1.0 INTRODUCTION

The State Energy Commission of Western Australia (SECWA) proposes a new coal fired power station at a site located 10 km east north east of Collie, Western Australia (see Figure 1.1). The power station will consist of two generating units with a combined capacity of 600 MW. The design and layout of the station will also provide for possible future extension to a capacity of 1000-1200 MW. The following facilities will be included in the project:

(i) two power generating units, comprising boilers and turbo-generators, each with a capacity of 300 MW;

(ii) on-site coal receival, crushing, storage and handling facilities;

(iii) off-site water supply and on-site water storage facilities;

(iv) cooling water system (utilizing mechanical draft or natural draft cooling towers);

(v) ash handling, storage, transport and disposal system;

(vi) on-site substation;

(vii) wastewater management system; and

(viii) ancillary facilities (water treatment plant, workshops, access roads, car park and offices).

2.0 NEED FOR THE DEVELOPMENT

A document outlining SECWA's generation planning for the 1990's has been prepared to justify the need for additional coal fired base load generating plant in Western Australia by the mid 1990's. That document will accompany copies of the ERMP for the Collie Power Station but is available independently from SECWA.

The growth of demand for power demonstrated by current trends indicates that additional base load generating capacity must be available by approximately October 1995. This forecast is based partly on recent growth trends and partly on the anticipated demand from new industrial and mining projects.

To maintain acceptable security of supply, and to allow for both maintenance and unscheduled shutdown, in planning for the new plant there is also a need to maintain installed generating plant with total capacity in excess of peak demand by a factor of approximately 30%.

3.0 EVALUATION OF ALTERNATIVES

Available sources of energy for power generation include coal, oil, natural gas, nuclear fuel and various renewable energy sources. Of these, coal from the Collie Basin was identified as an appropriate fuel option under the present Government Energy Policy as stated in the Green Paper "Energy Policy Options for Western Australia" (Government of Western Australia, May 1989). Also, Collie was identified as a suitable location for base load power generation in the south west of the State. The factors that led to these conclusions include the following:

(i) Renewable resources have the capacity to reduce the rate of growth in the use of fossil fuels, however they are unsuited to the supply of economic base load electricity.

(ii) Uranium must be excluded as an alternative fuel for generation because of environmental factors, Government policy and cost.

(iii) Oil is excluded as a fuel for base load generation because of cost and environmental factors arising from its high sulphur content relative to other fuels.

(iv) Although there is scope for additional gas turbines, because of their particular engineering performance characteristics and fuel cost factors this type of plant is most useful and economic for meeting peak demand rather than base load demand.

(v) There will be insufficient additional gas available to supply a base load power station. The gas pipeline is currently operating at maximum capacity.

Whilst SECWA is planning to install additional compressors for the pipeline the additional supplies of gas will likely be consumed by industries for which alternative fuels are more troublesome to use or more expensive, or which utilize natural gas as a raw material for manufacturing rather than as fuel.

(vi) SECWA has also examined the possible use of gas fired combined cycle plant to provide base load electricity. To date, however, no gas supply company has been able to demonstrate to SECWA that sufficient reserves of gas are available, and are available at long term economical cost, for the lifetime of the station.

(vii) Gas provides a valuable source of export income whilst local coal reserves are not of export quality due to comparatively low specific energy content.

Having identified coal to be the preferred fuel, it has been concluded that deposits within the Collie Basin are well suited to meet forthcoming needs for the reasons outlined below.

(i) Collie coal has one of the highest specific energy contents of the Western Australian reserves.

(ii) It has the additional favourable characteristics of a non-combustible (ash) content that is mid-range and a sulphur content that is very low.

(iii) The Collie Basin contains sufficient proven, shallow reserves to meet anticipated requirements.

(iv) The reserves are close to existing markets.

(v) The Collie region is served by a well-developed infrastructure.

(vi) Collie coal can be recovered by environmentally acceptable mining operations.

Studies of alternative sites indicated that a power station located very close to the coal source would have substantial cost advantages compared with a coastal site such as one at Bunbury, or in the Perth metropolitan area. Studies concluded that siting of a new base load power station at Collie was preferable due to the following factors:

(i) It is consistent with Government Energy Policy to locate new thermal power stations so as to deliver the lowest cost electricity.

(ii) It would be preferable on environmental grounds to site a new base load power station in the Collie area due to its location remote from major population centres and the availability of sites free from insurmountable environmental constraints.

Economic, environmental, geotechnical and land use factors were assessed for a range of sites around the perimeter of the Collie Coal Basin. These investigations led to selection of the preferred site, which is located between the northern margin of the Collie Coal Basin and the Collie River East Branch and consists largely of previously cleared land. Selection of the preferred site was based on proximity to prospective coal mining areas, availability of suitable ash disposal areas, accessibility, topography and surrounding land use.

SECWA has now purchased a total of 1900 ha of private property which includes the plant site area, and is presently negotiating the aquisition of a further 100 ha of Government land. The plant site (388 ha) will be securely fenced and the surrounding buffer area (1500 ha) will continue to support forest and grazing. Where site quality within this area permits, reforestation will be undertaken over previously cleared land.

Within this document, the term "plant site" refers to the 388 ha area that will support the power station plant, rather than the full 1900 ha that has been acquired by SECWA.

In accordance with its charter to assess and develop the State's energy resources, SECWA also conducted conceptual studies for a power station development in the Hill River area, north of Perth, during 1988. However in recognition of the commencement of private feasibility studies, in early 1989 SECWA decided to leave the evaluation of the Hill River Project entirely to the private interests concerned.

Those feasibility studies are presently being carried out by the Hill River Power Development Company Ltd for a new power station and coal mine at Hill River. This project proposal will be submitted to Government as a contender to meet WA's requirement for new power generating capacity by the mid 1990s.

4.0 DESCRIPTION OF THE PROJECT

The principal components of the project are briefly described below.

(i) Site

The preferred power station site of 388 ha comprises 315 ha of cleared land under pasture, 60 ha of jarrah-marri forest and 13 ha of degraded seasonal wetland (see Figure 5.5).

(ii) Power Generation

Power will be generated by two 300 MW conventional pulverized coal-fired units, each comprising a separate boiler and sharing a turbine hall, which will accommodate two turbo-generators and associated pumps. Coal bunkers and associated pulverizers will service the boilers.

(iii) Coal Supply

Approximately 1.5 to 1.9 million tonnes/year of Collie coal will be required to operate the station at an approximate 70% capacity factor. Coal crushing may be conducted either on-site or off-site. A "live" (operational) stockpile of 26,000 tonnes and a reserve stockpile of 364,000 tonnes will be maintained.

(iv) Cooling Water System

Two mechanical or natural draft cooling towers will be used for the cooling system, one for each unit.

(v) Water Supply

Water supply investigations indicate that coal mine dewatering can provide sufficient water of appropriate quality to meet power station supply requirements. These are estimated to be 25,000 m^3/day. However, a new borefield will also be established within the Collie Coal Basin to make up any possible shortfall and to provide a backup for operational security purposes. Additional make-up water will be obtained from site runoff, whenever the resultant water is of acceptable quality. A winter storage dam will be constructed to allow storage of mine water and groundwater. A pond for intermediate quality water will also be constructed to allow storage of process wastewater prior to re-use or disposal.

(vi) Combustion Gas Emissions

Exhaust gases from the combustion of coal fuel will be discharged through electrostatic precipitators where fly-ash will be removed, to a minimum efficiency of 99.5%, and the remaining gases exhausted through a chimney stack of suitable height.

(vii) Wastewater Management

Two alternative approaches to managing saline wastewater produced by the power station are being considered. These are: (i) sidestream softener/brine concentrator which involves treatment and re-use of process water with on-site disposal of water treatment wastes and saline concentrate, and (ii) ocean pipeline, which involves discharge of saline wastewater to the ocean via an overland pipeline. Regardless of the wastewater management process that is selected, operations will not require local discharge of high salinity wastewater.

(viii) Ash Disposal

Ash will be produced at a rate of between 104,000 and 212,000 (dry tonnes) per year, of which bottom ash will comprise between 25,000 and 30,000 tonnes per year. Two alternative methods for the disposal of fly-ash and bottom ash combined are being evaluated. These are: (i) high density slurry disposal in which ash is handled and disposed of as a slurry comprising 70% ash/30% water, and (ii) conditioned (moisture)/dry ash disposal in which ash is handled and disposed of in dry form or conditioned with water to prevent dust nuisance. The location of the fly-ash disposal facility will depend upon the disposal technique that is selected. Current studies indicate that on-site disposal utilizing high density slurry may be the most appropriate method. Regardless of the ash disposal process that is selected, operations will not require local discharge of environmentally unacceptable leachate or runoff from the ash disposal site.

(ix) Power Transmission

A system of new 330 kV transmission lines totalling approximately 3 km in length including a switchyard located on the site will be built linking Collie Power Station to the interconnected grid.

(x) Construction

Site clearing and earthworks will proceed during the first 24 months of the construction period. Following site preparation, erection of the major equipment items will commence. The first unit will occupy a period of five years of construction followed by testing and power production trials, and the second unit will come on load 12 months after commissioning of the first.

(xi) Workforce

A peak workforce of approximately 820 is expected to be involved in the construction of the Collie Power Station. The operating workforce is estimated to be 150 at minimum.

5.0 THE EXISTING BIOPHYSICAL ENVIRONMENT

The project area is located within the Darling Plateau on the northern boundary of the Collie Coal Basin and the Yilgarn Block. Most of the site is underlain by deep lateritic soils which overlie granitic rocks. The southern part of the site is underlain by deep sands of the coal basin. Climatically, the region is characterized by cool to mild, wet winters and hot, dry summers. The marked seasonality of rainfall influences the surface hydrology, with low lying areas becoming swamps during the winter and drying out during the summer. Similarly, flows in streams and rivers occur mainly during winter and spring.

Biologically, the site is located within the Northern Jarrah Forest, of which jarrah (Eucalyptus marginata) is the dominant species. The Northern Jarrah Forest is largely uncleared except in the major valleys where more fertile soils occur. The most valuable habitats ecologically are the wetlands and immediate surrounds which accommodate a relatively high proportion of the fauna, particularly during summer.

Land uses within the Northern Jarrah Forest include: hardwood and softwood timber production, water catchment, coal mining, mineral exploration, mineral processing, agriculture, recreation, flora and fauna conservation, power production and public utilities. The power station site itself comprises mainly cleared, private land which supports improved pasture and is used for grazing of sheep. A 66 kV transmission line passes through the southern part of the site, which also includes a small tract of State forest.

Important environmental issues in the region include the rising salinity of surface waters and the spread of jarrah dieback disease. Clearing of vegetation leads to rising levels of groundwater which dissolves salt stored in the soil profile. In turn, this causes saline base flow discharge to streams. As a result, the Collie River for much of the year carries salt concentrations above accepted potable limits and the water in Wellington Dam now exceeds potable limits. Jarrah dieback disease is caused by the fungus Phytophthora cinnamomi which attacks the roots of many plants and may kill a wide range of susceptible plant species. The disease spreads rapidly in warm moist situations and can be spread to new areas on the tracks or tyres of vehicles. There are many undesirable environmental side effects of dieback infection.

6.0 IMPACT OF THE PROJECT ON THE BIOPHYSICAL ENVIRONMENT

Construction

Construction of the power station and the associated borefield, pipelines and access roads will require the clearing of approximately 245 ha of vegetation. The types of vegetation that will be removed and the areas of each are estimated as follows:

Private land - Mostly pasture with some scattered trees:	129 ha
Private land - Wetland vegetation (subject to degradation by grazing):	12 ha
State forest - Upland jarrah forest:	85 ha
State forest - Wetland vegetation:	5 ha
State forest - Pine plantations:	14 ha

The loss of this vegetation may add marginally to the salinization of surface waters. In accordance with the regulations under the Country Areas Water Supply Act, SECWA will plant trees over an equivalent area of previously cleared land to counteract any salinization potential.

Other effects of clearing will be increased potential for erosion and dust generation from disturbed areas. These impacts will be controlled initially by drainage design and watering for dust suppression and, subsequently, by paving of areas within the power station site which are subject to traffic, and the establishment and maintenance of vegetation over unused parts of the site.

Construction of the power station or its associated facilities will not affect any rare or endangered species.

Operations

Assessment of the environmental impacts of the power station's operations leads to the following conclusions.

(i) Airborne Emissions

Dispersion modelling studies that were based on the discharge of gaseous emissions through a high chimney stack, and accounted for emissions from existing sources in the area, indicated that ground level concentrations of sulphur dioxide (SO_2), nitrogen oxides (NO_x) and particulates (finely divided ash materials) will all remain well within acceptable limits for public health in the area surrounding the power station site and within the site itself (see Section 7.2.1). The potential for emissions to cause "acid rain" is also negligible due to the small magnitude of the emissions and the dispersion of fallout over a very large area. Investigations have shown that ground level concentrations of SO_2 and NO_x will also be well below ecological safeguard guidelines recommended by the World Health Organization for Europe (see Section 7.2.1, Table 7.2).

(ii) Greenhouse Effect

The burning of Collie coal at the new power station will emit up to approximately 3.2 million tonnes of carbon dioxide (CO_2) annually. It is necessary to place this contribution to the increase in greenhouse gases into a global and Australian wide context.

On a world wide basis CO_2 emissions contribute approximately 50% of the total emission of man-made greenhouse gases to the potential global warming increment as the table below relates.

TABLE S.1

SOURCE OF GREENHOUSE GASES

Contribution to Incremental Warming			Source of Man-Made Emission
CO_2	50% ± 5%	-	15% deforestation and land clearing
		-	14% petroleum
		-	10% coal - 8% from power generation
		-	2% steelmaking, industrial and domestic uses
		-	5% natural gas
		-	6% other fuels and processes
CH_4	15% ± 5%	-	from agriculture, cattle, natural gas and biomass fuel
CFC	13% ± 3%	-	from aerosols, air conditioners, refrigerators, plastics
O_3	10% ± 5%	-	from motor vehicles
N_2O	9% ± 2%	-	from fertilizers, vehicles, biomass and fuel burning
Others	3%		

Source: **New South Wales Coal Association (1989)**

TABLE S.2

EMISSIONS OF CO_2 AND CONTRIBUTIONS TO POTENTIAL GLOBAL WARMING

Source	CO_2 Emissions Gt/annum	Proportion of Total Emission (%)	Contribution to Global Warming Increment (%)
Total Worldwide	28.3 (1)	100	50
Worldwide Power Industry	4.9	18	9
Australia	0.4 (2)	1.3	0.7
Australian Power Industry	0.1 (2)	0.4	0.2
Western Australia	0.03 (2)	0.1	0.06
WA Power Industry (SECWA)	0.006 (2)	0.02	0.01

Notes: (1) 19.1 Gt per annum CO_2 from burning of fossil fuel and 9.2 Gt per annum CO_2 from deforestation and land use. Sources; Instit. Eng. Aust. (1989); Keepin and Kats (1988).

(2) Australian emissions sourced from Electricity Supply Association of Australia (ESAA) survey in 1986/87. Contributions from land use and deforestation included as proportional to global values.

The worldwide power generation industry contributes approximately 18% of total CO_2 emissions and accounts for approximately 9% of the warming increment.

The power generation industry in Australia emits approximately 0.4% of total worldwide CO_2 emissions, which equates to a 0.2% contribution to the warming increment.

The role of Western Australia's power generation industry in CO_2 emission is very small. The emissions of CO_2 from local power generation equate to 0.02% of the worldwide total emissions and contribute 0.01% to the total global warming increment.

In this context, the new power station will contribute less than 0.01% to present worldwide CO_2 emissions and less than 0.005% to global warming. Although this trend is small it does represent an increase in CO_2 emissions that will need to be addressed by environmental management planning. Management programmes that will mitigate this additional contribution are discussed in Sections 7.0 and 9.0.

The gas nitrous oxide (N_2O) is also a greenhouse gas. For reasons of scientific convention in nomenclature, nitrous oxide is not included within the measurement term "nitrogen oxides" (NO_x). Whilst combustion gas emissions from coal fired plant contain measurable quantities of NO_x, they contain only negligible quantities of nitrous oxide so that their contribution to greenhouse gases in terms of nitrous oxide is also negligible.

(iii) Water Supply

Current planning indicates that mine dewatering will be the normal source of water supply for the power station. Groundwater abstraction will provide water supply in the event of a shortfall of supply from mine dewatering. The effects of groundwater abstraction from aquifers within the Collie Coal Basin cannot be predicted with certainty. Drawdown of the water table is unlikely to occur in the immediate vicinity of the borefield even if groundwater must supply the power station's total requirement. However, in the near surface aquifer drawdown of the order of several metres may occur, which in some areas may affect the extent and longevity of seasonal swamps.

There may, however, be changes in the composition of wetland vegetation in other areas. The extent to which these effects occur will depend on the balance between recharge and withdrawal. Whilst it is not possible to make accurate predictions of drawdown for specific locations, groundwater investigations have confirmed the ability of the regional groundwater reserves to support the proposed development should this be necessary.

(iv) Ash Disposal

The specific impacts of ash disposal will be dependent on the disposal method that is selected. Regardless of the disposal method that is chosen, the system design, disposal site location and operational methods will be formulated and implemented so that (i) environmental impacts are minimized and (ii) the disposal operations meet the environmental management requirements of the regulatory authorities and specific water quality objectives established by the Water Authority of WA for the Wellington Dam catchment.

Management of leachate which could be produced by either of the alternative methods will be the primary management objective. Ash contains salts and heavy metals which will readily dissolve in water that comes into contact with the ash. Each of the disposal methods under consideration will ultimately involve storage of disposed ash within an impoundment. Design, and operations management, will have the objective of minimizing the migration of leachate that is produced within the impoundment into underlying sediments and groundwater.

It is estimated that the inclusion of a clay blanket and slurry wall cut off in the ash dam can reduce leachate seepage by up to 98%. Further reductions in seepage of ash leachate by up to 99.9% can be effected by the inclusion of a high density polyethylene membrane. Trials will be conducted at Muja Power Station to determine the most appropriate lining method to be installed at the new power station to meet regulatory water quality criteria.

The long term impacts of ash disposal will depend upon ash placement, ash capping with clay and rehabilitation techniques that are employed. Together with other design factors, rehabilitation procedures will have the objective of achieving stabilized surfaces and of reducing leachate production and seepage losses to acceptable manageable levels.

(v) <u>Wastewater Management</u>

The potential environmental impacts of wastewater management will depend upon the management system that is selected.

For the sidestream softener/brine concentrator option, seepage from the saline concentrate evaporation pond represents the greatest potential impact. The pond will therefore be designed and constructed to minimize potential seepage losses. A network of monitor bores will be established to enable containment performance to be confirmed.

For the ocean pipeline disposal option, near shore water quality is the greatest area of potential impact. Although water quality projections for the wastewater to be discharged indicate it would readily comply with appropriate marine water quality criteria, detailed environmental investigations would be conducted to provide reliable confirmation of environmental acceptability.

7.0 IMPACT OF THE PROJECT ON THE SOCIAL ENVIRONMENT

Of the peak construction workforce of 820, in the order of 60% are expected to be local recruits, commuting from Collie, Bunbury and surrounding areas. The remaining workforce will be accommodated in construction camps and in guest houses, hotels and motels in Collie. Multiplier employment in Collie as a result of construction is expected to be relatively low (35%) due to the excess capacity following completion of the Worsley Alumina Refinery and Muja Power Station. Because of these and earlier construction projects, the residents of Collie and the available services are accustomed to meeting the demands of the construction workforce and, accordingly, few social problems are expected. Because of the diverse range of accommodation development in place, or being planned in the Preston Statistical Division, including Bunbury, competition between construction workers and tourists for accommodation should be minimized, if not completely eliminated.

The permanent operating workforce, estimated to be a minimum of 150, is expected to be recruited mainly (70%) from non-local sources. With an estimated multiplier service employment of 55%, mainly recruited locally, the total local permanent employment generated by the project is expected to be approximately 232. An estimated total incoming population of 330 is expected.

The project will significantly increase local employment and reinforce the level of regional employment, which is currently high.

As a result of SECWA's policy which actively encourages settlement in Collie it is expected that the majority of incoming people will settle in the town.

(i) Aboriginal and Archaeological Sites

There are no sites of Aboriginal significance that will be affected by the project. An archaeological survey revealed several minor archaeological sites which may need to be disturbed during construction. The WA Museum will be consulted prior to any such disturbances.

(ii) Noise

A survey of the existing background noise environment and a study of anticipated noise impacts arising from operation of the power station have been carried out. The results of the study indicate that, under worst-case conditions, noise levels exceeding 35 dB(A) may propagate up to 4 km to the south and 3 km east of the power station.

SECWA has endeavoured to maximize the surrounding buffer zone to include all of the area within the modelled 35 dB(A) limit. In doing so SECWA has purchased several nearby properties as they became available on the free market, and purchase of properties will continue to be an option to reduce noise impact.

Another option to overcome potential concern relating to noise generation includes the installation of noise controls on power station plant and equipment. The preferred option will be decided in conjunction with land purchase considerations prior to tendering of major plant equipment.

(iii) Traffic

Various alternative access routes have been assessed between the power station site and Collie. For operational reasons, particularly the avoidance of intersection between coal haulage traffic and passenger vehicles, SECWA favours access from the west via the Williams-Collie Road. Traffic impact analysis indicates that the route will be acceptable, providing that sub-standard sections of the Williams-Collie Road are upgraded. SECWA is prepared to negotiate this upgrading.

(iv) Water Supply

The location and configuration of the new borefield have been selected with the aim of minimizing the risk of interference with existing water supplies. Both existing private users and environmental requirements have been considered in the selection of the borefield site and the configuration of the borefield.

(v) Dust

The inherent moisture content of coal that will be used by the power station will prevent the general occurrence of significant dust nuisance at the power station. Dust nuisance potential will be the highest within the coal preparation area where coal stockpiles will be maintained. Traditional water suppression procedures will be employed in this area to provide a safeguard against dust nuisance potential.

(vi) Aesthetics

The power station will not be visible from the town of Collie. Only glimpses of the tallest structures will be visible from the Williams-Collie Road. A public look-out will be established to the north of the Power Station from which to view the station.

8.0 ENVIRONMENTAL MANAGEMENT COMMITMENTS

General Commitments

1. The proponent will adhere to the proposal as assessed by the Environmental Protection Authority and will fulfil the commitments made below.

2. The power station will be constructed and operated according to relevant Government statutes and agencies' requirements, including those of the following:

   - Environmental Protection Authority;
   - Water Authority of W.A.;
   - Department of Conservation and Land Management;
   - Department of Occupational Health Safety and Welfare;
   - Shire of Collie.

Design and Planning

The proponent is committed to:

1. the removal of all fly-ash particulate matter in excess of $0.08 g/m^3$, which is a National Health and Medical Research Council (NH&MRC) Guideline for New Plant (1985), from the boiler exhaust gases by the use of electrostatic precipitators, to the satisfaction of the Environmental Protection Authority.

2. the design of the power station boiler to limit nitrogen oxide (NOx) emissions to $0.8 g/m^3$, which is the NH&MRC Guideline for New Plant (1985), to the satisfaction of the Environmental Protection Authority.

3. the design of the power station and a suitably constructed chimney stack to limit the ground level concentrations of sulphur dioxide (SO_2) to comply with Victorian Environmental Protection Authority's Acceptable level of 486μg/m^3, one hour average; NH&MRC's ambient air quality goal of 60μg/m^3, twenty four hour average.

4. planning and design of the power station to limit noise emissions beyond the power station property boundary to 40dB(A) at the nearest residence, to the satisfaction of the Environmental Protection Authority.

5. the design of a coal ash disposal method which will meet the environmental management requirements established in the licence conditions set by the Water Authority of Western Australia for the Wellington Dam Catchment.

6a. the design of a wastewater management process which will meet effluent discharge quality criteria consistent with achieving the water quality objectives for the Wellington Reservoir which have been defined in the Draft Water Resources Management Strategy for the Collie Coal Basin. These criteria will allow no discharges with salinity in excess of 550mg/L TDS to be discharged into the surface waters of the coal basin, to the satisfaction of the Water Authority of Western Australia and the Environmental Protection Authority.

6b. should an ocean pipeline be identified as a means of removing from the Collie Basin saline wastewater produced by power generation, the proponent shall seek full environmental approvals for the proposal, to the satisfaction of the Environmental Protection Authority.

7. minimising the visual impact of the power station by the engagement of a landscape architect early in the design phase and prior to commencement of construction.

8. taking account during design stages, of forest hygiene requirements, to avoid, where practicable, sites and routes that involve a high risk of the spread of dieback into previously unaffected areas, by early consultation with, and to the satisfaction of, the Department of Conservation and Land Management.

Construction Phase

The proponent is committed to:

9. conducting a social monitoring programme during the construction and operations phase and liaising with the Deputy Premier's Department Social Impact Unit, South West Development Authority, Collie Shire Council and social welfare groups to assist in the resolution of any housing, education and social welfare issues that arise from this proposal to the satisfaction of the Local Authority and the Environmental Protection Authority.

10. controlling dust nuisance by water application via sprinkler or truck in areas of heavy traffic or soil storage, to the satisfaction of the Environmental Protection Authority.

    In the event of complaint relating to nuisance dust from construction activities, the proponent will investigate and take appropriate remedial action to the satisfaction of the Local Authority and the Environmental Protection Authority.

11. minimising water erosion due to surface runoff during earthworks by ensuring that earthworks construction contracts will include provision for control of drainage. Diversion channels above and below batters and around the perimeter of cleared areas will assist erosion control and allow turbid runoff to be diverted to sediment traps to the satisfaction of the Environmental Protection Authority.

12. minimising ongoing dust potential, erosion and visual impact by stabilisation or restoration of disturbed areas as soon as possible following construction, to the satisfaction of the Environmental Protection Authority and other relevant authorities.

Measures implemented will include:

(i) Minimisation of the areas of disturbance.

(ii) Proper storage and management of recovered and returned topsoil.

(iii) Replanting of disturbed areas with appropriate species.

13. initiating investigations and issuing a report to the Western Australian Museum in the event that any archaeological sites are revealed during construction. If appropriate, permission to proceed will be obtained before construction commences.

14. revegetating and stabilising temporarily disturbed areas, and contributing to reforestation of the Wellington Dam Catchment, in accordance with its obligation under the Country Areas Water Supply Act, 1976, to the satisfaction of the Water Authority of W.A.

15. the incorporation of dieback hygiene procedures within all earthworks construction specifications in areas of dieback infection, and protectable forest in accordance with and to the satisfaction of the Department of Conservation and Land Management.

Operations Phase

The proponent is committed to:

16. an emissions and ambient air monitoring programme.

    The emissions monitoring programme will confirm that stack emission specifications for particulates and nitrogen oxides (NOx) comply with the relevant guidelines as expressed under commitments 2 and 3. Measured levels of SO_2 will also be taken at the stack.

    The ambient air monitoring programme will be affected by the establishment of an automated monitoring station equipped with a continuous sulphur dioxide monitor and high volume sampler to measure particulate concentrations.

    The resulting levels of sulphur dioxide and particulates measured will be used to validate computer model predictions of ambient air quality for sulphur dioxide and particulates.

    The above monitoring programme will be to the satisfaction of the Environmental Protection Authority. In the event that relevant guidelines for ambient air quality are not complied with, the proponent will develop operational strategies to mitigate unacceptable air quality events to the satisfaction of the Environmental Protection Authority.

17. installing networks of groundwater observation bores around the ash disposal pond and storage ponds containing saline water. Monitoring will be conducted at intervals agreed to by the Water Authority of W.A. In the event that monitoring indicated leakages that could have significant environmental impact, remedial strategies will be formulated and implemented to the satisfaction of the Water Authority of W.A. and the Environmental Protection Authority.

18. extending the existing network of regional groundwater observation bores in the Collie Basin as necessary to cater for the proposed new borefield and to ensure groundwater levels are monitored in those areas that have been identified as being at risk from drawdown. The monitoring programme and reporting of results will be to the satisfaction of the Water Authority of W.A. In the event that monitoring indicated drawdown is occurring to the detriment of either existing groundwater users or to local wetlands, remedial strategies will be developed by SECWA to the satisfaction of the Water Authority of W.A. and the Environmental Protection Authority.

19. establishing monitoring transects and reference quadrats in wetland areas identified to be at most risk from drawdown and assessed at appropriate intervals to determine whether changes to species composition or structure are occurring. Should significant detrimental changes to wetland vegetation be indicated by monitoring remedial strategies will be formulated by SECWA to the satisfaction of the Department of Conservation and Land Management and the Environmental Protection Authority.

20. developing a vegetation monitoring programme to measure the effects of atmospheric emissions from the power station on the surrounding forest. In the event that monitoring identifies unacceptable detrimental effects, remedial strategies will be formulated by SECWA and implemented to the satisfaction of the Department of Conservation and Land Management and the Environmental Protection Authority.

21. controlling dust nuisance from the on-site coal storage and crushed coal stockpiles by the use of water sprays.

22. maintaining an annual audit of the greenhouse gas, carbon dioxide which results from the burning of Collie coal, to the satisfaction of the Environmental Protection Authority.

23. implementing a noise survey following commissioning of the power station to confirm model predictions of noise levels established at various locations outside the SECWA property boundary. If the survey indicates that noise levels are excessive, remedial strategies will be formulated and implemented to the satisfaction of the Environmental Protection Authority.

Decommissioning

24. The usual life expectancy for a coal-fired power station is 30-40 years. Once decommissioned the power station will be used for public purposes which have yet to be determined. Rehabilitation of the site including appropriate management of solid and liquid wastes will be a pre-requisite to future use of the area and will be carried out to the satisfaction of the Environmental Protection Authority.

1.0 INTRODUCTION

1.1 Overview

The State Energy Commission of Western Australia (SECWA) is proposing a new 600 MW coal-fired power station at a site near Collie, to satisfy projected increases in electricity consumption. Demand forecasts indicate that additional base load generating capacity will be required by approximately 1995. During the intervening period, SECWA will install small capacity gas turbines which will provide the necessary generating capacity to cater for seasonal and diurnal peak demand. Whilst these turbines will satisfactorily cater for load growth in the short term, the medium term scenario is for a reduction in the availability of gas for power generation due to increasing market sales. Consequently, much less gas will be available for use in power stations, which will necessitate the use of increasing amounts of expensive distillate to fuel the turbines. In the event that substantial new gas supplies are not available by the mid 1990s, it will be more economic to install a new power station based on coal fuel. Even though the capital cost of coal-fired power plant is much higher than that for combustion turbines, coal fuel is significantly less expensive than distillate, which provides an economy that is essential for base load generation.

SECWA presently operates three power stations to satisfy base load electricity requirements for the south west interconnected grid system. These are located at Kwinana, Bunbury and at Muja, south east of Collie. Kwinana power station is currently capable of both coal or gas firing, whilst Bunbury and Muja stations burn coal mined at the Collie Basin.

Initial planning considerations for the new power station involved the application of a wide range of economic, environmental and engineering criteria. Development of a coal fired power station located in the Collie Coal Basin area was assessed to be a viable option. A more detailed rationale for utilizing coal as the energy source is presented in Section 3.0, along with the evaluation of alternative sites that were proposed for consideration. The new power station is proposed to be located approximately 8 km east north east of Collie, just south of the Collie River East Branch. Its regional location is shown on Figure 1.1.

1.2 Proponent Details

The proponent for this project is the State Energy Commission of Western Australia. SECWA is a body corporate which exists pursuant to the State Energy Commission Act (1975-79). The function of SECWA is described in Section 27 of the Act:

"... to provide, maintain and extend throughout the State an efficient, coordinated and economical supply of energy in the form of electricity or gas."

SECWA also has a number of corporate objectives including:

"to develop, operate and maintain the electricity and gas systems at the lowest possible cost, consistent with high levels of safety and reliability and sympathetic consideration for the environment."

1.3 Environmental Impact Assessment

1.3.1 General

Under the provisions of the Environmental Protection Act, 1986, any proposal that, if implemented, could have a significant effect on the environment should be referred to the Environmental Protection Authority (EPA). The EPA determines the appropriate level of environmental assessment required. When proposals are likely to result in significant environmental impact, the EPA advises the proponent of the required level of assessment, which initiates the formal process of "Environmental Impact Assessment".

The level of assessment for the Collie Power Station has been set as an Environmental Review and Management Programme (ERMP). Guidelines provided by the EPA to assist SECWA in the preparation of this document are listed in Appendix B.

The EPA will make this ERMP report available for public review and comment, then assess the environmental implications of the proposal. The

EPA will report its findings to the Minister for Environment, who is responsible for setting conditions and procedures for the implementation of the proposal.

(A Works Approval will be required prior to the commencement of construction and an Operating Licence will also be required.)

1.3.2 Role of the ERMP

This document is designed to provide information to the EPA and the public to enable detailed evaluation of the likely environmental effects of the project.

Specifically, this document aims to:

- identify the need for a new power station;
- rationalize the use of coal as an energy source;
- assess the significance of the potential environmental effects in relation to the following components: clearing and site earthworks, pumping groundwater from a new borefield, on-site storage of solid waste, off-site wastewater disposal and emissions to the atmosphere;
- identify the potential social effects of the construction and operation phases on the local community; and
- define a management strategy to minimize the environmental and social effects.

1.4 Scope and Timing

The scope of this proposal involves the construction and commissioning of two 300 MW generating units and associated infrastructure. Long term planning identifies the need for a further two 300 MW units at the same site, but these may not be required before the year 2000. SECWA understands that any further units will be subject to separate environmental impact assessment which will include the cumulative impacts of all industry in the Collie area.

In terms of timing, the detailed design and all statutory approvals are anticipated to be complete by approximately mid 1990. The critical time path will then be dependent on the boilers.

Under normal circumstances, calling of tenders, ordering and delivery, construction of foundations and structures and installation of the two boilers will span nearly six years. Commissioning of the first unit should commence in the latter half of 1995. Should the predicted growth in demand change in the next six to eight months, the commissioning date for each unit will be altered, as appropriate.

1.5 Interaction with Other Proposals

Power transmission proposals to integrate the new Collie Power Station within the south west grid system have been addressed separately in two Public Environmental Reports (PER) (SECWA 1985 and SECWA 1988). New transmission corridors are proposed from the new station south to Muja Power Station, and north to Kwinana via the proposed new terminal near the Kemerton Industrial Estate (these corridors are illustrated on Figure 1.1). They have been approved by the EPA and are subject to a number of environmental management commitments. These new transmission works will link Kwinana and Muja Power Stations to the new Collie station, thus significantly enhancing existing system reliability.

Whilst it is noted that the Collie Basin Management and Planning Group has recommended the establishment of a heavy industrial area near Collie, at present no major initiatives have been confirmed.

There is a possibility that a new coal mine will be developed to supply the Collie Power Station. Consideration of the environmental impacts of coal mining is beyond the scope of this ERMP. Environmental aspects of existing coal mining operations in the Collie Coal Basin are covered by Agreement Acts between the Government and the relevant mining companies as well as by the provisions of the Environmental Protection Act.

It is recognized that the environmental effects resulting from operation of the proposed Collie Power Station may interact with those from the existing Muja Power Station and result in cumulative effects that are more significant than the perceived impacts when considered in isolation. For this reason, specific aspects of the new station's operations have been addressed in more detail. These aspects are in relation to airshed quality, water supplies and wastewater disposal.

2.0 NEED FOR THE DEVELOPMENT

This section discusses the need for a new base load power station in the context of existing generating capacity, the projected demand for electricity and the characteristics of demand in terms of constant demand (base load) and short term peak demand (peak load). Selection of an energy source for the station is addressed in Section 3.0.

A document outlining SECWA's generation planning for the 1990's has been prepared to justify the need for additional coal fired base load generating plant in Western Australia by the mid 1990's. That document will accompany the ERMP for the Collie Power Station but is available independently from SECWA.

When planning for new generating capacity, it must be borne in mind that a range of factors influence the scope of a new power station development, such as the need for:

- o existing demand for base load and peak load supply
- o additional capacity to meet the growing demand for electricity;
- o provision of standby generating capacity to cater for major plant shutdowns;
- o replacement of generating capacity as ageing stations are decommissioned;

and

- o the possibility that demand may unexpectedly exceed forecasted levels.

Before discussing existing generating capacity and demand forecasts, some brief background information is presented to provide an appropriate perspective.

2.1 Background

In 1945, the State Energy Act was proclaimed and an administrative body known as the State Electricity Commission assumed responsibility for electricity production and supply to consumers. Increased power demand in the Perth metropolitan area was met, initially, by construction of new units at the East Perth Power Station. Subsequently, the South Fremantle Power Station was commissioned in 1951.

In 1955, the State Electricity Commission commenced planning for an interconnected electricity transmission grid for the entire south west of the State. As part of this scheme, new power stations were commissioned at Bunbury in 1957 and at Muja, near Collie, in 1965.

A separate body, the Fuel and Power Commission, was constituted in 1972 with responsibility for energy policy and planning. However, in 1975, the Fuel and Power Commission and the State Electricity Commission were amalgamated to form the present State Energy Commission of Western Australia.

The major events in power station development during the 1970s and initial half of the 1980s are as follows:

1970 - development of Kwinana Power Station commenced;

1981 - closure of East Perth Power Station;

1981 - commissioning of Muja Stage C;

1985 - commissioning of Muja Stage D which completed the Muja station;

1985 - closure of South Fremantle Power Station.

2.2 Existing South West Electricity System

The existing south west transmission grid now extends as far north as Kalbarri, east to Kalgoorlie and south to Albany. All of the coal-fired power stations are interconnected so that any of the individual stations can supply power for use in load centres throughout the south west.

The generating system comprises three base load stations, located at Kwinana, Muja and Bunbury, and three small capacity gas turbines. The gas turbines have been installed at Kwinana, Geraldton and Kalgoorlie to cater for peaks in demand.

Additional gas turbine plant is also currently being installed at Kalgoorlie, Pinjar (north of Perth) and Mungarra (near Geraldton). It is anticipated that further gas turbine plant will also be necessary prior to the commissioning of Collie Power Station in October 1995.

The capacities of each station and the fuels utilized are summarized in Table 2.1.

TABLE 2.1

POWER STATION SYSTEM

Power Station	Stage and Date Commissioned	No. of Units and Capacities	Maximum Capacity at Each Station	Fuel
Existing				
Kwinana	Stage 1 - 1970/71	2 x 109 MW		Coal - gas
	(or 2 x 120 MW)			(Oil)
	Stage 2 - 1972/73	2 x 120 MW		Oil or gas
	Stage C "	2 x 120 MW		Coal
		(or 2 x 200 MW)		(Oil or gas)
	Gas turbine "	20 MW		Natural gas
			900 MW	
Muja	Stage A - 1966	2 x 60 MW		Coal
	Stage B - 1969	2 x 60 MW		Coal
	Stage C - 1981	2 x 200 MW		Coal
	Stage D - 1985	2 x 200 MW		Coal
			1040 MW	
Bunbury	4 Units	4 x 30 MW		
	No. 1 - 1957			Coal
	No. 2 - 1959			Coal
	No. 3 - 1960			Coal
	No. 4 - 1961			Coal
			120 MW	
Geraldton	Gas turbine 1972	20 MW	20 MW	Natural gas
Kalgoorlie	Gas turbine 1984	20 MW		Distillate
	Gas turbine 1989	37 MW		Distillate
			57 MW	

TABLE 2.1(CONT'D)

POWER STATION SYSTEM

Power Station	Stage and Date Commissioned	No. of Units and Capacities	Maximum Capacity at Each Station	Fuel
Mungarra	Gas turbine 1989	74 MW	74 MW	Natural Gas
		TOTAL =	2211 MW*	
Proposed				
Pinjar	Gas turbine 1990-91	259 MW		Natural Gas and Distillate
Mungarra	Gas turbine 1990	37 MW		Natural Gas
Site to be Advised	Gas turbine 1992-94	(est) 300 MW		Natural Gas and Distallate
		TOTAL =	596 MW	

***Footnote:** Note that 111 MW of capacity installed as of November 1989

2.3 Planning for the Future - Power Demand Forecasts

Accurate power demand forecasts are required for the short-to-medium term to assess the need for, and capacity of, new generating plant. This is particularly the case for base load power stations because of the extended lead time required for design and construction.

It is extremely difficult to predict accurately the future demand for electricity. Forecasts are based partly on recent trends in growth of demand and partly on the anticipated demand from major industrial and mining developments as they are announced. Cancellation or re-scheduling of large energy-consuming projects is a primary factor in modification to demand forecasts.

The most recent power demand forecasts for the south west system are given in Table 2.2 and are shown schematically on Figure 3.2. Three forecasts are provided - a central (or most likely) prediction, a high (or possible maximum) prediction and a low prediction. For comparison, during the 1986/87 financial year, domestic electricity sales increased by 5.2%, whilst industrial and commercial electricity demand increased by 9.7%. For the 1988/89 financial year, domestic electricity sales increased by 5.4%, whilst industrial and commercial electricity demand increased by 14.2%.

Power demand forecasts should be considered in the context of existing generating capacity and demand, to enable clarification of the need for a new base load station. The cold weather maximum power demand in 1987/88 was 1560 MW, which was supplied from a total installed generating capacity of 2100 MW. For the 1988/89 period the cold weather maximum power demand was 1740 MW, supplied from a total installed generating capacity of 2100 MW.

The excess in installed capacity compared to peak demand is essential for security of supply, in the event of major breakdown or any other unscheduled maintenance shutdown. SECWA considers that a safety margin of approximately 30% excess of installed capacity compared to peak demand is essential to maintain similar reliability levels to those achieved in the past and similar to those achieved by other power generating authorities elsewhere in Australia. Whilst for the 1987/88 period the reserve of installed capacity was approximately 35%, for the 1988/89 period there was an erosion of reserve capacity to approximately 21%. Therefore, simple extrapolation of the necessary safety margin to the 1996/97 forecasts in Table 2.2 indicates that the additional generating capacity from the proposed Collie Power Station must be available by that time. Existing coal-fired plant will need to be operated at maximum capacity over the next 5-6 years to supply the growth in base load demand as discussed in the following section.

2.4 Base Load and Peak Load Requirements

Base load is an industry term that refers to the portion of the total electricity requirement which is effectively constant throughout the year. Coal-fired power stations provide primarily base load electricity because they are most economical in this mode of operation. Peak load refers to that portion of the

TABLE 2.2

ELECTRICITY LOAD FORECASTS - SOUTH WEST SYSTEM ANNUAL MAXIMUM DEMAND (MW GENERATED)[1] 1989/90 TO 2008/09

	1989/90		1996/97		2008/09	
Forecasts	MW	% Growth	MW	% Growth	MW	% Growth
Central	1906	9.5	2550	3.1	3444	3.0
High[2]	1918	10.2	3037	3.9	4443	3.9
Low[3]	1890	8.6	2270	2.1	2778	2.1

Notes:

1. Prior to 1994/95 the winter demand is the annual maximum demand. From 1994/95 the summer maximum demand becomes the annual maximum demand.

2. Phase 2 of the Barrack Silicon Smelter is included in the forecast only.

total electricity requirement which exceeds base load, which occurs over relatively short periods, and is characterized by fluctuating but high energy demand. For SECWA peak demand generally occurs during the mid-winter and mid-summer months when maximum power demand is brought about by the use of appliances including heaters, air conditioners and hot water systems.

As shown in the forecasts for 1989/90, the south west electricity system is currently experiencing a relatively high percentage growth in demand. New resource based industry, the interconnection of the eastern goldfields, and associated increase in light industrial and commercial activity, have contributed to demand growth for the south west electricity grid.

Whilst demand is not expected to continue to expand at such high rates, SECWA proposes to cater for the annual peak levels through a programme of gas turbine installations. In the next six to eight years, a further 500-600 MW of peak load, gas turbine capacity may be installed at various locations in the south west of the State.

The primary roles of the new gas turbines will be for "peak lopping" during diurnal and seasonal peak demand periods, and for emergency back-up during major scheduled and unscheduled shutdowns of other generating plant. The turbines will therefore only operate some of the time and their capacity factor will be low, in the order of 15% for a given period. Capacity factor is a measure of the energy produced by a generating plant compared to its total generation capacity under conditions of continuous operation at full load.

In contrast, to operate large base load stations on a cost-effective basis, the generating units should preferably be utilized at an average capacity factor of about 70 to 75%. SECWA's forecasts indicate that additional base load capacity will be essential by about 1995. The Collie Power Station is a viable option to fulfil that requirement.

3.0 EVALUATION OF ALTERNATIVES

This section of the ERMP discusses the alternatives available to SECWA if the identified demand for additional base load electric power in the south west of the State is to be met in a manner that is consistent with the various energy policy options available to the Government. These have been identified in a recent Green Paper entitled "Energy Policy Options for Western Australia" (Government of Western Australia, May 1989).

Accordingly, alternative energy sources are discussed to demonstrate the basis of selection of coal as an appropriate fuel for base load power generation. Various possible locations for the power station are evaluated on the basis of environmental, engineering and economic criteria.

3.1 Alternative Energy Sources for Power Generation

Western Australia has renewable and nonrenewable sources of energy. The most important of these are reviewed in the following sections with respect to their application to base load power generation.

3.1.1 Coal

Coal of commercial quality and quantity is known to occur at several sites in Western Australia as shown in Table 3.1. Of these known deposits, only those at Collie have been developed to date. The other coal deposits have not been exploited for a number of reasons, including distance from markets, cost of extraction and relatively inferior quality. However, it is probable that one or more of these deposits will eventually contribute to the State's power generation requirements.

Mining of coal near Collie commenced in 1883 and has continued to the present day, during which time 75 million tonnes have been extracted, mainly for power generation in the south-west of the State. The low sulphur content relative to heat content makes Collie coal well suited to local power generation. However Collie coal is not of sufficiently high quality to meet export standard specifications. Coal from the Collie mines currently accounts for approximately 75% of the electricity generated in the south west of the State.

TABLE 3.1

CHARACTERISTICS OF COAL DEPOSITS IN WESTERN AUSTRALIA

Deposit Location	Average Specific Energy (MJ/kg)	Total Demonstrated Reserves-1989 ($x10^6$ t)	Average Moisture Content (%)	Average Ash Content (%)	Average Sulphur Content (%)
Esperance-Salmon Gums	7.5	1,000	60	11	1.9
Eneabba	15	150	30	19	1.4
Hill River	19	470	26	14	1.3
Margaret River	28	500	8	8	0.6
Collie	19.5	480	25	10	0.7

Known coal reserves in the Collie Coal Basin, which are amenable to extraction using currently available technology, amount to 482 million tonnes, of which 50% has been dedicated for power generation. These reserves are considered sufficient to supply existing and projected power requirements in the south west for approximately 100 years. It is probable that future technological advances will enable extraction of a higher proportion of deeply buried seams, which could substantially extend the life of the field.

3.1.2 **Oil**

The main producing oil fields in Western Australia lie in the Carnarvon Basin. Oil is also being produced in small quantities in the Canning Basin at the Blina, Sundown, West Terrace and Lloyd fields. The recoverable reserves of oil identified as at December 1987 amounted to approximately 20 x 10^6 kL. (WA Department of Mines, 1988). This amounts to only 2% of Western Australia's fossil fuel reserves.

SECWA has adopted a programme to reduce the quantity of oil that is used for power generation, for the reasons listed below.

(i) Oil has become a relatively expensive fuel in comparison with coal.

(ii) There has been a growing attitude that oil should be conserved for those uses for which alternative raw materials are not as readily available or as easily used, for example transport.

(iii) As Australia is not fully self-sufficient in oil production, the use of alternative energy sources, such as coal, helps to minimize fuel imports and dependence on overseas suppliers.

Therefore, at present, oil fuels are only used for power generation at regional power stations, where transport factors make oil a more economic fuel than coal, and at major base load power stations for light up, low load support and emergency purposes.

Although prospects for future oil discoveries in Western Australia are good, it is unlikely that SECWA will use oil to produce base load electricity in the south west of the State due to the highly unfavourable economic factors.

3.1.3 Gas

Western Australia is well endowed with natural gas reserves, which represent 63% of the State's fossil fuel reserves. Gas was first produced to supply domestic and industrial needs in the Perth area in 1971, from the Dongara field.

Currently identified recoverable reserves of natural gas amount to 861.31 x 10^9 m^3 with a further 90.56 x 10^6 kL of condensate (WA Department of Mines, 1988). These figures include both offshore gas fields and the smaller onshore fields.

The development of the natural gas reserves of the North West Shelf has created a valuable source of export income and the construction of the Dampier-Perth Natural Gas Pipeline has resulted in the availability of large quantities of gas for domestic and industrial use in the south west of the State.

In some instances, natural gas has replaced oil and coal as fuel for base load power generation. SECWA also has gas-fired combustion turbines at Geraldton and Kwinana, and intends to supply peak load electricity with additional turbine plant planned to be installed at Pinjar (north of Perth) and Mungarra (near Geraldton).

Gas turbines are very economical in supplying a discontinuous peak load of electricity but are generally unsuitable for continuous generation of base load power because of their high fuel cost. It is also more efficient to directly supply domestic users with natural gas for heating and cooking rather than supply base load electricity generated from gas fuel. Direct domestic utilization of gas also has the benefit of reducing peak electricity demand, thereby reducing the requirement for generating plant to service this demand.

It is anticipated that contracted gas supplies from the North West Shelf will be largely committed, within 3-5 years, to industries for which alternative fuels are more expensive or troublesome or to industries which use natural gas as a raw material for manufacturing rather than as a fuel. The gas pipeline is currently operating at maximum capacity, however SECWA is proceeding to install additional compressors to the pipeline to increase the gas supply to the State's south west. Gas is also being purchased from alternative sources. As new industries establish and consume additional supplies the amount of gas for power generation will be limited and the use of gas in this role will significantly decrease in the medium to long term.

3.1.4 Combined Cycle and Cogeneration Plant

Opportunities to increase the energy conversion efficiency of thermal power plants are available through the use of cogeneration and combined cycle systems.

Combined cycle plant consists of one or more combustion turbines which drive generators and pass hot exhaust gases to a waste heat recovery boiler which in turn provides steam to operate a turbo-alternator set. Combined cycle plant is considerably more expensive than traditional combustion turbine plant which will be used for peak lopping duty over the next few years. It would not be cost effective to install combined cycle plant for peak lopping duty as the inherent higher efficiency and resultant fuel saving would not be sufficient to offset the additional capital cost of the additional waste heat boilers and turbine components that are required.

For combined cycle plant to be cost effective it must be run at medium to high load factors which is inconsistent with the peak lopping duty for which gas turbines will be required.

In recent years there has been a rapid increase in the usage of gas in Western Australia to the extent that there is now only a limited amount of gas available for power generation. This gas will be used largely to displace oil and coal at Kwinana Power Station and only a small amount will be available for use in either traditional or combined cycle gas turbine plants.

In the longer term additional gas may be available for power generation. SECWA is actively pursuing supplies of additional gas, however, until firm contracts are in place there is only limited scope for combined cycle plant in the power generation system. Cogeneration involves the production of heat, electrical or mechanical energy from waste heat that would otherwise be discharged to the environment. Cogeneration results in high energy efficiency. SECWA is presently examining the potential to establish cogeneration from industrial processes but is limited by the lack of industries which could effectively participate in a cogeneration scheme.

3.1.5 Nuclear

According to the Australian Year Book Australian Bureau of Statistics (1983), Australia contains about 19% of the free world's resources of low-cost uranium. Western Australia's known reserves of uranium, while small in comparison to those of the Northern Territory, are nevertheless considerable, with over 70,000 tonnes of uranium oxide identified. The largest of the State's known uranium deposits occur at Yeelirrie, 450 km north of Kalgoorlie. Thorium is also found in Western Australia. This element can be transmuted to fissile uranium and used in the same manner in power generation.

Although Australia is already a significant uranium producer and has the potential for much greater production, there are no current plans for development of nuclear power stations in Australia. This is due mainly to the availability of abundant coal resources from which electricity can be more efficiently produced. Also, enriched uranium, the feedstock for nuclear power plants, is not produced in Australia. Current disadvantages of nuclear power generation include high capital cost, the long lead time required for planning and construction, and doubts concerning the integrity of long term disposal of highly radioactive spent fuel rods. Another important disadvantage of nuclear power plants is their large minimum economic size which currently makes them unsuitable for use in this State's relatively small power generation system.

The role of nuclear fuel for the production of electricity in Western Australia in the long term cannot at this time be predicted.

3.1.6 Renewable Energy Resources

There are many renewable sources of energy that can be converted to electricity, some well proven and others still in the early stages of development. SECWA has undertaken a variety of applied research into the use of renewable energy sources to supplement existing conventional generators. SECWA's Renewable Energy Branch deals with all aspects of possible renewable and alternative energy uses in it's systems. The following section discusses the results of research together with other renewable energy sources as yet unproven in Western Australia. Their application to base load power generation is the principal reference in the context of this document.

a. Tidal Energy

"Tidal energy is a dispersed energy source derived from regular fluctuations in the combined gravitational forces exerted by the moon and the sun, at any one point on the earth's surface, as the earth rotates" (NEAC Report No. 14, 1981).

The north west coast of Western Australia has an exceptional tidal range of around 11 m (normal maximum tidal ranges at Fremantle are approximately 1 m) and therefore has potential suitability for the application of well proven water driven turbine technology for power generation.

SECWA has made detailed assessments of the tidal energy potential of Secure Bay and Walcott Inlet as they have suitable topographical and tidal characteristics.

Research indicated that there is potential generating capacity of 570 MW and 1,250 MW at Secure Bay and Walcott Inlet, respectively. However, the distance between these locations and the power demand centre in the State's south west, and the extremely high cost of civil works associated with such projects, makes this potential alternative energy source economically unviable at present. In addition, the potential impact of a tidal power station development on the marine and estuarine ecology of the suitable sites is not known, and therefore extensive environmental studies would be necessary before this alternative could be proven acceptable.

b. Wind Energy

Whilst wind energy technology is relatively well developed, there are major constraints to its application to base load generation. These are principally related to the fluctuation of available winds and the consequent inability to continuously meet demand. For this reason, wind turbine installations would also require conventional generators as a back-up.

The largest wind turbines currently available are in the 1-2 MW range. The main application of this equipment is perceived as a supplement to the south west interconnecting system, or to a more remote regional supply system where conditions are suitable.

Although wind turbine technology is not sufficiently developed to provide large base load requirements, SECWA has already installed wind turbine generators at appropriate locations in the State. For example, six wind turbines have been erected at Salmon Point, Esperance. These are contributing a total of 360 kW to the local supply grid, which is approximately 3% of demand. Savings in Esperance Regional Power Station's use of heavy fuel oil are expected, after the initial capital costs of the turbines are offset.

Wind turbines are also currently operating at South Fremantle and are connected into the south west grid system for detailed analysis. Rottnest Island also has wind turbine power generation equipment.

c. Direct Solar Energy

Solar energy is similar to wind energy in that geographic, seasonal and diurnal fluctuations of sunlight intensity make transformation into constantly available electricity difficult and costly. For this reason, conventional back-up generators are usually required with solar based plants.

SECWA, together with the West German Government, conducted research based on a solar/diesel power plant constructed at Meekatharra in 1982. This hybrid plant was the largest of its type in the southern hemisphere. The solar/waste heat recovery section of the plant contributed up to 10% (100 kW) of the electricity produced. However, a number of technical and economic problems were encountered which require resolution before this type of system could be more widely utilized.

Photovoltaic cells, although expensive, offer the potential for a clean, reliable source of electricity, particularly as a substitute for diesel in remote areas. At present photovoltaic technology is costly and prohibits widespread use. Low voltage electricity is supplied by this method to microwave telecommunications towers as well as environmental monitoring equipment, such as SECWA's various meteorological stations.

In conclusion, solar energy has only minor potential to contribute to total electricity generated in the south west. Direct applications are presently limited to water heating and to remote areas where diesel generation is highly expensive. Application to base load electricity generation is not yet technically or economically viable.

d. Hydro Energy

The low rainfall and subdued relief of Western Australia, particularly the south west, limit the opportunity to develop hydroelectric power stations. There are limited opportunities in the northern areas of the State, however these have no possible economic role in the supply of base load power to the south west centres due largely to power losses and costs associated with transmission of power over long distances.

e. Wave Energy

There are few sites in Australia or Western Australia that have the necessary wave climate and proximity to a power demand centre to warrant the construction of a wave power plant.

One small scale application has been initiated at Esperance where SECWA intends to purchase electricity from an international company that has proposed construction of a 1 MW wave power plant. If the project proceeds it will be the largest of its kind in the world. In theory the wave power plant will reduce the quantity of heavy fuel oil consumed at Esperance Regional Power Station by 6.6%. The type of plant that is proposed is not sufficiently technically advanced to be considered for larger scale base load power production in the near future.

f. Geothermal Energy

Geothermal energy consists of heat trapped in the earth's crust. There are two basic types - hydrothermal and conductive. Hydrothermal resources (geysers, hot springs) are virtually non-existent in Australia but conductive resources are quite common. These are large underground reservoirs of warm/hot water which theoretically could be tapped and used to create steam to drive a turbine.

Although it has been estimated that Australia's geothermal energy resources could provide the equivalent of 1% of our fossil fuel consumption each year, the utilization of geothermal energy for base load power generation has yet to be proven technically, economically or environmentally feasible.

3.1.7 Environmental Comparison

It is difficult to compare the environmental effects of a wide range of disparate energy sources. Renewable sources of energy have obvious environmental appeal but are not economically suited to large scale base load generation for incorporation in the South West Interconnected System. On the other hand, the environmental effects of nuclear power generation are matters of widespread controversy, particularly in relation to the disposal of high level radioactive wastes and to the risks of serious accident.

For power generation based on fossil fuels (oil, gas and coal), the main environmental issues are air quality, effects of cooling water discharge, disposal of solid wastes and the effects of surface disturbance associated with extraction of the resource and its transportation to the power station.

Of these issues, the effects of cooling water discharge are normally independent of the fuel that is used.

Air quality is perhaps the major environmental concern associated with fossil fuel power stations, although it is not normally a problem with gas-fired plants as sulphur in the natural gas is readily separated and removed at the well-head. With oil and coal, the potential for degradation of air quality from sulphur dioxide emissions depends mainly on the sulphur content of the particular fuel, whereas oxides of nitrogen can be controlled by boiler design and operational efficiency.

In the northern hemisphere power generation has been identified as a contributor to "acid rain". The potential for "acid rain" to result from power generation in the south-west of Western Australia is negligible. Important factors include the very small emission quantities compared to industrialized parts of the northern hemisphere, and the very large areas over which emissions from power generators are dispersed.

The contribution to global "greenhouse gases" of carbon dioxide produced from the combustion of fossil fuels in electrical plant in Western Australia is extremely small. However this issue cannot be disregarded and is therefore addressed in Sections 7.0 and 9.0 of this report.

Oils with a wide range of sulphur contents are available. However, low sulphur oils attract premium prices. It is fortuitous that Australian oils and coals, including Collie coals, are relatively low in sulphur in comparison to many of the fuels marketed worldwide.

Combustion of coal produces much higher volumes of solid wastes (mainly fly-ash and bottom ash) than either oil or gas, and development of acceptable disposal systems for these solid wastes constitutes a significant environmental management issue.

In terms of the extraction of the fuel, both underground mining of coal and production of oil and gas from wells are generally comparable in the areas of land that are affected. Surface mining of coal, on the other hand, involves substantial disturbance over relatively large areas. There are also significant differences in environmental impacts, depending on the mining method employed. For example, strip mining enables the mined areas to be progressively rehabilitated, whereas open cut mining usually results in a permanent hole. Coal mines in the Collie Coal Basin operate under State Agreement Acts, which require implementation by the mining companies of approved Environmental Management Programmes, including programmes for rehabilitation of overburden dumps and other disturbed areas.

3.1.8 Conclusions

From the discussion of alternative fuels in Sections 3.1.1 to 3.1.6 the following factors are decisive in identifying coal utilization within a new power station as a viable option for providing the sustained base load capacity required for the south west of the State:

i) Renewable resources have the capacity to reduce the rate of growth in the use of fossil fuels, however due to their inherent characteristics they are unsuited to the supply of economic base load electricity.

ii) Uranium must be excluded as an alternative fuel for generation because of environmental factors, Government policy and cost.

iii) Oil is excluded as a fuel for base load generation because of cost and its superiority for other applications, e.g. transport.

iv) Although there is scope for additional open cycle gas turbines this type of plant is more suitable for meeting peak demand rather than base load demand.

v) SECWA has also examined the possible use of gas-fired combined cycle plant to provide base load electricity. To date, however, no gas supply company has been able to demonstrate to SECWA that sufficient reserves of gas are available, and are available at long term economical cost, for the lifetime of the station.

vi) Gas provides a valuable source of export income whilst local coal reserves are not of export quality due to their low specific energy content relative to other sources of coal.

vii) The major cost variable of running a power station is fuel. The cost of gas is likely to be more expensive than coal on a per unit energy basis. Gas is best used in peak demand gas turbines which contribute a relatively small amount to overall fuel costs for electricity generation compared to base load power stations.

Having established that coal is the preferred fuel, a comparative evaluation of Western Australia's various coal deposits was conducted. It was concluded that the coal deposits of the Collie Basin are best suited to meet forthcoming needs for the reasons outlined below.

(i) Collie coal has one of the highest specific energy contents of the Western Australian reserves (refer to Table 3.1).

(ii) It has the additional favourable characteristics of a non-combustible (ash) content that is mid-range and a sulphur content that is very low.

(iii) The Collie Basin contains sufficient proven shallow reserves to meet anticipated requirements.

(iv) The reserves are close to existing markets.

(v) The Collie region is served by a well-developed infrastructure associated with the only coal resource that has been developed in Western Australia.

3.2 Alternative Sites for a Coal-fired Power Station

3.2.1 Criteria for Site Selection

The principal criteria that were applied in the selection of the site for a new coal-fired power station were:

- proximity to a coal source or an economic system of transport;
- distance to the power demand area or to an existing transmission system;
- proximity to existing infrastructure;
- availability of cooling water of suitable quantity and quality;
- location relative to the existing township and the direction of prevailing winds;

- o availability of sufficient area to accommodate power station infrastructure and additional area to provide a noise buffer zone;
- o suitable fly-ash disposal area;
- o environmental constraints, for example, the stability or sensitivity of the surrounding ecosystem;
- o regional planning considerations;
- o SECWA's overall strategic planning for future power generation and supply.

These criteria were applied to four general areas of the State before investigating specific sites. The findings of the site selection process are outlined below.

3.2.2 General Areas Considered for the Power Station Site

The four general areas that were investigated as possible localities for the new power station were:

(i) a metropolitan coastal site;
(ii) coastal sites due west of the Collie Basin, e.g. Bunbury;
(iii) sites near the Hill River coal deposits;
(iv) areas adjacent to the Collie Coal Basin.

(i) A metropolitan coastal site would have the major advantages of being close to the load demand centre and having well developed support services as well as a labour force. However, suitably large metropolitan coastal sites are not readily available and have important competing land uses, e.g. residential, commercial, recreational. This renders the cost of the few sites available extremely high. There are also air quality issues which would limit the operation of a power station in the metropolitan area. These principally arise from the cumulative effects of concentrated industry and vehicle emissions. It is also doubtful whether construction of a power station in such a prime location would be publicly acceptable. There is also a significant cost penalty associated with transport of coal from Collie. Therefore, a metropolitan coastal site has not been further investigated.

(ii) Detailed investigations have been conducted at a SECWA property which lies adjacent to the existing Bunbury Power Station. This site has direct access to sea water for cooling purposes. A comprehensive programme of environmental investigation concluded there were no insurmountable environmental problems associated with this site. However, the engineering costs associated with maintaining environmental acceptability, combined with the significant cost penalty associated with transport of coal from Collie, have discounted this site. The visual impact resulting from the close proximity of the site to Bunbury's central business district and associated residential areas has also been recognized as an unfavourable factor.

(iii) In accordance with its charter to assess and develop the State's energy resources, SECWA conducted conceptual studies for a power station development in the Hill River area, north of Perth, during 1988. However in recognition of the commencement of private feasibility studies, in early 1989, SECWA decided to leave the evaluation of the Hill River Project entirely to the private interests concerned.

Those feasibility studies are presently being carried out by the Hill River Power Development Company Pty Ltd for a new power station and coal mine at Hill River. This project proposal will be submitted to Government as a contender to meet WA's requirement for new power generating capacity by the mid 1990s.

(iv) Areas adjacent to the Collie Basin have significant advantages over the alternative localities discussed above. Compared with the Bunbury location, a saving of up to 25% of the annual coal transport costs can be expected. The Collie township is readily capable of providing labour and services to the construction and operational phases of the power station.

Private, cleared land and areas of dieback infected State forest, of sufficient size for a power station, are available in the perimeter area of the Collie Coal Basin. All potential sites in this area are within a distance suitable for truck or conveyor belt transfer of coal from both existing and proposed mines.

Extensive studies of the local groundwater resources, commissioned by SECWA and supervised by the Water Authority, have concluded that there is sufficient water available for the new power station, on a sustainable yield basis.

The comparison of alternative localities for a coal-fired power station is summarized in Table 3.2. This comparison indicates that Collie is the most appropriate area for the utilization of Collie Coal. A new power station at Collie could operate with acceptable environmental impacts in relation to air quality, cooling water discharge and solid waste disposal.

3.2.3 Alternative Sites in the Collie Area

A number of areas located around the perimeter of the Collie Coal Basin were investigated as prospective power station sites. The criteria considered in this evaluation are listed below.

(i) Topography and geology, in particular the amount of earthworks required to prepare each site, and the availability of suitable sites for water storage and ash disposal.

(ii) Proximity to and accessibility from areas of shallow coal, amenable to extraction by open cut or strip mining methods.

(iii) Location of power station must not sterilize coal reserves or adjacent land necessary for overburden storage during mining.

(iv) Site area sufficient to ensure that the potential for future expansion of the station is not constrained by physical barriers (topography, rivers) or other land uses (mining, overburden dumps).

(v) Proximity to existing transmission facilities.

(vi) Existing and future land use of the site and adjacent properties.

(vii) Distance from residential communities and individual residences, particularly in relation to potential noise impacts.

(viii) The quality of forest subject to impact by the power station, in particular the presence or absence of high quality quarantined forest.

TABLE 3.2

COMPARISON OF ALTERNATIVE AREAS FOR THE NEW COAL FIRED POWER STATION

CRITERIA	HILL RIVER AREA	METROPOLITAN COASTAL AREA	BUNBURY AREA	COLLIE AREA
. proximity of coal supply	. within 10 km . suitable for truck transfer	. around 200 km . direct rail trans port link already exists	. around 50 km . direct rail trans- port link in existence	. within 10 km . suitable for truck or conveyor
. proximity to power demand area or trans- mission lines	. will require connection to proposed 330 kV transmission lines to be constructed from Perth	. close to existing power demand centres . upgrading of existing trans- mission lines necessary	. close to antici- pated demand centres . transmission lines in exist- ence but will require upgrading	. reasonably close to major sources . transmission lines existing but will require some upgrading
. infra- structure and labour	. limited in availability	. present	. present	. present
. availability of cooling water	. suitable quality . groundwater being evaluated but expected to be sufficient	. sea water	. sea water	. suitable quality and quantity of groundwater . mine dewatering water
. main environ- mental consider- ations	. saline water discharge to ocean . mining and power station in close proximity to flora and fauna reserves	. ash disposal sites limited . close residential areas-noise . air quality issues limit develop- ment in Kwinana	. heated water disposal effects on marine environment . proximity to residents, noise control	. saline water management in catchment area
. availability of suitable land	. sites of adequate area available	. land expensive . few large sites available on coast . strong compe- tition for alternative uses e.g. residential and recreational	. SECWA's property adjacent to Bunbury Power Station near . Bunbury Port . Limited ash disposal sites	. private, cleared or dieback infected land available with suitable ash disposal areas

(ix) Prevailing wind directions in relation to emissions from the Muja Power Station, and in relation to the transport of airborne emissions and propagation of noise from the new power station.

Figure 3.1 shows the four areas around the perimeter of the coal basin which were considered for siting of the power station. The advantages and disadvantages of each are summarized below:

<u>Area A (near Muja Power Station)</u>

Advantages:
- o Proximity to mineable coal resources.
- o Proximity to existing infrastructure including transmission lines, access roads and water supplies.
- o No private residences in close proximity.

Disadvantages:
- o Sites of adequate area all encroached either onto areas underlain by potentially mineable coal reserves or onto areas required for mine overburden disposal.
- o Close proximity to Muja Power Station and Muja Coal mine could result in some problems due to congestion and effects of particulate emissions.
- o Suitable ash disposal sites do not appear to be readily available.

<u>Area B (south of coal basin)</u>

Advantage:
- o Proximity to private residences can be avoided.

Disadvantages:
- o Distance from mineable near-surface coal resources.
- o Sites encroach on quarantined forest.

<u>Area C (east of coal basin)</u>

Advantage:
- o None apparent.

Disadvantages:
- o Distance from mineable near surface coal resources.
- o Close to private residences.

Area D (north of coal basin)

Advantages:
- o No private residences in close proximity.
- o Close proximity to 330 kV transmission lines.
- o Suitable topography.
- o Includes suitable areas for water storage and ash disposal.

Disadvantages:
- o Requires significant upgrading of access.
- o Proximity to Collie River East Branch.

The economics of coal transportation weighed heavily in favour of Areas A and D. Considerable effort was expended investigating Area A before it was concluded that a site of adequate dimensions could not be accommodated within this area, without significant traffic congestion and environmental problems.

Within Area D, several potential sites were identified and the preferred site was selected after drilling to delineate the northern margin of mineable coal and after a geotechnical appraisal which indicated the presence of suitable sites for ash disposal.

The specific sites considered, and detailed considerations applying to individual sites, remain confidential, as other studies have identified other suitable sites which may be developed in the future, and SECWA does not wish to engender speculation in relation to any such sites.

An area between the Collie River East Branch and the northern margin of the Collie Coal Basin, 8 km east-north-east of Collie, was selected as the preferred site. The plan for layout and placement of infrastructure related to power station operations may be subject to modification depending on the eventual proximity of possible future coal mining operations.

3.3 No Action Alternative

SECWA could follow one of three alternative options instead of proceeding with the construction of the Collie Power Station. These are:

- o not to build new base load plant;

- o to develop an alternative coal-fired power station;
- o to build new base load plant which uses an alternative fuel.

(i) As SECWA's power generation planning incorporates minimum acceptable levels of reserve plant capacity, growth in demand would lead to reduced system reliability if no new plant were built. This would have the following undesirable effects:

- o The south-west interconnected grid would become increasingly less reliable as existing power generation facilities failed to match the growing load demand.

- o SECWA would be increasingly forced to ration or cut power supplies. This would have major social costs through loss of commercial and industrial output, disruption of social activity and general inconvenience.

- o New industry would not be attracted to the State and existing industry may relocate elsewhere. Therefore none of the direct and indirect employment benefits would be experienced.

(ii) An alternative to Collie coal exists near Jurien Bay. The Hill River Power Development Company Pty Ltd has proposed the establishment of a mine and power station to utilize this resource. That proposal is the subject of a separate ERMP.

(iii) If a new coal-fired base load plant were not built, demand from growth could be met by installing additional gas turbine plant to that already planned. The major disadvantage of this option is that gas turbines can only use gas or liquid fuels and at present, suppliers are unable to guarantee SECWA long term economic supplies of gas in the quantities which would be required. SECWA is already planning to increase gas turbine capacity to around 600-700 MW. Any commitment to further increase this without guaranteed supplies of economically priced gas would expose SECWA to risk of greatly increased fuel cost either for oil or for new supplies of gas. These costs would have to be passed on to consumers by way of tariff increases.

4.0 DESCRIPTION OF PROJECT

Important aspects of the proposed Collie Power Station are described below to enable subsequent evaluation of environmental impacts. A detailed description of project engineering and infrastructure is not provided as this information is not strictly relevant to the purpose of this section, which is to establish the basis of interaction between the power station and the environment.

The new station will be similar in most respects to the base load power stations that are presently operated by SECWA at Muja, Bunbury and Kwinana.

4.1 Outline

A conceptual diagram of the power station is provided in Figure 4.1. This depicts the flows of materials and energy that are involved in the production of electricity from coal, and highlights those aspects of the project which require environmental assessment, viz:

- o site clearing and earthworks;
- o groundwater abstraction;
- o ash disposal;
- o wastewater management, and
- o combustion gas emissions.

Before describing these aspects of the project in more detail, an overview of the principal plant components, facilities and layout is given below, followed by a basic operational description.

4.1.1 Summary of Principal Facilities

The Collie Power Station will include the facilities outlined below.

(i) Coal Handling: Coal stockpiles will be established on-site to cater for periods of shutdown in the mines and variations in delivery rates.

(ii) Water Supply: The water supply system will utilise groundwater from mine dewatering bores, supplemented by groundwater from a new power station borefield located within the Collie Coal Basin. A water storage dam will be constructed to allow storage of the mine water and the new borefield groundwater. A pond for intermediate quality water will also be constructed to enable storage of process wastewater prior to re-use or disposal.

(iii) Power Generation: Two generating units each of 300 MW capacity will be installed. The steam-driven turbo-generators, together with associated water and steam circulation systems, will be housed in a common turbine hall. Each unit will also have its own boiler for steam generation, which will be a separate partially enclosed structure. Additional facilities including air heating systems, feedwater heating and pumping systems, and ash extraction systems, will be installed for each generating unit.

Two stockpiles will be maintained. There will be a reserve stockpile which will store delivered coal. At this stage it is not known whether the coal will be crushed prior to delivery to the station. The transport of crushed coal to the plantsite is the responsibility of the mining company who will seek environmental clearance for this practice. If not, crushing facilities will be provided on-site.

The second coal storage area will be a "live" (operational) stockpile of crushed coal, which will be immediately reclaimable to provide feed material to the coal bunkers near to the boilers.

Water spraying facilities to control dust will be provided at the on-site crushing facility, stockpiles and at each coal transfer point. Stockpiles will have a base of compacted clay of low permeability. Interceptor drains will be constructed to collect runoff from all coal receival, storage and handling areas and directed to the coalyard runoff pond, where particles are settled out before the water is re-used within the power station.

(iv) Combustion Gases: The combustion gases from each boiler will be passed through electrostatic precipitators and then vented to atmosphere via a single reinforced concrete chimney stack.

(v) Ash Handling: Fly-ash from the precipitators will be collected in silos from where it will be either (i) pumped to the fly-ash site for permanent disposal or (ii) transported in dry (moisture conditioned) form to a landfill site. Bottom ash from the boilers will be transferred and combined with fly-ash for disposal.

(vi) Cooling System: A re-circulating evaporative cooling water system has been selected because of its lower water requirement in comparison to a "once-through" system. Cooling will be achieved in two evaporative cooling towers which will reduce the water temperature to about 25^{o}C. These towers will be dominant features at the site.

(vii) Power Transmission: Transmission facilities will include step-up transformers, a new on-site switchyard and substation and 330 kV transmission lines totalling approximately 3 km in length. Transmission works to integrate the new power station within the south west supply grid have already been assessed and approved by the EPA (SECWA, 1985, 1988).

(viii) Ancillary Facilities: Other facilities at the power station site will include workshops, stores, offices, drainage systems, roads, car parks, oil storage and fire protection services.

4.1.2 Power Station Layout

The layout of plant items, coal handling areas, water impoundments and the ash disposal area is shown on Figure 4.2. The land encompassed by the security fence has an area of approximately 388 ha. It is relevant to note that the substation will be located on-site and in close proximity to the power station. The placement of power station facilities may be subject to relocation within the site depending on the eventual proximity of possible future coal mining operations.

4.1.3 Summary of Station Operation

The operational aspects of the power station are depicted schematically on Figure 4.3 and summarized below.

Coal will be conveyed from stockpile to the coal bunkers at a maximum rate of approximately 250 t/h, if both turbo-generators are utilized to capacity.

Assuming a 70% capacity factor, approximately 1.5 to 1.9 million tonnes of coal will be consumed at the station each year.

During operation, coal from each bunker is pulverized in a mill, comprising rotating steel rolls, prior to delivery to the boilers in a stream of heated air. Firing is initiated with fuel oil, therefore an oil storage facility will be required to provide fuel for re-starting the units after shutdown.

To produce electricity, the pulverized coal is burned in the boiler furnace, which heats water circulating through steel tubes within the boiler. The high pressure steam that is produced is piped to the turbine hall to drive the turbo-generators to produce electric power. Low pressure steam exhausted from the turbines is cooled in a condenser and pumped back to the boiler as water, for conversion once again to steam. (Cooling water circulating through the condenser is cooled by evaporative cooling as previously described.)

Products from combustion within the boiler (mainly carbon dioxide and water vapours, but including oxides of sulphur and nitrogen) will be discharged through electrostatic precipitators where the residual noncombustible constituents of coal (fly-ash) will be removed, and the remaining exhaust gases released to the atmosphere through the chimney stack.

4.2 Construction and Scheduling

From an environmental viewpoint, the important aspects of the construction phase are the degree of site disturbance and the consequent impacts of this disturbance on the peripheral environment. The major site earthworks are outlined below and the likely project schedule is given.

4.2.1 Site Preparation

As a large proportion of the site is already cleared for pastoral purposes, clearing of site vegetation will be confined to the southern end of the site, i.e. the areas nominated for coal receival and storage.

Substantial earthworks will be conducted to prepare the site for the construction of plant. Principal features of the proposed site earthworks are listed below.

- o Earthworks will involve conventional "cut-and-fill" operations.
- o Excavation and transfer of approximately 1.4 million cubic metres of material will be required to level the site.
- o Water retention and ash storage embankments are estimated to involve excavation and placement of an additional 0.5 million cubic metres of material.

4.2.2 Project Schedule

It is anticipated that site preparation as described above will proceed during the first 12 months of the civil works phase.

Erection of major equipment items will commence following the completion of earthworks and installation of concrete foundations. Items such as boilers, turbines and pulverizers will be fabricated elsewhere and will need to be ordered approximately 18 months prior to the time they are required on-site. Once on site, the erection of this equipment is estimated to require a period of 36 months.

Following installation, the equipment will undergo testing and production trials. This commissioning period is expected to occupy the last 12 months prior to commercial service.

The construction sequence for major plant components and the anticipated schedule are illustrated on Figure 4.4. Overall, the period between commencement of earthworks and commissioning of the first unit will be 60 months, with a further 12 months before the second unit is commissioned.

4.3 Water Supply

4.3.1 Water Requirements

The annual average water requirement is expected to be approximately 25,000 m^3/day. Water demand will peak during the hotter months, especially if the units are operating at full load. Replacement of evaporative water losses from the cooling water system is the primary requirement of make-up water to the station.

Make-up water must be of good quality, with total dissolved solids concentration (TDS) less than 1,000 mg/L and, preferably, less than 600 mg/L.

These requirements mean that existing surface water supplies in the area are unsuitable as make-up for the station. For example, the Collie River has constraints with respect to available volume and TDS. Water from Wellington Dam is unsuited because it has a TDS range up to 1,100 mg/L and has other priority uses.

4.3.2 Proposed Water Sources

The lack of a suitable surface water supply means that the primary water source will be groundwater from nearby aquifers in the Collie Coal Basin. Two sources will be developed for the project, as follows:

- water produced by dewatering coal mines;
- groundwater abstracted from a new borefield.

In addition, site runoff that will be collected in on-site dams will be utilized for power station processes. These three water sources are described below.

(i) Mine Dewatering:

Recovery of groundwater from mining areas is an obligatory aspect of coal mining in the Collie Basin. It is the coal companies that have the responsibility to find an acceptable means of disposal of the water, which would otherwise flood the working faces within the mine.

Feasibility studies by the coal companies have shown that the mine water is generally suitable for power station use. Therefore, as a conservation measure, SECWA has adopted the policy of maximizing the utilization of water supplied by the coal mines as far as is possible in respect of chemical quality.

(ii) New Borefield:

SECWA proposes to develop a new borefield that is independent of mine dewatering operations. This will guarantee a water supply to the station in the event that mine supplies are interrupted. Experience with the borefield for the Muja Power Station and complementary groundwater investigations, confirm that adequate resources of low salinity groundwater are available in the Collie Basin. There are currently no other users of this deep borefield.

Consequently, it is proposed to establish a new borefield at a location some 8 to 12 km south of the power station. The borefield will extend over a total of approximately 100 ha, with a probable layout as shown on Figure 4.5. Individual bores are expected to be able to produce 2,000 to 2,200 m^3/day. Important features of the proposed borefield are listed below.

- o Approximately sixteen bores will be installed, up to 400 m in depth and abstracting water from depths greater than 150 m below surface.
- o Combined easements for powerlines, pipelines and access tracks will be 22 m wide.
- o Total easement length, at the borefield and to the power station, will be about 30 km.
- o Where possible, the pipelines will follow existing transmission line easements, to reduce the length of new easements.

(iii) Site Runoff:

In general, runoff from roofs and paved areas is expected to have adequate quality for use in the cooling water system. The drainage system will be designed to direct good quality runoff to the water supply storage pond, where suspended material will be allowed to settle.

4.3.3 Water Quality and Storage Considerations

Typical analyses of mine water and groundwater are shown in Table 4.1. The expected quality of clean site runoff is speculative at this stage, but should be superior to both mine water and groundwater with respect to many of the parameters listed in the table.

TABLE 4.1

EXPECTED COMPOSITION OF POWER STATION WATER SUPPLIES
(before treatment)

Parameter	New Borefield	Mine Water
pH	5.2-5.7	3.0-8.0
Conductivity (μS/cm)	400-600	250-1,700*
Total Dissolved Solids (mg/L)	400-600	120-860*
Ca (mg/L)	3	2-65
Mg (mg/L)	15	1-52
Na (mg/L)	70	31-235*
K (mg/L)	10	1-30
Fe (mg/L)	1.5	0.05-10
HCO_3(mg/L)	15	0-132
Cl (mg/L)	150	36-476*
SO_4 (mg/L)	7	0-395
SiO_2 (mg/L)	15	1-26*
CO_2 (mg/L)	100	Not Available
H_2S (mg/L)	3	Not Available

* Upper limit values are from samples obtained from water in mine pits. Concentrations from dewatering bores are expected to be closer to lower limit.

Two main on-site dams are proposed for storage of the station's process water supplies. These are described below and illustrated on the diagram of Power Station layout (refer back to Figure 4.2).

- o Water Storage Pond: This will be the receival and storage point for good quality water that is supplied to the power station from the mine dewatering and/or the borefield. The TDS of this water is expected to be in the range 200-400 mg/L. Good quality runoff from station buildings and grounds will also be directed to the water storage pond following removal of oil and grease, and suspended solids by mechanical means. The capacity of this storage will be 250 megalitres, sufficient for 10 days' supply for the power station.

- o Intermediate Quality Pond: This pond will receive blowdown from the cooling towers and wastes from the sidestream filter. The TDS of this water is expected to be in the range 2000-4000 mg/L. The storage capacity will be approximately 110 megalitres. A portion of water from this pond will be used for fly-ash conditioning whilst the remainder will be either treated within the brine concentrator for re-use, or filtered for disposal.

It is intended that these two storages will enable the day-to-day supply of process water to be optimized in response to fluctuations in availability and quality of the various water sources.

Runoff from the coalyard area will be collected in a small pond where suspended material will be allowed to settle and the water re-used or piped for disposal.

4.3.4 Treatment of Process Waters

The water supplies from both mine dewatering and the new borefield will require treatment before use in the power station. Preliminary treatment will occur as the water is pumped to the on-site storages. The water will pass through standard de-gassing towers to facilitate the release of dissolved gases (carbon dioxide and hydrogen sulphide), which also acts to raise the pH and precipitate some dissolved iron.

Additional water treatment will need to be conducted on-site. The level of treatment will vary for specialized uses, the three main uses being cooling water, boiler make-up and potable water.

In broad terms, the additional treatment will be as follows:

- o aeration, coagulation and filtration to remove precipitated iron;
- o neutralization with caustic soda;
- o standard chlorination of the potable supply;
- o specific dose chlorination of cooling water to preclude algal growth in the cooling system;

- purification of boiler make-up in a demineralization plant; and
- removal of dissolved oxygen from boiler make-up using small amounts of hydrazine.

The form, means of delivery and storage of chemicals used for water treatment are listed in Table 4.2. Both caustic soda and sulphuric acid will be used for regeneration of resins in the demineralization plant. (The fate of wastewaters from water treatment processes is addressed in the following section.)

4.4 Wastewater Management

In Section 4.3 the process water make-up requirements are estimated to be approximately 25,000 m^3/day. The requirement for make-up water arises from evaporative loss from the cooling water system, and loss of process water that is stored as moisture content in fly-ash that has been transferred to disposal. This section describes the various sources of wastewater, how it will be stored, the manner in which some will be recycled and, finally, the disposal methodology for excess wastewater.

TABLE 4.2

USAGE OF CHEMICALS FOR WATER TREATMENT

Chemical	Delivery/ Consumption	Storage	Annual Consumption
Caustic soda	By 25 tonne road tankers	35 m^3 steel tanks	250 t
Sulphuric acid	By 25 tonne road tankers	35 m^3 steel tanks	150 t
Chlorine	Produced on site by electrolysis of brine	Produced and used simultaneously - no storage	30t
Hydrazine	By road transport in 200 L drums	In 200 L drums	1,200 l

A schematic diagram of the water management proposals is given as Figure 4.6. Whilst this diagram appears to be quite complex, it should be noted that the various wastewaters are well contained and that there will essentially be only a single wastewater stream that requires consideration in respect of treatment and/or disposal methodology. Further details are provided in the sections below.

4.4.1 Wastewater Generation

Wastewaters will be generated from various stages of the process water system. The major waste stream will be blowdown from the cooling towers. Up to approximately 4,000 m^3/day will be discharged from the cooling water system to prevent the excessive build-up of salts caused by evaporative concentration. Smaller quantities of wastewater will be generated throughout the plant, including:

- o backwash from filters;
- o regenerants and rinse water from the demineralization plant;
- o waste stream from the water purification plant; and
- o boiler blowdown.

Figure 4.6 shows that the water management system incorporates maximum re-use of wastewater from sources such as those above. However, the excess wastewater that is unsuitable for re-use has required appropriate treatment and disposal facilities to be included in the power station's water management facilities.

4.4.2 Treatment and Disposal of Wastewater

SECWA recognizes that the power station operations must consider the need to minimize the discharge of water containing dissolved salts to the Wellington Dam catchment in accordance with the Water Authority strategy for the area.

Several alternative methods of wastewater treatment have been investigated and assessed by SECWA and specialist wastewater treatment consultants in order to identify the most suitable method. Investigations have identified two potentially suitable methods for saline wastewater disposal. These are discussed as follows:

(i) Wastewater Treatment (Sidestream Softener/Brine Concentrator)

This approach is based on the inclusion of a sidestream softener plant in the cooling water circuit to reduce the concentration of silica by treatment with lime and magnesium hydroxide allowing the circuit to operate with comparatively low blowdown water production.

Cooling circuit blowdown is directed to a brine concentrator which utilizes an evaporation process to achieve concentration by a factor of 50-80 fold and thus greatly reduces the volume of water that must be stored.

The high quality condensate from the brine concentrator will be chemically adjusted for re-use by the addition of sulphuric acid, calcium chloride and sodium sulphate before direct re-use in the cooling circuit or as boiler make-up following further treatment in the demineralization plant.

The highly saline condensate will be discharged to a suitably lined evaporation pond of approximately 1.3 hectares for permanent storage of accumulated salts. When the power station is retired the pond will be evaporated to dryness. At this stage offsite disposal of dried salt to salt lakes or other suitable sites will be assessed. Otherwise the pond will be sealed with an impervious cover and rehabilitated by the placement of a layer of topsoil and the establishment of appropriate vegetation.

(ii) Ocean Discharge Pipeline

In this approach, wastes from the sidestream filter, cooling tower blowdown and demineralization plant are diverted to an intermediate quality pond with sufficient capacity for storage of one week's wastewater generation. Water from the intermediate quality pond is treated by multi-bed filtration to remove oil, grease, polymerized silica and other suspended materials before transfer by pipeline to a suitable ocean discharge site. The discharge water would be clear, have TDS in the range 2,500-3,500 mg/L, and low nutrient concentration, and would not contain toxic contaminants. Discharge water would readily meet water quality criteria appropriate to near shore marine waters.

The pipeline would range in diameter from 300-450 mm and would incorporate seven pumping stations en-route to the coast.

Regardless of the wastewater management process that is selected, operations will not require local discharge of water exceeding the limits imposed by the Water Authority of Western Australia. Issues which will be resolved before the most suitable treatment option is selected include:

- o The environmental acceptability and suitability of discharge through a pipeline to the ocean near Bunbury.

- o The environmental acceptability of seepage protection systems for on-site wastewater ponds.

- o The effects of combining Muja and Collie Power Station wastewater management systems.

- o The effects of combined power station and coal mine water management for the Collie Basin.

4.5 Ash Disposal System

Disposal of the large quantities of fly-ash that will be produced at the power station is a technically challenging task due to the range of economic, logistic and environmental constraints which must be overcome. A summary of aspects which have been considered in determining the optimum disposal system is provided below.

4.5.1 Quantities of Solid Waste

The main types of solid waste to be produced are described below along with their rates of production.

(i) Fly-ash: Mostly consists of amorphous alumino-silicate particles in the size range 2-50 μm in diameter. Annual production will be about 104,000 to 212,000 tonnes.

(ii) Bottom Ash: Aggregates of ash which are similar to a sandy gravel in texture. Annual production is expected to be about 25,000 to 35,000 tonnes.

(iii) Mill Rejects: Comprising pyrite nodules, coal and shale fragments of approximately gravel size. Annual production will be about 20,000 tonnes.

4.5.2 Selection of a Disposal Method

As fly-ash comprises approximately 80-85% of the solid waste produced, the characteristics of this material largely dictate the solid waste disposal method. Planning for the project considered four broad options for the disposal of fly-ash, namely:

- o for use as pozzolanic cement additive or as an additive in the manufacture of clay bricks;
- o disposal by landfill in low density slurry form into bunded impoundments;
- o slurry disposal by landfill in high density slurry form into bunded impoundments; and
- o disposal of dry (or moisture conditioned) ash to a landfill system or combined with overburden from coal mining.

The comparative advantages and disadvantages of these alternative disposal systems are summarized in Table 4.3. The perceived low demand for byproduct ash indicates that disposal will necessarily be the preferred management approach.

4.5.3 Selection of a Disposal Site

From an operational perspective, it is preferable to locate the disposal site close to the power station. However both off-site and on-site locations have been considered during the feasibility studies.

A major factor influencing the choice of site is that it should have a foundation with low permeability to reduce the potential for leachate generation which would arise through seepage of water that has been in contact with the ash.

The approximate chemical analysis of ash pond water is shown in Table 7.4. Infiltration, i.e. loss of slurry water from the fly-ash pond, has the potential

TABLE 4.3

COMPARISON OF FLY-ASH DISPOSAL ALTERNATIVES

Alternative	Advantages	Disadvantages
Low Density Slurry Disposal	o Optimizes potential for future recovery of ash. o Facilitates dust control. o Relatively low degree of supervision and management required.	o Requirement for large area o With a single pond system rehabilitation must wait for pond to fill and dry. o Potential for groundwater contamination (depending on pond design and site conditions).
High Density Slurry Disposal	o As above. o Lower water usage. o Lower land requirement. o Reduced leachate potential. o Improved rehabilitation characteristics.	o With a single pond system rehabilitation must wait for pond to fill and dry. o Potential for groundwater contamination, but having lower contamination risk than low density slurry disposal.
Sale for Pozzolanic Cement or Brick Manufacture	o Beneficial use of valuable resource, otherwise wasted. o No impacts on terrestrial or aquatic ecosystems or land uses.	o Large contained storage. o Markets are smaller than ash production and can be serviced by stations closer to markets.
Dry Disposal on land	o Optimizes potential for future recovery of ash. o Can be progressively rehabilitated. o Ash can be compacted during placement thereby minimizing storage areas required. o No water supply requirement except for surface dust control.	o Potential for severe dust generation prior to rehabilitation. o High degree of management required. o Potential for groundwater contamination (but lower than for slurry disposal). o Difficult to transport to landfill site.

to lead to groundwater contamination. Prevention of seepage of ash pond water and thus the risk of groundwater contamination, will be minimised by the methods outlined in Section 7.2.3.

Investigations of geology and soil conditions in the area surrounding the proposed power station indicated three potential ash disposal sites. These are:

- a valley within the power station site;
- a relatively flat off-site area; and
- an off-site valley (3.5 km east-northeast).

The valley sites were preferred on the basis of low permeability, particularly in the lower levels of the valleys where kaolinite and vermiculite clays are present. Whilst the two valley sites could not be distinguished on environmental criteria, there was a clear preference for the on-site location in terms of construction and operational costs.

The valley selected as being potentially suitable is located immediately to the west of the proposed power station buildings, and has sufficient capacity to store all fly-ash and bottom ash for the life of the station depending on the disposal method that is selected.

4.5.4 Ash Disposal Operations

SECWA and its consultants have devoted considerable effort to deriving the optimum ash disposal strategy, based on both local experience at the Muja Power Station and the performance of relatively new strategies adopted in the eastern states. Given that disposal may be by the slurry method, investigations have focussed on water management aspects of the slurry system. This recognizes that water becomes contaminated when used as slurry water and that there is likely to be excess water in the system which will subsequently require disposal.

In low density systems, fly-ash is mixed with water to create a slurry of 70% water/30% ash which can be readily transferred to disposal by pipeline. Conventional low density slurry disposal presently used at the Muja Power Station has demonstrated the requirement for an extensive land area to accommodate the disposal ponds.

High density slurry disposal which involves a slurry of 30% water/70% ash has advantages over the low density slurry disposal, principally the reduced water requirement for ashing and reduced land requirements. Depending on the wastewater management process that is selected, saline discharge waters could be utilized as the slurry motive water. High density slurry disposal also has the following comparative advantages:

- o the fly-ash can be stacked with an angle of repose of approximately 5°, which means that the amount of land area required for storage is greatly reduced;

- o the ash dries rapidly to form a stable, non-dusting deposit with little or no free ash water at the base of the heap;

- o the ash heaps may be more readily contoured and capped with clay to assist the shedding of rainfall, thus further reducing the potential for leachate generation; and

- o rehabilitation of the ash heap is easier because of the reduced moisture content and contouring ability of the ash.

High density slurry is already in use at a number of mines in Australia for tailings. In Queensland fly-ash disposal by dense phase slurry is under pilot-scale evaluation. Bulk samples of fly-ash have been despatched by SECWA to Queensland for testing. Scale-up of dense phase slurry disposal for local application will be trialed when the results of pilot-scale trials have been assessed.

Dry ash disposal to landfill has the advantage over slurry disposal of minimal water requirement. The only water routinely required is for dust control and moisture conditioning of the ash. Ash disposed of under dry conditions can be compacted following deposition and can be progressively rehabilitated so that storage areas can be minimized and leachate production can be controlled. This approach does suffer the disadvantages of transport difficulties, high dust nuisance potential and high management requirement.

Further issues which will be resolved before a final option is selected include:

- o The environmental acceptability of seepage protection systems including recompacted clay blankets, slurry wall cut-offs and high density polyethylene membranes for on-site ash disposal areas.

- o The effects of power station ash disposal systems on the Collie Basin.

4.6 Atmospheric Emissions

4.6.1 Types of Emissions

Most emissions to the atmosphere will occur as a result of burning coal in the boilers. These will comprise both gaseous and particulate emissions, which are identified below. In addition, there is potential for dust generation during the initial site preparation phase and there may be minor emissions of coal dust from the coal handling operations and stockpiles.

(i) Gaseous Emissions

Combustion of coal will produce the following gases that are of significance to air quality.

- o oxides of nitrogen (NO_x)

- o sulphur dioxide (SO_2)

- o carbon dioxide (CO_2).

NO_X production is dependent on such factors as boiler design and operational efficiency. The quantities of SO_2 generated by coal combustion are more dependent on the sulphur content of the coal. Fortunately, Collie coal has extremely low sulphur content (0.2% to 0.8% by weight), especially in comparison to coal routinely used for power generation overseas (1.0-3.0% by weight). For this reason, together with the very small magnitude of the total emission quantity and the large area over which the emissions are dispersed, the operation of the power station has negligible associated risk of creating acid rain.

A more detailed discussion of air emissions from the power station can be located in Appendix A (Air Quality Assessment) of this document.

Combustion of coal will also produce carbon dioxide gas which is a greenhouse gas. The burning of Collie coal at the new power station will emit up to approximately 3.2 million tonnes of CO_2 annually based on expected annual average consumption of 1.7 million tonnes of coal. It is necessary to place this contribution to the increase in greenhouse gases into a global and Australia-wide context.

On a worldwide basis, CO_2 emissions contribute approximately 50% to the potential global warming increment as the table below relates.

The worldwide power generation industry contributes approximately 18% of total CO_2 emissions and accounts for approximately 9% of the global warming increment.

The power generation industry in Australia emits approximately 0.4% of total worldwide CO_2 emissions, which equates to a 0.2% contribution to total global warming increase.

The role of Western Australia's power generation industry in CO_2 emission is very small. The emissions of CO_2 from local power generation equate to 0.02% of the worldwide total greenhouse gas emissions and could contribute 0.01% to total global warming.

In this context, the new power station will contribute less than 0.01% to present worldwide CO_2 emissions and less than 0.005% to increased global warming.

Although this trend is small it does represent an increase in CO_2 emissions that will need to be addressed by environmental management planning. Management programmes that will mitigate this additional contribution are discussed in Sections 7.0 and 9.0.

Table 4.4 indicates that the gas nitrous oxide (N_2O) is also a greenhouse gas. For reasons of scientific convention in nomenclature, nitrous oxide is not included within the measurement term "nitrogen oxides" (NO_x). Whilst combustion gas emissions from coal-fired plant contain measurable quantities of NO_x they contain only negligible quantities of nitrous oxide so that their contribution to greenhouse gases in terms of nitrous oxide is also negligible.

TABLE 4.4

SOURCE OF GREENHOUSE GASES

Contribution to Incremental Warming			Source of Man-Made Emission
CO_2	50% ± 5%	-	15% deforestation and land clearing
		-	14% petroleum
		-	10% coal - 8% from power generation
		-	2% steelmaking, industrial and domestic uses
		-	5% natural gas
		-	6% other fuels and processes
CH_4	15% ± 5%	-	from agriculture, cattle, natural gas and biomass fuel
CFC	13% ± 3%	-	from aerosols, air conditioners, refrigerators, plastics
O_3	10% ± 5%	-	from motor vehicles
N_2O	9% ± 2%	-	from fertilizers, vehicles, biomass and fuel burning
Others	3%		

Source: New South Wales Coal Association (1989)

TABLE 4.5

EMISSIONS OF CO_2 AND CONTRIBUTIONS TO POTENTIAL GLOBAL WARMING

Source	CO_2 Emissions Gt/annum	Proportion of Total Emission (%)	Contribution to Global Warming Increment (%)
Total Worldwide	28.3 (1)	100	50
Worldwide Power Industry	4.9	18	9
Australia	0.4 (2)	1.3	0.7
Australian Power Industry	0.1 (2)	0.4	0.2
Western Australia	0.03 (2)	0.1	0.06
WA Power Industry (SECWA)	0.006 (2)	0.02	0.01

Notes: (1) 19.1 Gt per annum CO_2 from burning of fossil fuel and 9.2 Gt per annum CO_2 from deforestation and land use. Sources; Instit. Eng. Aust. (1989); Keepin and Kats (1988).

(2) Australian emissions sourced from Electricity Supply Association of Australia (ESAA) survey in 1986/87. Contributions from land use and deforestation included as proportional to global values.

(ii) Particulate Emissions

The main particulate emission will be in the form of minute particles of fly-ash, the incombustible component of coal. There is a residue of approximately 85 kg of fly-ash for each tonne (1000 kg) of coal burnt in the boilers. Whilst most of this material will be recovered by electrostatic precipitators, a very small proportion (0.5%) will escape recovery and will be discharged to atmosphere.

In addition, minor quantities of carbon particles will be intermittently produced when the boilers are restarted by oil firing.

4.6.2 Projected Rates of Emission

The projected maximum gaseous and particulate emissions are listed in Table 4.6. The mass flow rates given correspond to the emission rates used in the air quality modelling studies for this proposal. These figures are overestimates as the power station will operate at 70% capacity factor compared to 100% as assumed by the tabulated data. The higher station generating capacity and higher load factors were assumed in the modelling work to enable a safety factor to be included.

Where applicable, corresponding values of flue gas concentrations are also given in Table 4.6, for comparison to the current National Health and Medical Research Council (NHMRC) guidelines. The flue gas (i.e. in-stack) concentrations are obviously within the NHMRC guidelines.

TABLE 4.6

PROJECTED MAXIMUM GASEOUS AND PARTICULATE EMISSIONS FOR COLLIE POWER STATION

Constituent	Mass Flow (g/sec)	Flue Gas Concentration (g/m^3)	1985 NHMRC Guidelines for New Plant (g/m^3)
Nitrogen Oxides	<422	<0.7	0.8
Sulphur dioxide	976	-	N/A
Particulates	20	<0.08	0.08

Notes:

(1) The above figures are based on a 600 MW station at full load and assume a coal sulphur content of 0.7%.

(2) All flow rates and concentrations are given at $0^{o}C$ and standard pressure.

(3) Nitrogen oxides are expressed as NO_2 at a 15% oxygen reference level.

(4) Particulate flows are expressed at the 12% CO_2 reference level and assume that the electrostatic precipitator has an efficiency of about 99.5% (up to 99.9% is achieved at other SECWA coal-fired power stations).

(5) There is no NHMRC guideline for SO_2 flue gas concentrations for power stations.

These emission rates will be achieved through introduction of the following control measures:

- o application of rigorous specifications to boiler design to limit nitrogen oxide emissions to 0.5 g/m^3;

- o installation of electrostatic precipitators which will collect in excess of 99.5% of the fly-ash and hence reduce particulate emissions to satisfactory levels.

The gaseous emissions from the power station will be discharged to atmosphere through a single high stack of suitable height. Atmospheric dispersion will dilute the emissions so that the concentration of contaminants at ground level in the surrounding environment will meet appropriate NHMRC standards.

4.7 Workforce

The workforce involved in construction of the power station will vary in number as construction proceeds, as shown in Figure 4.7 and Table 4.7.

The maximum workforce of approximately 820 is expected late in the sixth year, when erection of most of the major plant items will be underway. The anticipated division of the peak construction workforce into various labour categories, based on past power station construction projects, is shown in Table 4.7.

Earthworks and site preparation will commence within one year of project approval, following detailed design. Construction workforce numbers will steadily increase over the following four years, as shown in figure 4.7, until commissioning of the first unit, in the fifth year. Immediately prior to commissioning of the first unit, the peak construction workforce is estimated to be 820 persons. Based on previous power station construction projects the composition of the peak construction workforce, in terms of labour categories is shown in Table 4.7.

The gradual decline of construction workforce numbers, following commissioning of the first unit, will coincide with an increase in the size of the operations workforce that will be required to operate the power station. This change in the composition of the workforce will also occur following commissioning of the second unit, when the peak operations workforce is expected to reach a minimum of 150 persons. The expected composition of the operations workforce in terms of labour categories is shown in Table 4.7.

TABLE 4.7

WORKFORCE - LABOUR CATEGORIES

Labour Category	No. of Workers Total
Construction	
Professionals, Semi-Professionals, Technicians and Clerical	125
Skilled Tradesmen	403
Semi-Skilled and Unskilled Workers	292
CONSTRUCTION TOTAL	820
Operations	
Salaried employees	55
Wage staff	79
Non-established service staff	17
OPERATIONS TOTAL	151

4.8 Decommissioning

The initial two units of the new Collie Power Station are expected to operate for 30-40 years from about 1995. This is the usual life expectancy for a coal-fired power station. Once decommissioned, the power station will be used for public purposes which have yet to be determined. Rehabilitation of the fly-ash impoundment will be a prerequisite to future use of the area.

5.0 THE EXISTING BIOPHYSICAL ENVIRONMENT

5.1 General

The project area is located within the Darling Plateau, a physiographic unit consisting of extensive dissected uplands. Geologically, the Darling Plateau consists mainly of ancient crystalline and metamorphic rocks. Several small sedimentary basins, including the Collie Coal Basin, lie within the plateau.

The Darling Plateau is vegetated by the Northern Jarrah Forest which consists of an array of vegetation complexes of which jarrah (Eucalyptus marginata) is the dominant species. The Northern Jarrah Forest has an area of approximately 10,000 ha, extending between Mundaring and the Collie area, and bounded to the west by the coastal plain and to the east by the wheatbelt area. It is largely uncleared as a result of its status as State forest and low soil fertility, but supports a number of land uses. These include hardwood production, water catchments, pine plantations, bauxite mining and processing, coal mining, agriculture, apiculture, recreation, flora and fauna conservation, power production and residential settlements.

The region experiences cool to mild, wet winters and hot dry summers. The marked seasonality of rainfall is reflected in the surface hydrology, in that surface water flow and wetlands are largely ephemeral.

5.2 Landform Soils and Geology

The proposed site of the power station lies adjacent to the Collie River East Branch. It consists of ridge and hillside landform that is gently undulating and rises from a reduced level of 220 m AHD near the river to 240 m AHD at the ridges, at slopes of 5-15%.

The surface soils within the project area are shown on Figure 5.1 and listed below:

(i) Lateritic soils:
   - caprock on the ridges
   - gravelly colluvial soils on the slopes;

(ii) Grey alluvial sands overlying clays along drainage lines; and

(iii) Deep sands (Nakina Formation).

Geologically, the proposed site abuts the northern margin of the Collie Coal Basin. The portion of the site which lies outside of the basin consists of crystalline basement rocks including granites, gneisses, migmatite, dolerite and diorite, which are overlain by lateritic soils of 20 m or more thickness. The small portion of the site that lies within the Collie Coal Basin is underlain by Nakina Formation sands and a sequence of coal measures containing thin, steeply dipping and faulted seams of coal.

The bulk of the Collie Coal Basin lies south of the proposed site. The basin is approximately 26 km long and 13 km wide. It consists of three sub-basins; Shotts, Muja and Cardiff, which contain several hundred metres of sandstones, shales and coal seams that are overlain by laterized sands and clays of the Tertiary Nakina Formation.

The seismic activity risk of the proposed site is classified as Zone 0, the lowest risk zone.

5.3 Climate and Meteorology

This section summarizes relevant aspects of the available climatic data which has been derived from Collie Post Office Records (records from 1899), Worsley Refinery (records from 1980) and SECWA's meteorological monitoring stations in the Collie area (records from 1983). The data show that the Collie area experiences a climate characterized by warm dry summers and cool wet winters.

5.3.1 Temperature

Mean summer maximum temperature is 31^{o}C whilst mean summer minimum temperature is approximately 12^{o}C. Mean winter maximum temperature is 16.5^{o}C whilst mean winter minimum temperature is 4.7^{o}C. The monthly variation in mean temperatures is illustrated on Figure 5.2.

5.3.2 Rainfall and Evaporation

Collie has an average annual rainfall of 988 mm (Bureau of Meteorology 1975). The proposed site is expected to have an average annual rainfall that is approximately 1.5% lower, i.e. 973 mm.

Rainfall in the area is markedly seasonal. Winter rainfall (April to October) totals 880 mm and exceeds summer rainfall (November to March) which totals 100 mm by a factor of nine. Collie, and the project site, are situated between the 1000 mm and the 800 mm rainfall isohyets. To the east of the 800 mm isohyet rainfall decreases markedly. Evaporation exceeds rainfall for seven months of the year and, on average, totals approximately 1500 mm per annum.

Rainfall intensity-duration curves for Collie, prepared by the Bureau of Meteorology, indicate the critical six minute intensities are 74 mm/h and 82 mm/h, for return periods of 1 year in 10 and 1 year in 100, respectively. Rainfall and evaporation data are shown graphically on Figure 5.2.

5.3.3 Wind

Seasonal wind roses based on data recorded at Collie Post Office are shown on Figure 5.3. The most common winds are south easterlies and these occur most frequently during summer mornings. West to north west sea breezes occur during summer afternoons and stronger west to south west winds occur during the passage of cold fronts, principally during winter. Local topography is not expected to significantly affect wind direction and, accordingly, Collie Post Office records are considered representative of winds at the new power station site.

5.3.4 Flood Risk

Whilst records indicate that flood events are rare due to relatively consistent winter rainfall, exceptionally wet winters may cause isolated flooding. Collie experienced severe flooding in 1964, following winter rainfall that was above average throughout the State. The previous flood event was recorded in 1926.

The minor susceptibility of the Collie township to flooding arises from its location close to normal water level in the Collie River. In comparison, the proposed power station site is located 20-30 m higher in elevation and for this reason has very low flood risk.

5.4 Water Resources

5.4.1 Surface Waters

The site is located within the drainage basin of the Collie River East Branch, which has a catchment of approximately 1,300 km^2 upstream of the proposed project site. The Collie River East Branch flows to the west, and joins the Collie River, which enters the Wellington Dam downstream of Collie. Wellington Dam provides domestic water to Collie and the Great Southern towns as well as irrigation water to the coastal plain.

Flow in the Collie River East Branch is highly seasonal. In summer and autumn, flow is commonly nil, whilst in July and August flows of up to 60 million cubic metres/month have been recorded. Average annual discharge from the East Branch is 52 million cubic metres.

Two seasonal streams drain the proposed site to the Collie River East Branch. Site observation following heavy rain, in October 1984, together with aerial photographic records, show that flow rarely derives from the headwaters which are within the Collie Coal Basin. Streamflow predominantly results from a series of springs located downstream of the boundary of the coal basin sediments. Photographic records indicate that streamflow arising from these springs ceases by late summer.

The TDS concentration of water within the Collie River East Branch varies widely. Data obtained from the Water Authority in 1984 indicate that TDS concentration averages between 475 mg/L and 2,700 mg/L. Samples collected from the river during site surveys conducted in 1984 had TDS concentrations of 1400 mg/L in August and 2,300 mg/L in October.

Similarly, samples collected from the eastern site drainage had a TDS concentration of 4,900 mg/L, whilst the western site drainage had a TDS concentration of 2,100 mg/L. A spring feeding the western site drainage had a TDS concentration of 490 mg/L. Flow data for these two streams are not available.

5.4.2 Groundwater

The proposed site straddles a boundary between areas of different geology and stratigraphy. Groundwater hydrology is markedly different either side of the boundary. North of the boundary, and outside the Collie Coal Basin, unconfined groundwater occupies fractures in the basement rock and pore spaces in the overlying lateritic soils. Although mainly fine grained, the lateritic soils contain relatively permeable zones through which water percolates readily. In addition, considerable moisture is stored in the unsaturated zone.

Seasonal, perched groundwater is common within the valley floors. In general, groundwater tables are close to the surface at lower elevations, rising beneath the higher areas at gradients less than those of the terrain, so that water tables may be tens of metres deep below the upland ground surfaces.

Within the Collie Coal Basin the hydrogeology is more complex. Infiltration rates in many areas are very high due to the presence of deep, coarse sands and gravels at the surface. However, downward percolation is limited in places by the presence of clay sediments.

The sedimentary strata of the Collie Coal Basin include shales, claystones and coal seams of low permeability, and sandstones of relatively high permeability. The latter strata form a succession of confined aquifers within the basin. Recharge of the sandstone aquifers occurs around the margins of the sub-basins, where the sandstone strata subcrop beneath permeable soils.

Shallow, unconfined, perched aquifers also occur within the coal basin, particularly within sands of the Nakina Formation and within alluvial valley soils.

5.5 Air Quality

Few direct measurements of air quality parameters are available for the proposed site or adjacent land. Therefore existing air quality must generally be inferred, on the basis of neighbouring land use.

The proposed site is in a rural setting surrounded by extensive areas of State forest containing approximately 10% cleared areas developed as farms. The most significant local sources of emissions are the Muja open-cut coal mine and power station, approximately 12 km to the south, the town of Collie, approximately 8 km to the south west, and the Worsley Alumina Refinery, approximately 22 km to the west. The alumina refinery and the power station are sources of SO_2 and NO_x. Motor vehicles within Collie are sources of NO_x and minor quantities of hydrocarbons. The power station and the open-cut coal mine are sources of particulates. Agricultural and forest management activities including fires could also be expected to be a sporadic source of particulates.

None of the sources discussed above are likely to have a major impact on air quality at the proposed site, although emissions from the Muja Power Station and Worsley Refinery are considered to be significantly large so as to require inclusion in the air dispersion modelling studies. A limited programme of sulphur dioxide monitoring, using a "Teco pulsed fluorescent" monitoring device, was conducted on site between July 1984 and December 1985. The results showed that sulphur dioxide was rarely present at detectable concentrations.

5.6 Background Noise Levels

Noise surveys were conducted to evaluate the existing noise climate within the area surrounding the proposed power station site. Three measuring stations were monitored between 2200-0400 hours on 26/27 October 1984 and again on 3/4 November. The lowest background noise level (mean minimum noise level L_{90}) obtained by monitoring was 19 dB(A), whilst the highest was 38 dB(A). The principal sources of background noise were found to be crickets, nocturnal animals including frogs and birds, and wind. The locations of the monitoring stations and the results of the surveys are given in Figure 5.4 and Table 5.1, respectively.

5.7 Flora and Fauna

Approximately three quarters (315 ha) of the proposed site has been cleared and is used for pasture. An area of 60 ha of uncleared forest remains in the southern part of the site, whilst remnants of native overstorey vegetation occur throughout, but particularly in the moist valley areas. In the vicinity, vegetation consists of two distinct types: upland forest and wetlands. On the upland slopes and ridgetops where shallow lateritic caprock or colluvial gravels occur, jarrah and marri are the dominant tree species, bull banksia is a common small tree, and species of Hakea, Grevillea, Dryandra and Acacia are common among shrub layers. On some heavier, deeper soils and on

TABLE 5.1

MEASURED OVERALL BACKGROUND NOISE LEVELS IN dBa, re 20 μPa

Measuring Position	Date/ Time of Survey	Noise Levels L_{90}	L_{10}	Weather Conditions	Observations
MP1	27 Oct 84 0118 hrs	25	28	Dry; temperature drop from 12^{o} to $4^{o}C$; (late night: clear sky; no clouds; no wind after 2200 hours; humidity approximately 50%	Distant frog activities; occasional crickets; no local traffic
MP2	27 Oct 84 0052 hrs	23	28	As above	Distant frog activities; no crickets; one by-passing car
MP3	26 Oct 84 2348 hrs	19	22	As above	Max 24 dBa, due bird noise, 22-23 dBa due to barking dog, no crickets
MP1	03 Nov 84 2333 hrs	34	38	Dry, temperature approx $15^{o}C$; approx 20-40% clouds; wind speed approx 4 - 6 m/sec at higher altitudes; 2-4 m/sec at lower altitude; winds from south-east; humidity approx 70%	Rustling tree and bush leaves, crickets; no local traffic
MP1	04 Nov 84 0315 hrs	26	30	As above	As above
MP2	03 Nov 84 2355 hrs	30	34	As above	As above
MP2	04 Nov 84 0342 hrs	25	30	As above	As above
MP3	03 Nov 84 2256 hrs	25	31	As above	As above
MP3	04 Nov 84 0226 hrs	22	23	As above	As above

some lower slopes, yarri, wandoo and flooded gum replace or share dominance with jarrah and marri. The distribution of vegetation types within the proposed site is shown on Figure 5.5.

Structurally, the forest has four recognisable strata:

- The upper canopy, usually jarrah and marri trees, which in the mature forest reaches 20 m to 30 m above ground level.

- A lower tree canopy, 3 m to 6 m high, including species of Banksia, Hakea, Persoonia and Dryandra.

- A shrub layer comprising zamias, blackboys, wattles and many other plants.

- A ground layer of prostrate shrubs, grasses, herbs, ferns and mosses.

The wetland vegetation varies in its structure and floristic composition depending on soil type and moisture regime. The project area wetlands include the components listed below.

- Low ti-tree heathlands with emergent swamp banksias and paperbarks.

- Taller shrublands dominated by Hakea prostrata, Hakea varia, Melaleuca viminea, blackboys and flooded gums.

- Dense swards of sedges and bullrushes, in a few instances surrounding seasonal ponds.

- Mixed shrubland, generally with an overstorey of flooded gum or marri.

A site survey was carried out in 1984 to determine whether any rare, endangered or geographically restricted species were present. The results of the survey indicated that none were present.

The portion of the proposed site that has not been cleared has been selectively logged, and was burnt a short time before the 1984 site survey. Whilst the area contains a relatively diverse suite of flora, the plant species, plant associations and vegetation structures that are present are widespread in the Darling Range.

As much of the site is cleared, it is considered unlikely that any significant fauna species are present. The fauna which does occur at the site would generally be species that are common and widespread.

5.8 Ecology

The various natural habitats of the area show consistent relationships between geology, landform, soils, surface hydrology, groundwater hydrology and vegetation, as depicted on Figure 5.6. The ecological and environmental conditions in the project area are summarized in Table 5.2.

Wetland habitats have particular ecological importance. Apart from the presence of surface water, which is necessary for the survival of many species of birds and mammals, the wetlands support vegetation which provides a moist, cool, sheltered micro-climate enabling many species to survive the hot summer months. As a result, wetland habitats support more diverse and more dense populations of fauna than are found in the upland habitats.

The vegetation complexes in the jarrah-marri forest are adapted to the hydrologic regime and the low nutrient status of their substrates. For example, jarrah growing on deep lateritic soil has been shown by Dell, Bartle and Tacey (1983) to have two types of root systems: a horizontal one that taps the shallow organic-rich topsoil, and a sinker root system, capable of tapping the groundwater table to a depth of over 40 m.

The biotic community is constantly fixing, utilizing and dispersing energy and nutrients, which are continually recycled in the ecosystem. Nutrients are released from decaying matter and recycled by the action of microscopic decomposers. The nutrients follow similar pathways through the food chain as energy, passing from one trophic level to another (see Figure 5.7).

The medium in which all nutrients are eventually carried through the ecosystem is water; hence nutrient cycles are inseparably linked to the hydrological cycle.

TABLE 5.2

ECOLOGICAL RELATIONSHIPS

LANDFORM	SOIL	VEGETATION REGIME	HYDROLOGICAL SIGNIFICANCE	FAUNAL COMPONENT
Ridge tops and slopes	Lateritic gravel and caprock	Jarrah/Marri Open Forest Jarrah/marri, bull banksia, hakea, blackboy, zamias	Dry in summer months	Characteristic habitats for large, wide-ranging mobile species including macropods.
Lower to intermediate slopes	Lateritic gravels	Marri Open Forest Sheoaks, hakea, bull banksia	Moderately dry during the summer months	
Wide flats and lower slopes	Grey sands	Swamp Woodland I Swamp banksia, sheoaks, christmas trees	Moist during the majority of the year	Provides an important summer refuge for many species. Supports relatively high densities of fauna.
Valley floor	Grey sands overlying clays	Swamp Woodland II Swamp banksia/ Paperbark relatively dense understorey of shrubs	Saturated during most of the season	Rarer species tend to be associated with these habitats.

5.8.1 Environmental Modifiers

Whilst much of the region surrounding the project area consists of native forest vegetation, the environment is far from pristine. There are a number of operative processes which are actively modifying the environment of the region. These processes and their effects need to be recognized as a background in consideration of the biophysical impacts of the project.

a) Forest Clearing and Reforestation

Forests within the relatively moist and fertile valley slopes and floors have been selectively cleared for agriculture. Uplands have escaped clearing due to low soil fertility and the presence of lateritic caprock. In the region surrounding the proposed site, approximately 20% has been cleared for agriculture. A further 15% of forest in the region has been cleared for mining, water supply, townsites and associated urban and industrial infrastructure.

Reforestation is also in progress in the region. The Department of Conservation and Land Management (CALM) has an ongoing programme of reforestation at exhausted gravel pits and mine sites. SECWA also has a reforestation programme, as required by statutory procedures for management of the Wellington Reservoir catchment. SECWA has effectively reforested over 500 ha of previously cleared land in the catchment as part of this programme.

b) Timber Production

Most of the jarrah-marri forest in the general area has been logged to supply mills at Collie (Bunnings and Saunders), Bunbury and Darkan. Logging results in a thinning of the forest canopy, introduces logging debris to the forest floor and causes prolific jarrah-marri regrowth. Whilst these effects are not necessarily all detrimental, they do represent a shift in ecological balance that must be recognized as a significant environmental change.

c) Fire Control

Fire control measures have been introduced by the Department of CALM to protect commercial timber resources and human life and property. Prescribed burning to reduce fuel loads is routinely conducted at three to eight year intervals in State forest areas. Biological research has shown that regular "cool burning" has affected the composition of the jarrah forest. The jarrah forest ecosystem is naturally adapted to fire and requires a varied fire regime to maintain ecological diversity. A number of species, including jarrah, are able to survive fires by resprouting from either underground root stocks or from growth centres located beneath the bark of the trunk and limbs. Many other species including Banksia and Hakea require hot fires to open tough woody seed casings whilst other species such as blackboy (Xanthorrhoea) require fire to stimulate flowering.

The uniformity of fuel loads that results from prescribed burns prevents the opportunity for hot fires to occur. This acts to limit species and structural diversity in a forest ecosystem that naturally has the ability to accommodate hot fires and subsequently regenerate.

d) Jarrah Dieback Disease

The Northern Jarrah Forest, including the Collie region, is undergoing radical ecological change due to the spread of jarrah dieback disease which is caused by a soil-borne root fungus, Phytophthora cinnamomi. The dieback fungus attacks and kills jarrah trees as well as a number of other more highly susceptible plants including Banksia grandis and Persoonia longifolia, by infection of roots by zoospores. Not all plant species are susceptible to the disease. Legumes tend to be resistant or even antagonistic to the disease, whilst marri (Eucalyptus calophylla) and Bullich (E. megacarpa) are resistant.

New infections of the disease occur through transport of infected soil or plant materials. Extensive areas of State forest have been quarantined to restrict the spread of the fungus by transportation of infected soil.

Very large areas of the Northern Jarrah Forest have already been infected by dieback and the disease is apparently continuing to spread in many areas.

Forest clearing, logging and the spread of jarrah dieback disease have all combined to reduce overall forest transpiration. As a result, groundwater levels have risen in some areas, extending the areas of low-lying swamps and increasing the conditions which are conducive to the spread of dieback disease. As groundwater levels rise, dissolved salts stored in the soil profile are re-dissolved, causing brackish conditions in swamps and in the baseflow component of streams.

The vegetation of the valley floors within the power station site includes many large dead eucalypts, the death of which may be due to inundation and/or the accompanying increase in salinity. The salinity of the Collie River has increased to the extent where water in the Wellington Dam has become, at times, unsuitable for domestic consumption.

TABLE 5.3

RESOURCES AND CORRESPONDING PRIORITIES IN THE COLLIE BASIN

RESOURCES	PRIMARY LAND USE	LAND USE COMPONENTS
. coal	. mining	. deep mining areas
		. open cut mines
		. mine infrastructure
		. dump sites
		. final voids
		. rehabilitation area
. energy infrastructure	. power generation	. power station
		. transmission lines
. water resources	. water supply	. bore fields
		. groundwater recharge areas
		. groundwater storage
		. catchment supply
		. reservoirs, rivers
. urban infrastructure	. urban	. special rural land
		. residential land
		. industrial land
	. transport	. commercial zones
		. roads and railways
. environmental	. recreation	. active and passive
	. conservation	. nature conservation
. forests	. forestry	. hardwood production
		. softwood production
. agricultural land	. agriculture	. agro forestry
		. crops and grazing
		. horticulture
. raw materials	. quarrying	. quarries and pits

5.9 Land Use, Tenure and Zoning

Land use in the vicinity of the proposed site, and the region in general, reflects the traditional economic base of forestry, grazing, agriculture and mining. Land use in the Collie Basin region is shown on Figure 5.8, whilst additional details for the area in the vicinity of Collie are provided on Figure 5.9.

A recent report to Cabinet by the Collie Basin Land Use Working Group (1987) listed priorities for land use within the catchment that were considered to be appropriate for the period extending from the present time until early next century. This information is presented in Table 5.3 in the order of priorities determined by the working group.

There are four principal categories of land tenure in the Collie Basin, which are listed and described below.

<u>State Forest</u>: This occupies 65% of the coal basin and is administered, in respect of forest conservation, production and recreation, by the Department of CALM.

<u>Privately Owned Rural Land</u>: This is mostly cleared agricultural land, which constitutes 30% of the coal basin. Small areas of uncleared freehold land, all lying outside the coal basin, have been used for forest production. There are considerable areas of productive farmland around the northern, southern and eastern margins of the coal basin.

<u>Townsites and Urban Areas</u>: Substantial parts of Collie and Allanson, and all of Muja, Shotts, Collie Burn and Cardiff, lie within the basin and constitute approximately 5% of its area.

<u>Other Reserves</u>: Small areas of reserve declared under the Land Act for various purposes are vested in a number of government agencies. Small areas of vacant Crown land also exist.

6.0 THE SOCIAL ENVIRONMENT

6.1 Regional Perspective

The Shire of Collie is considered to be the area of primary relevance in terms of both direct and indirect social impacts resulting from the proposed power station. The recruitment of local workers for the new power station is a direct social impact. The recruitment of workers to jobs which were created as an indirect result of the project (for example, catering personnel) is considered to be an indirect social impact. Of course both direct and indirect social impacts may occur over a broader area. This broader area is approximated here by the Preston Statistical Subdivision, as defined by the Australian Bureau of Statistics, and represents the study area for the analysis of the social environment.

The Preston Statistical Subdivision occupies a total area of 6112 km^2. It includes the City of Bunbury as well as the towns of Collie and Harvey. The economy is based on a diverse agricultural industry, mining of coal and bauxite, and forestry and tourism.

6.2 Population

Data compiled by the Australian Bureau of Statistics from the 30 June 1986 census indicated the estimated resident population of the Shire of Collie to be 9,674 persons, whilst the estimated resident population for the whole Preston Subdivision was estimated to be 56,925. These data, together with a summary of previous census data for the subdivision and the whole of Western Australia, are given in Table 6.1.

Population projections produced for the Collie Shire by the South West Development Authority are shown on Figure 6.2. These projections are based on annual average growth rates derived from the surveys listed below.

(i) Actual Census Count 1976-81

(ii) Estimated Resident Population 1976-81

(iii) Actual Census Count 1971-81.

TABLE 6.1

ESTIMATED RESIDENT POPULATION AND PRIVATE DWELLINGS
PRESTON STATISTICAL SUBDIVISION
AND WESTERN AUSTRALIA
1976-1986

Stat Area at June 30 1981	Census 30 June 1976			Census 30 June1981		Census 30 June 1986		%Change 1976/86	
Zone	(square kilometres)	Est. Resident Population	Priv. Dwellings	Est. Resident Population	Priv. Dwellings	Est. Resident Population	Priv. Dwellings	Est. Resident Population	Priv. Dwellings
(i) PRESTON STATISTICAL SUBDIVISION									
Bunbury(C)	612	20,600	6,102	22,445	7,235	24,731	8,521	20	40
Capel	554	2,470	705	2,963	868	3,983	1,292	61	83
Collie	1,662	8,080	2,459	9,064	2,816	9,674	3,201	20	30
Dardanup	529	2,910	835	3,608	1,078	4,442	1,403	53	68
Donny-brook/-Balingup	1,540	3,030	1,039	3,380	1,093	3,763	1,278	24	23
Harvey	1,766	7,110	2,146	8,305	2,750	10,332	3,523	45	64
TOTAL	6,112	44,200	13,286	49,765	15,840	56,925	19,218	29	45
(ii) WESTERN AUSTRALIA									
TOTAL	2,525,000	1,178,340	370,941	1,300,056	445,700	1,459,019	10,366	19	38

Source: Australian Bureau of Statistics

These estimates indicate that by the year 2000, the population of the Shire of Collie would be between approximately 12,000 and 17,000 persons.

6.3 Employment

Table 6.2 describes the employment structure of the Collie Shire during the period 1966 to 1986. The 1986 data indicate that mining, electricity/gas/water, wholesale/retail and community service industries are the principal employers in the region. The historical data also illustrate the increasing relative importance of mining, electricity/gas/water, community services and construction industries as employers and the relative decline in the importance of agriculture.

The total employment multiplier for the Collie Shire has been calculated at 1.55. This can be simply interpreted to mean that the addition of one job in a basic industry leads to an additional 0.55 service jobs within the Shire.

6.4 Unemployment

Unemployment figures for the Collie Shire and other statistical zones are shown in Table 6.3.

The data presented in Table 6.3 indicates that the 1986 percentage unemployment in Collie (9.6%) is very close to the figure for percentage unemployment over the State (9.4%). The figure for the increase in percentage unemployment between 1981 and 1986 in the Collie Shire (4.7%) is also very close to the figure for increase in percentage unemployment over the whole Preston Subdivision (4.4%). Table 6.2 indicates that employment in the electricity/gas/water sector has increased more rapidly over the last 20 years than employment in any other industry in Collie. It follows, therefore, that this industry sector has contributed significantly to the high employment rate in Collie.

6.5 Housing and Land

The number of private dwellings within the Collie Shire increased by 30% to 3201 in the period 1976-86. This rate of growth is higher than the concurrent growth in estimated resident population over the same ten year period (20%). Homeswest has 395 rental units in the Shire and 28 units for Aboriginal grant applications. At the end of February 1988, 38 persons were awaiting Homeswest housing (Homeswest, pers. comm.).

TABLE 6.2

EMPLOYMENT STRUCTURE OF COLLIE SHIRE 1966 - 1986

INDUSTRY	1966 TOTAL	1966 %	1976 TOTAL	1976 %	1981 TOTAL	1981 %	1986 TOTAL	1986 %
Agriculture, Fishing, Forestry	153	5.1	140	5.0	122	3.3	102	3.1
Mining	718	24.0	777	27.9	961	26.4	1,097	32.9
Manufacturing	319	10.7	141	5.1	170	4.6	174	5.2
Electricity, Gas, Water	205	6.9	300	10.8	367	10.1	585	17.6
Construction	312	10.4	170	6.1	518	14.2	92	2.8
Wholesale, Retail	428	14.3	398	14.3	385	10.6	423	12.7
Transport, Storage	299	10.0	198	7.1	149	4.1	86	2.6
Communications	36	1.2	25	0.9	31	0.9	21	0.6
Finance	34	1.1	63	2.3	139	3.8	113	3.4
Public Admin.	48	1.6	41	1.5	72	2.0	81	2.4
Community Services	252	8.4	306	11.5	377	10.3	400	12.0
Entertainment Recreation, Hotel	133	4.4	89	3.2	119	3.3	111	3.3
Other	56	1.9	131	4.7	233	6.4	4	0.1
TOTAL EMPLOYED PERSONS	2,993	100.0	2,779	100.0	3,643	100.0	3,338	100.0

Source: Australian Bureau of Statistics

TABLE 6.3

UNEMPLOYMENT ESTIMATES
JUNE 1981 AND JUNE 1986

Statistical Zone	June 1981 % Workforce Unemployed	June 1986 % Workforce Unemployed	Increase in Unemployment 1981-1986
Bunbury City	6.3	10.5	4.2%
Collie Shire	4.9	9.8	4.7%
Dardanup Shire	3.4	6.8	3.4%
Donnybrook-Balingup	4.8	12.7	7.9%
Capel Shire	3.9	6.6	2.7%
Harvey Shire	4.2	8.5	4.3%
Preston Subdivision	5.2	9.6	4.4%
Western Australia	6.3	9.4	3.1%

Source: Australian Bureau of Statistics, 1981 and 1986 Census

Recent accommodation data indicate that there are 100 caravan sites and 98 hotel rooms or units available in the Collie Shire (RAC 1988). The broader study area has over 1000 caravan sites and 700 rooms or units within hotel, motel or guest house establishments.

Preferred areas for urban expansion in Collie have been identified north of the town centre, between Collie and Allanson, and west of Allanson along the Coalfields Highway. The availability of urban development sites outside of these areas is constrained by land use conflicts which arise due to other priorities.

6.6 Community Infrastructure and Services

The township settlement of Collie began in the 1890's as a result of earnest coal mining activity in the Collie Coalfield. Small scale power generation in Collie and the encouragement by the Government for Collie Coal to be used in the early 1900's, providing the town with a stable industry and income.

Hence, given Collie's early settlement and long period of steady growth, the town has become a well developed centre with established community facilities and services. Long standing facilities include a district hospital, annexe of Curtin University (School of Mines), Technical and Further Education (TAFE) Centre, Senior High School, a private high school, three primary schools, the Collie Museum, public library, two large community halls, olympic standard swimming pool and a range of community, sporting and senior citizens clubs.

The Collie Senior High School has an enrolment of 570 students in 1990, with a capacity for a further 100 students, while Saint Edmonds College has 120 enrolled students and capacity for a further 60 students.

Since 1987 there have been many developments and additions to Collie's community facilities and services. The Collie Recreation Centre opened at Roche Park in early 1988 and includes conference facilities, creche, basketball courts, a stage and sports lounge. The Collie District Hospital was extended in 1989, increasing its total bed capacity from 63 to 83 beds. The hospital currently operates at an occupied bed average of 48 - 50 beds.

The Margaretta Wilson Community Centre, funded primarily by State Government, opened in 1989 and includes Police and Citizens Youth Club, Senior Citizens, Meals on Wheels and Podiatrist.

A modern shopping complex, the Collie Boulevard, was opened on the north side of the town in 1989 and includes a large supermarket and 30 specialty shops.

In the broader area, the Preston Statistical Subdivision, there are twenty five primary schools, six secondary schools and thirteen non-government schools which together had a total enrolment of 13,155 pupils in the second semester of 1989 (Ministry of Education). In addition there are two educational support schools which had a combined enrolment of 46 handicapped students in 1989. There are also two regional colleges of TAFE, one in Bunbury and one in Collie, which had a combined enrolment of 4,935 students in 1989. Enrolments in primary and secondary schools since 1984 have grown steadily in proportion to the population growth.

There is a regional hospital and private hospital in Bunbury and smaller hospitals in Collie, Donnybrook and Harvey. The Preston Statistical

Subdivision has a total of over 360 hospital beds and is serviced by 60 resident doctors. Specialist medical services, such as radiology and orthopaedics, are also available in Bunbury.

6.7 Ethnography

An ethnographic survey was undertaken to assess whether or not there are any sites which could be affected by the project, and whether these are of significance to living Aborigines. The survey report is detailed in a separate document. As this report contains sensitive materials relating to Aboriginal mythology, it is not available for public review and only a brief summary is reported herein.

One mythological site, based on a system of natural pools, was identified by Aboriginal representatives. This site is located well away from the power station (Table 6.4).

TABLE 6.4

LIST OF NEWLY RECORDED SITES OF SIGNIFICANCE IN THE SURVEY AREA

WA MUSEUM NO.	DESCRIPTION OF SITE	DISTANCE FROM POWER STATION SITE
S2108	Natural pool system - Mythological	12 km
S2107	Camping Ground - Ethnographic	4 km
S2106	Spring - Ethnographic	1 km

Two additional ethnographic sites were identified: an Aboriginal camping area on the western bank of the Collie River East Branch and a spring 2.8 km further upstream on the river bank. Both sites were used by Aborigines following European settlement.

All Aboriginal representatives consulted agreed that no sites of a mythological or ritual nature existed, nor to their knowledge had existed formerly, in the area to be disturbed by the project.

6.8 Archaeological Sites

An archaeological survey for Aboriginal sites was conducted within the power station boundary and in the vicinity of a network of borefields and several pumping stations to the south of the power station site. The survey report is contained in a separate document which, in order to protect identified sites, is not available for public review.

One archaeological site (WA Museum No. S2117) and two isolated finds (stone artefacts) were located during the survey. The site consisted of a scatter of 12 quartz artefacts within a blowout at the western edge of the power station site, adjacent to a seepage. One of the isolated finds, a quartz steep-sided scraper, was located in the vicinity of the eastern seepage on the power station site. The other isolated find was located in the proposed borefield area, on the eastern side of the Collie River South Branch. None of these sites is considered to be scientifically important or to require further study or protection. However, in recognition of the provisions and requirements of the Aboriginal Heritage Act, SECWA will liaise with the WA Museum before any disturbance to Aboriginal sites is conducted.

7.0 IMPACT OF THE PROJECT ON THE BIOPHYSICAL ENVIRONMENT

The biophysical impacts of the project are reviewed here in two parts, the first of which examines the construction phase and the second the operations phase. The overall impacts of the project are briefly summarized in Table 7.1

7.1 Impact of Construction

The 388 ha power station site currently supports approximately 60 ha of native vegetation, which includes relatively undisturbed jarrah forest, remnant stands of wandoo, marri, flooded gum and some wetland vegetation.

Clearing will be carried out to accommodate the power station and its associated facilities, additional areas required for construction activities, and a sufficient proportion of surrounding land to minimize the risk of bushfire damage to installations. Vegetation to be established as part of the site landscaping programme will partially offset this loss.

The remaining 1500 ha surrounding the plant site will provide a buffer and will continue to support pasture, jarrah forest and wetland vegetation.

The total area within the 388 ha site which will be affected by construction activities amounts to 200 ha. This includes the ash and water storage areas and an allowance for access roads within the site area.

The types of existing vegetation to be removed during construction, and the areas of each, are given below.

Pasture	129 ha
Jarrah forest, relatively undisturbed	59 ha
Wetland vegetation, degraded	12 ha

Surveys of the natural vegetation indicated that as no rare or endangered flora or fauna species exist within the site, none would be affected by clearing. Whilst loss of habitat, and death or displacement of some of the fauna from within the site will unavoidably result from site preparation, these are clearly negligible effects on a regional scale. The balance of vegetated land

TABLE 7.1

IDENTIFICATION OF BIOPHYSICAL INTERACTIONS

ACTIVITY	PRIMARY IMPACTS DIRECT EFFECTS	SECONDARY IMPACTS INDIRECT EFFECTS
Site Clearing and Earthworks	Removal of 59 ha of jarrah forest and associated vegetation in southern part of site. Some trees removed from remainder of site.	Locally decreased transpiration leading to rise in water table and/or minor increase in recharge to Collie Basin aquifers. Potential for minor increase in salinity of surface water. Offset by interception of spring flows. Also offset in medium term by reforestation.
Earthworks for Ash Disposal Area, Coal Yard Runoff Pond and Mine Water Reservoir	Removal of 12 ha of wetland vegetation. Interception of streamflows.	Localized rise in water table adjacent to pond sites. Minor reduction in surface discharge to the Collie River East Branch.
Construction of Power Station Buildings and Facilities	Reduced infiltration over 69 ha. Runoff collected in drain water reservoir.	Localized decline in water table levels beneath the site. Accumulation of water in surface storage. Minor seepage leads to localised rise in surrounding water tables.
Operation of Borefields for Station Water Supply	Eventual drawdown of groundwater levels in areas of aquifer sub-crop within the Collie Coal Basin.	Drawdown of aquifers with possible loss of wetland vegetation. As the borefield is only to be operated as a back-up for mine dewatering, drawdown risk is minimal. Possible reduction in extent of swamp-type vegetation.
Power Station Operations:		
- Coal Handling Plant	Generation of airborne dust (because of the safeguards to be implemented, only minor dust levels are expected).	Possible minor effects on vegetation growing downwind.
- Gaseous and Particulate Stack Emissions	Dispersion of airborne emissions within 4 km radius of power station. No expected effects.	No effect expected.
- Wastewater	Small potential for leakage of saline leachate from evaporation pond.	No effect expected.
- Fly-ash Disposal	Not determined as yet.	No determined as yet.

compared to cleared land that has been historically achieved by economic development within the region will not be significantly affected by the project.

Clearing of forest vegetation in the southern part of the site will reduce the quantity of groundwater that is removed by transpiration from this specific area of land. As the areas to be cleared lie mainly within the Collie Coal Basin, this is unlikely to have effects at the surface level. The additional groundwater storage that results from reduced transpiration will tend to flow southwards into the basin, where it may add slightly to the recharge of sedimentary aquifers.

As the majority of the site is cleared, the additional clearing of 60 ha of forest vegetation is not expected to impact upon the quality of water runoff into the Collie River East Branch.

Construction activities will generate dust and will increase the erosion potential of surface soils within the area, for the duration of the construction period.

Dust generation will be controlled within levels that do not create nuisance using traditional procedures involving watering of roads and stockpile areas. It is inevitable that construction will result in dust levels higher than at present during very hot, dry and windy conditions. However, significant transport of dust beyond the site boundaries is considered to be unlikely.

Erosion management will be jointly undertaken with runoff control. Removal of vegetation and soil compaction by earthworks will create relatively high runoff potential. During construction, control of drainage within working areas will prevent major erosional damage on site but some fine sediment will inevitably be exported. Most of the fines will redeposit on low ground adjacent to the Collie River East Branch. Only the finest fractions remaining in suspension will drain into the Collie River East Branch.

As the construction phase nears completion, landscaping and soil stabilization work will be instituted to enable dust, erosion and runoff to be controlled in the long term.

There is also potential for indirect losses of vegetation to occur as a result of the spread of jarrah dieback disease, which could be locally enhanced by construction activities. Stringent forest hygiene procedures will be implemented in accordance with the Department of CALM's requirements to minimize this effect.

7.2 Impacts of Operation

The environmental impacts that will arise from operation of the proposed power station can be categorized as below and are reviewed accordingly.

(i) Atmospheric Emissions
(ii) Water Supply Impacts
(iii) Ash Disposal
(iv) Wastewater Disposal
(v) Electric and Magnetic Fields.

7.2.1 Atmospheric Emissions

Combustion of coal produces gaseous and particulate emissions which, under certain circumstances, can be harmful to human health or may adversely affect environmental values.

In Section 4.6 the anticipated emissions from the new power station are categorized and quantified (refer back to Table 4.6). This table shows that the anticipated concentrations of sulphur dioxide, nitrogen oxides and particulates in the flue gas are all within the guidelines recommended by the NHMRC. However, this does not in itself guarantee that the quality of air at ground level, surrounding the power station, will remain within acceptable limits.

As a result of the need to better define emission effects, a mathematical atmospheric dispersion model has been used to evaluate the effect of atmospheric emissions from the power station on ground level air quality within the peripheral environment. A more detailed discussion of air emission modelling can be located in Appendix A (Air Quality Assessment) of this document.

The Gaussian plume dispersion model (DISPMOD) which was developed in the Kwinana Air Modelling Study (KAMS, 1982) was used in the modelling work. This model was tested extensively during KAMS and, as part of the current study, was shown to compare well with a US EPA model (ISCST). ISCST has been adopted by the Victorian EPA in their document entitled "User Manuals for use with the Plume Calculation Procedure" (VEPA, 1984).

Two sets of modelling work were conducted:

(i) emissions from the Collie Power Station were considered in isolation; and
(ii) other sources of airborne emissions in the region were taken into account.

Apart from the emission data, input of environmental information to the model includes actual wind speed, direction, atmospheric stability and temperature data measured over a period of 12 months at a meteorological base station in the Collie Basin area.

The modelling work initially concentrated on dispersion of the sulphur dioxide emissions from the power station and utilized these modelling results for graphical display. The predicted ground level concentrations of sulphur dioxide which would result from operation of the power station, together with all other local sources of discharge, are shown on Figures 7.1 to 7.3. It should be noted that a safety factor was incorporated in the model by the use of inflated values for SO_2 concentrations from the Muja Power Station (21% in excess of actual values) and for the proposed new power station (17% in excess of predicted values).

Comparison of the predicted ground level sulphur dioxide concentrations to Australian and International air quality standards given in Table 7.2 indicates that air quality in the periphery of the power station will be acceptable at all times in terms of sulphur dioxide concentration. The conservative results produced by using atmospheric dispersion modelling techniques to estimate ground level concentration of emission gases have been verified by previous measurement surveys. Ground level concentrations of SO_2 predicted for the area surrounding Muja Power Station were checked over a three month period by a base station containing SO_2

measurement equipment. Comparison of base station measurements to model predictions showed that model predictions overestimate actual concentrations by a variable factor of up to 50%.

Evaluation of the acceptability of nitric oxide/nitrogen dioxide and particulate emissions did not require preparation of separate isopleth diagrams. The application of the dispersion factors and indices derived from the sulphur dioxide dispersion results to the emission data for these parameters indicates that ground level concentrations of all parameters would comply with relevant criteria. Neverthless, further investigations will be undertaken to re-examine the ground level concentrations of pollutants with other models and consideration of more detailed station design parameters which will affect dispersion characteristics in the Collie area. These parameters will be optimised to meet desired ground level concentrations. The comparative data are listed in Table 7.2.

The operation of the power station will also result in the production of the greenhouse gas carbon dioxide. Table 4.4 in Section 4.6.1 identifies the quantities of this gas that will be produced. Environmental management initiatives that have been implemented to reduce greenhouse gas impacts are discussed in Section 9.0.

7.2.2 Water Supply Impacts

There will be two sources of water supply for the power station: mine water that will be supplied from the dewatering of an operating coal mine, and groundwater that will be abstracted from deep aquifers within the coal basin. Mine water will be preferentially utilized to the extent enabled by availability and quality.

Abstraction of groundwater will have both direct and indirect environmental effects.

The borefield installations, pipelines, powerlines and access tracks will require clearing of approximately 45 ha. The types of vegetation that will be cleared are summarized below.

Upland jarrah-marri forest	26 ha
Wetland vegetation	5 ha
Pine plantations	14 ha

TABLE 7.2

COMPARISON OF PREDICTED GROUND LEVEL CONCENTRATIONS WITH RELEVANT AIR QUALITY CRITERIA

Ground Level Concentrations ($\mu g.m^{-3}$)	SO_2 Annual Ave.	SO_2 24 hr Ave.	SO_2 1 hr Ave.	NO_x Annual Ave.	NO_2 24 hr Ave.	NO_x 1 hr Ave.	Particulates Annual Ave.	Particulates 24 hr Ave[7].
STANDARDS: (Relevant air quality criteria)								
US EPA[1]	80	365	-	100	-	-	75	260
WHO[2] Environmental Health Criteria	50	125	-	-	-	-	-	120
WHO[3] Ecological Safeguard	30	100	-	30	-	95[8]	-	-
VEPA[4] Acceptable levels.	-	171	486	-	123	300	-	-
Detrimental levels (not to be exceeded).	-	314	972	-	308	513	-	-
NHMRC[5] ambient air qual. goals	-	60	-	-	-	320	90	-
SOURCES: Predicted and derived ground level concentrations								
CPS[6] alone	2	30	382	0.54	8	103	0.05	0.75
CPS[6] and others	7	75	408	4.6	50	266	0.05[9]	0.75[9]

N.B. Those missing entries for some averaging times are due to different criteria adopted by some bodies.

Notes:
1. United States Environmental Protection Agency (1977) Primary Standards
2. World Health Organization (1979)
3. World Health Organization (1982)

4. Victorian Environmental Protection Authority (1981)
5. National Health and Medical Research Council (1985)
6. Proposed Collie Power Station
7. Ave. = Average
8. Four hour average.
9. Particulates from other sources are not detectable above background at the power station site. SECWA (1989).

The routes of the pipeline and associated service corridors have been located to minimize, as far as practical, the need to clear pine plantations and wetland vegetation. Botanical examination of the service corridor routes reported in separately available documents has indicated that there are no rare or endangered plant species or any particularly unusual or high quality vegetation within them. The impact of the clearing work will therefore be negligible on both a local and regional basis.

Depending on the quality and quantity of water that can be supplied from coal mine dewatering, groundwater abstraction may be as high as 25,000 m^3/day. Groundwater will be pumped from aquifers located more than 100 m below ground surface.

Aquicludes are known to occur within the strata overlying the groundwater production zone. Shallow aquifers in the borefield area are perched, therefore abstraction from underlying aquifers should not cause local effects.

Depending on the duration and volume of abstraction, pumping from deep aquifers may tend to cause water table drawdown around the margins of the coal basin, where the deep aquifer's host strata approach the ground surface. Seasonal drawdowns of the order of several metres within the recharge zones are possible based on worst case assumptions. Accordingly, whether or not drawdown is progressive or seasonal will depend on the balance between withdrawal and recharge. This can not be predicted based on current knowledge, but will be examined carefully by ongoing environmental management works which will include biennial reporting of aquifer performance to the Water Authority of WA.

If aquifer drawdown at the margins of the coal basin does occur, two effects are possible:

(i) Baseflow to ephemeral streams may be reduced, but would likely be undetectable due to the normally wide range of streamflow volume. Previous land use practice has already increased base flow volumes through clearing and raising of water tables.

(ii) Where aquifer drawdown affects wetland areas, reduction of vegetation density and species diversity is likely to occur. There will be a shift in species composition towards more drought tolerant plant species.

It is possible that some wetland areas at the periphery of the coal basin could be affected by water table drawdown. This will be monitored as discussed in Section 9.5.5.

The supply of mine water to the power station will not generate environmental impacts that need be considered here. Responsibility for any possible impacts of mine dewatering is assigned to the coal mining companies in their "Special Agreement Acts".

7.2.3 Ash Disposal

Whilst the disposal method to be used for fly-ash produced by the power station has yet to be finalized, the potential environmental impacts of each option are sufficiently similar to enable description for the purposes of assessment.

Fly-ash contains a variety of elements which may be dissolved by water in contact with the ash. The chemical composition of fly-ash is shown in Table 7.3 to provide an indication of the major and detectable trace elements which are typically found.

Each of the alternative ash disposal methods will involve deposition of ash within a storage impoundment created by the construction of geotechnically secure earthfill embankments designed for water retention and by provision of an effective lining to reduce hydraulic permeability.

For each of the alternative ash disposal methods the major potential impact of disposal will be leachate migration from the storage impoundment into underlying soil and groundwater.

The Water Authority of WA has established a strategy to significantly improve the quality of water stored within the Wellington Dam. The strategy includes a requirement that all discharges of water from the new power station must be of potable standard or better. Previous experience with fly-ash disposal has shown that water that has contacted fly-ash would not comply with potable standards. Environmental management methods for the fly-ash disposal operations therefore focus on means by which leachate generation and seepage may be controlled.

For both of the alternative disposal methods, present planning recognizes the possible need to install high density polyethylene (HDPE) liners within the base of the storage impoundment to preclude the seepage to soil and groundwater of water that has contacted fly-ash. As the cost of incorporating an HDPE liner within the storage impoundment will be very high, trials of high density slurry disposal that are proposed for the Muja Power Station will examine the necessity for HDPE lining. When deposited as a high density slurry, fly-ash sets and forms a hard surface which does assist environmental management in two ways:

(i) Following drying, deposited slurry creates a seal that effectively prevents seepage losses of excess water.

(ii) Following drying, deposited slurry sheds incident rainfall so that resultant runoff is not contaminated with soluble ash constituents.

Therefore the leachate generation characteristics of the trial high density slurry disposal operation to be conducted at Muja Power Station will be confirmed before a decision to proceed with the HDPE lining is finalized.

Further design features which will be incorporated to minimize the quantity of potentially contaminated water that is produced by fly-ash disposal include the following:

(i) Construction of bypass drains around the disposal area to isolate stormwater runoff from deposited fly-ash.

(ii) Construction of a containment pond to store stormwater runoff or excess water and to enable evaporation to dryness of collected water.

TABLE 7.3

TYPICAL CHEMICAL COMPOSITION OF FLY ASH

Chemcial	Units	Amount in Flyash
SiO_2	mg/g	350-500
Al_2O_3	mg/g	200-300
Fe_2O_3	mg/g	100-150
CaO	mg/g	35
MgO	mg/g	25
TiO_2	mg/g	15
P_2O_5	mg/g	15
Na_2O	mg/g	6
K_2O	mg/g	2
SO_3	mg/g	3
Cl	mg/g	0.1
Zn	µg/g	500
Mn	µg/g	450
Cu	µg/g	100
Ni	µg/g	135
Co	µg/g	50-100
Cr	µg/g	130
Cd	µg/g	20-40
Hg	µg/g	0-0.5
Pb	µg/g	20-70
Se	µg/g	<3

(iii) Progressive rehabilitation of the landfill surface by the placement of a clay seal overlain by topsoil and planted with appropriate vegetation.

The quality of fly-ash leachate as measured at Muja Power Station is indicated in Table 7.4. This would closely approximate the quality of fly-ash seepage water at the proposed power station.

In the case of high density flyash disposal the potential for leachate seepage can be most effectively minimised through the construction of the ash pond lining. As previously stated the effectiveness of various lining methods will be assessed in conjunction with the high density slurry disposal trails proposed for Muja Power Station. Following completion of trials the effectiveness of pond liners can be assessed and the most efficient arrangement of operation, and pond construction and lining implemented.

One possible lining arrangement as follows may prove to be effective. The base of the ash storage pond to be lined with a 500mm layer of recompacted clay over which will be placed a 200mm sand detector layer with leakage sensors and effluent extraction system. Over this layer may be an optional HDPE membrane, and a further 200mm protective layer of sand to prevent puncture.

The exact arrangement of liners will not be known until completion of the previously mentioned tests. It is at this stage, when the variables are known, that the overvall system can be designed specifically to meet the Water Authority of Western Australia discharge criteria.

7.2.4 Wastewater Disposal

The characteristics of potential environmental impacts that may arise from the disposal of excess wastewater differ between the two disposal options that are presently under review as discussed below.

(i) Sidestream Softener/Brine Concentrator

Whilst this option will provide the benefit of water conservation through the ability to re-use high quality condensate from the brine concentrator, it will also produce a high salinity concentrate that will require management. At the present time it is proposed to utilize an on-site evaporation pond to store and concentrate to dryness the high salinity concentrate.

TABLE 7.4

ASH DISPOSAL : PROBABLE SEEPAGE QUALITY

Parameter	Units	Probable Seepage Quality Muja Slurry Water	 Muja Ash Pond Water
pH	-	4.0	3.2
TDS	mg/L	2000	4628
SO_4	"	500	660
SiO_2	"	-	207
Cl	"	-	753
Ca	"	-	304
Mg	"	-	12
Na	"	-	550
K	"	-	46
Cr	µg/L	70	302
Mn	"	540	195
Fe	"	190	301
Co	"	100	552
Ni	"	210	-
Cu	"	490	180
Zn	"	710	49
Cd	"	-	55
Hg	"	-	1
Pb	"	50	20

Notes:

- No analysis available.

Ca Expressed as $CaCO_3$.

Seepage from the evaporation pond represents the greatest potential environmental impact, therefore the pond will be carefully engineered and constructed to reduce potential seepage loss to negligible volumes. One method of reducing seepage loss, which is currently being investigated, is the inclusion of a layer of sand containing a drain and pump system placed on the pond lining. This system reduces the hydrostatic head on the lining to 300mm, thus reducing the pressure which causes seepage. A network of monitor bores will be established to enable the containment of the ash water to be confirmed. Any leakage which may occur through the primary pond liner will be intercepted and collected by recovery drains situated over a secondary liner.

(ii) Ocean Pipeline

Wastewater management based on an ocean pipeline has previously been identified as a means of removing from the Collie Basin saline wastewater produced by power generation. Preliminary investigations of a pipeline discharge to the existing Bunbury Power Station cooling water outfall have been conducted. The conclusions of preliminary work have indicated that an ocean pipeline alternative may be feasible; however, further detailed environmental investigations would be required, to enable adequately reliable confirmation of environmental acceptability.

Selection of the wastewater treatment system to be used will be based on desirable water quality objectives for the Wellington Dam catchment identified by the Water Authority of WA. In the event that an ocean pipeline discharge system is found to be the preferred option, further impact and management investigations, as identified above, would be conducted to enable appropriate assessment and subsequently to ensure that the disposal operation could be safely conducted.

7.2.5 Electric and Magnetic Fields

The transmission of electric current through a linear conductor generates both an electric and a magnetic field in the space surrounding the conductor. In recent years the possibility that electro-magnetic fields may have definable ill effects on human health has received considerable research attention. The location of residential dwellings in close proximity to high voltage transmission lines, and associated facilities, has been one area of concern.

The EPA recently commissioned an investigation of the possible health effects of electro-magnetic fields caused by high voltage transmission (Scott and Furphy, 1987). The investigations measured both electric and magnetic fields in the vicinity of high voltage transmission lines in Western Australia. The results are presented in Figure 7.4.. When compared to recommended limits established by the World Health Organization (WHO, 1984, 1987), and the International Radiation Protection Association (1989), field strengths measured in WA were found to be considerably lower than recommended maximum levels.

Investigation of the human health issues determined that the present data base and research findings are not conclusive at this time. However, as a precautionary measure, buffer zones which isolate routine human presence from the zone of high field strength are now incorporated in transmission route planning.

The proposed power station will be connected to a switchyard and transmission network by a 330 kV transmission line of 3 km length. The transmission line will be located within a 60 m wide standard easement within which no dwellings or prolonged human activity will be permitted. SECWA considers this to be an appropriate level of management.

8.0 IMPACT OF THE PROJECT ON THE SOCIAL ENVIRONMENT

Collie has a historically close association with primary industry. The Mining and Electricity/Gas/Water sectors currently provide over 50% of the town employment.

The Collie Shire and local residents thus appear to view properly managed industrial developments as greatly beneficial to the town and residents. General discussion with the Collie Shire and various sectors of the community indicate that the project has general community support.

8.1 Population and Employment

8.1.1 Construction Phase

The expected variation in the construction workforce for the Collie Power Station over the eight year construction period is shown in Figure 4.7 (Section 4.7). The workforce numbers are expected to reach a maximum of approximately 820 workers in the sixth year of construction (Table 8.1).

During the construction of Muja Stages C and D SECWA estimated that 60% of the construction workforce commuted daily from Collie or Bunbury. These are considered as local workers. The remaining 40% of the workforce, the non-local component, consisted primarily of contractors using construction camps and sub-contracting personnel who utilised hotels, motels and guest house units in Collie.

During the peak construction period of the proposed Collie Power Station the non-local component of the workforce is estimated at 330 persons. This peak period will last only about six months.

It is considered that the resultant multiplier or service employment in Collie will be small. This is supported by observations during construction of the much larger Worsley Alumina Refinery, which also overlapped with expansion of Muja Power Station (Stages C and D). Multiplier employment was only affected in specific sectors of the local Collie economy (hotels, motels and the recreational industries). In effect, the project is expected to return the local economy to a level of activity which approximates the experience of previous construction periods.

TABLE 8.1

**ESTIMATE OF EMPLOYMENT IMPACT
CONSTRUCTION PHASE**

Local Component	490
Non-local Component	330
Total Direct Construction Workforce	820
Total Short-term Multiplier Employment (Preston Subdivision)	290
Total Jobs	1,110

In the broader secondary area, there has been sufficient development of the economy in recent years to lead to the creation of some service employment due to the presence of the construction workforces. Using an employment multiplier, the estimate of service employment generated would be 290. This may be high, as, depending on other projects, there may be considerable excess capacity, especially within the City of Bunbury. It is considered that the majority of these indirectly generated jobs would be filled by workers from the local area.

8.1.2 Operations Phase

Socio-economic impact of the operational phase of this type of project depends primarily on the extent of labour migration to the region. Data gathered from the Electricity Commission of New South Wales indicate that an operating power station requires at least 70% of its personnel to have extensive education, training and specialized skills. For the purposes of this analysis, it has been assumed that this labour will come from non-local sources.

With an expected minimum total power station workforce of 150, 105 would be required from non-local sources (Table 8.2). Service multiplier employment has been estimated using 0.55 workers for each basic non-local job. These additional jobs are expected to be filled from local sources.

A total population increase to the study area of approximately 250 has been estimated on the assumption that 63% of the incoming workforce would be married (based on the 1986 Census figure for Preston Statistical Subdivision).

Each married person is assumed to represent an average household size of 3.3 persons. As the socio-economic characteristics of the incoming workforce may be different from those of the existing regional population (i.e. lower percentage married, lower household size), these figures may also be considered as the upper limit for increased population due to the project.

TABLE 8.2

ESTIMATE OF EMPLOYMENT IMPACT - OPERATIONS PHASE

Workers from Local Sources	45
Workers from Non-Local Sources	105
Total Direct Workforce	150
Multiplier service employment (Mainly Local Sources)	58
Total Jobs	208

It is not considered that this number of incoming personnel would cause a significant socio-economic impact; however, it must be emphasized that this analysis has assumed that there are no other large projects in the area competing for local labour or attracting non-local labour to the Collie Shire during the same period.

The project will significantly increase local employment and reinforce the level of regional employment, which is currently high.

8.2 Community Infrastructure and Services

The influx of non-local workers for the Proposed Collie Power Station will occur gradually over a period of several years, thus allowing each service to respond over time to the increased need for that service.

Furthermore, the expected increase in demand for community services will vary significantly in relation not only to the number of non-local workers employed at a particular time, but also in relation to the proportion of construction workers versus operation workers. There will be some overlap of construction and operations personnel, however, this will not occur at the peak construction period.

8.2.1 Construction Phase

During peak construction period the non-local component of the construction workforce is expected to reach a maximum of 330 persons. Due to the itinerant nature of the construction industry the majority of these workers are expected to be unmarried and without dependents.

Because of this, and based on experience with construction of Muja stages C and D, for each non-local construction worker only 0.1 dependents are estimated to accompany the worker and reside in the area. Thus, we may expect an influx of approximately 330 workers and 33 dependents at the peak construction period, which will last for approximately six months. The essential community services in Collie, such as medical and educational services are currently operating well below capacity.

The Collie District Hospital has a capacity of 83 beds, but operates at an average of only 48-50 occupied beds.

The Collie Senior High School currently has 574 students enrolled. More specifically the school operates with 24 classes which requires the use of 27 rooms (Ministry of Education). The school has a further 2.5 rooms available to be used as classrooms, and thus would easily be able to absorb an additional enrolment of say 35 school-age dependents. Should the Collie Senior High School or one of the three primary schools in Collie not have sufficient classroom facilities to cope with a high enrolment number the Ministry of Education will be notified and additional portable classrooms will be provided, as discussed further under Operations Phase (8.2.2.).

The most significant expected impact due to the influx of non-local construction workforce will be an increased pressure on accommodation facilities. This is discussed in Section 8.3 Housing and Land Use.

8.2.2 Operations Phase

As previously discussed the essential community services in the Collie area such as medical and educational services, are currently operating below capacity, and are expected to accommodate the small increase in demand for these services.

The number of operations workers, unlike the construction workforce, will remain constant over the operational life of the Collie Power Station. Therefore, the increased demand upon community services will be more long term when compared to increased demand resulting from construction personnel.

For operation of the Collie Power Station a total of 105 workers are expected to come from non-local sources. As previously stated 63% of the incoming workforce is expected to be married, and each married person is assumed to represent an average household size of 3.3 persons. Should all of the non-local workers and their respective families reside in Collie, which is unlikely, an estimated stable increase in the Collie population of approximately 250 people will be realised as a direct result of operation of the Collie Power Station. As the population of Collie in 1886 was 9077 people (Australian Bureau of Statistics, 1986) this influx of 250 people represents a population increase of 2.75%. Because not all non-local operations workers will reside in Collie this figure will actually be lower.

As previously mentioned the Collie District Hospital has a total capacity of 83 beds, and operates at an average of 60% (48-50 occupied beds). Thus the present medical facilities will easily provide for this small increase in population, and would actually be able to cope with a far larger increase in population.

An assessment of the ability for educational facilities to meet an increased enrolment is rather more complicated. From discussion with the Ministry of Education, the additional 66 families which may reside in Collie for the operational life of the Collie Power Station, are expected to yield 33 primary students and 15 secondary students who may attend government schools.

Presently the three Government schools in Collie are operating close to capacity. Amaroo Primary School is the largest (450 students enrolled in 1989) and most central, being located just to the north west of the town centre. Because this primary school is the most central and is also located close to the newest residential subdivisions, it is considered that most of the additional primary students would attend Amaroo Primary School. In this case at least one, and possibly two, additional temporary classrooms would be required at the school. Should additional classrooms be required at either of the other primary schools they will likewise be provided by the Ministry of Education once the need is established, as follows.

All school principals complete a detailed census for the Ministry of Education twice per year covering student numbers, staff required and staff accommodation required. This census and any other requests from the principal to the Ministry of Education would initiate the provision of additional facilities.

It is likely that most of the additional secondary students would be distributed over school year levels 8,9 and 10 with perhaps a few additional students in years 11 and 12. Although one additional class may have to be formed, no additional classrooms will be required as the Collie Senior High currently operates with two rooms not being used as classrooms.

8.3 Housing and Land Use

8.3.1 Construction Phase

In Collie an extreme shortage of rental accommodation was experienced during construction of stages C and D of Muja Power Station. It appears that there was a conflict of use between construction workers and holiday/tourist users. To avoid the recurrence of this conflict of use, construction camps will be provided to accommodate up to 70% of the non-local construction workforce. The remainder of the non-local workforce is expected to reside in temporary accommodation in Collie or Bunbury.

During construction of stages C and D of Muja a peak construction workforce of 700 workers, with an estimated 300 non-local workers, was reached and this peak period lasted for about 6 months. To accommodate the construction workforce SECWA provided 30 houses for married, key personnel and major contractors also provided housing to their married, key personnel. A construction camp for up to 390 single men was established in Shotts Road South, well out of town and about 1 kilometre away from the nearest residence. The construction camp provided meals and held a liquor licence to reduce pressure on the towns facilities. The Shire Council considered the construction camp was well located and managed. As a result neither town or farm residents were inconvenienced, and no complaints were received by the Shire or SECWA.

A similar construction camp for single men will be located near the project site, out of town and isolated from all residences. Actual sites for these temporary facilities will probably be selected by the major construction contractors, however, the contractor will follow these guidelines for the selection of camp sites:

- o Location of camp sites will be subject to approval of the Collie Shire and SECWA.

- o Camp sites will not be located in vested reserves or on the flood plains of streams or rivers.

- o Where possible camp sites will be located adjacent or close to existing access roads.

- o Camp sites will not be located in areas of forest or woodland if development of the site would require felling of trees which would not otherwise occur.

- o Other things being equal, preference is to be given to sites that:

    - do not require excavation
    - have already been degraded in some way
    - have minimal visual impact.

- o If camp is to be located on a site not previously surveyed, an archaeological inspection will be carried out prior to the establishment of the camp.

- o Erosion will be minimised at the camp site by planting of vegetation, and any other erosion control measures deemed necessary.

- o The camp site, on diserection, will be rehabilitated to its previous condition by contouring and planting of vegetation.

A portion of the construction workforce which will not reside in the construction camps (up to 30%) but will reside in temporary accommodation in either Bunbury of Collie. It is anticipated that this use will not conflict with tourist/holiday use of accommodation as there will be far more accommodation available than at the time of construction of stages C and D of Muja Power Station.

Currently there are 44 hotel/motel rooms available in the town of Collie. This will be greatly increased within the next 3 years as the development of two large motels proceeds. A $1.8 million, 36 room motel complex is to proceed on Atkinson Street on the northern side of Collie, the first stage of which will be complete at the end of this year. A further 48 room hotel just to the west of Collie is also planned to commence this year (Collie Mail, 22 February, 1990).

Further hotel-motel developments have also taken place in the wider area of the Preston Statistical Subdivision, including Bunbury, thus competition between construction workers and tourists for accommodation should be minimised, if not completely eliminated.

8.3.2 **Operations Phase**

(i) Housing

The number of operations workers, unlike the construction workforce, will remain fairly constant throughout the operational life of the project. To estimate the distribution of the operations workforce of the Collie Power Station, reference was made to the Worsley Alumina Refinery. A gravity model was devised which, in the absence of specific housing policies, indicated that 48% of the incoming operations workforce would locate at Collie and the remaining 52% would locate at Bunbury. However, it is SECWA policy to provide housing for key personnel in the Collie Township.

Presently, SECWA owns 120 houses in Collie which are used by operations personnel. Some of these houses are being purchased by the staff who reside in them under a special staff purchase agreement. Forty one (41) additional lots have recently been purchased by SECWA in the Collie area and more lots will be purchased as new subdivisions are developed. These will be allocated to new housing for key personnel at the Collie Power Station.

There have recently been two large releases of subdivided residential lots in the town of Collie, providing adequate land for the projected expansion of the township. Because cheap rental accommodation is limited in the town itself, some operations personnel may be required to reside in some of the smaller surrounding towns or Bunbury.

To facilitate the operations workers living outside of Collie, SECWA currently operates a bus service between Muja Power Station and the various town centres. This service will be extended to include the Collie Power Station and other town centres, where cheap rental accommodation may be found.

(ii) Land Use

Coal mining, power generation and water production have been designated as the three highest priority land uses for the region, for the next 20-30 years. Construction of the power station will not conflict with future coal mining, nor will it unduly interfere with water production.

Development of the site will, however, alienate approximately 35 ha of grazing land. As this area constitutes less than 1% of grazing land within the Collie Basin region, the net effect on primary production will be negligible.

The power station site, including parking areas, will occupy a total of 388 ha. Surrounding the actual power station site, however, is a further 1500 ha owned by SECWA, which will act as a buffer zone. The purpose of the buffer zone is to isolate the power station operations from immediate neighbours and thus also reduce any possible noise and air pollution impact upon adjacent properties.

The buffer zone was formed by SECWA purchasing adjacent properties, over a period of many years, as they become available on the free market. Many of these properties are currently leased to individuals and families who operate the properties primarily for sheep farming. The southern boundary of the power station site has recently been moved northwards to avoid potentially economic coal seams. As such the buffer zone along the southern boundary has been reduced in places adjacent to the coal mining lease.

Given the extent of the buffer zone SECWA expects that the power station operations will not adversely impact upon neighbouring properties. This has been confirmed through detailed air pollution dispersion modelling studies and also through noise emissions modelling studies. Worst case air pollution modelling studies indicate that none of the annual, 24 hour or 1 hour Victorian Environmental Protection Authority standards for ground level concentrations of sulphur dioxide (SOx) and nitrogen oxides (NOx) are exceeded (Appendix A). Noise levels with noise control were also predicted, through detailed noise modelling, to be below the appropriate Noise Abatement Neighbourhood Annoyance Regulations, 1979 (amended 1981 and 1982) at the locations of the nearest 6 residences (Section 8.5).

Possible dust generation will be controlled by frequent watering of dust generating areas by either water-truck or an automatic sprinkler system, and thus will not impact upon adjacent residences and their operations.

8.4 Ethnography and Archaeology

8.4.1 Ethnographic Values

The three Aboriginal sites identified during the survey are all located outside the perimeter of the proposed development and will not be disturbed by project activities. The existence of these sites has been reported to the Department of Aboriginal Sites.

8.4.2 Archaeological Sites

As only one small archaeological site was recorded within the power station site, and the number of artefacts recorded was too small to provide any meaningful analyses, no further recording at the power station site is considered to be warranted. Permission to disturb this site will be sought prior to construction.

SECWA acknowledges its obligations to report any new sites that may be located during construction, as outlined in the Aboriginal Heritage Act 1972-80.

8.5 Noise

Prediction of noise emission and noise propagation from the proposed power station was made using computerized mathematical modelling techniques for the dispersion of sound. An inventory of noise source data was compiled from information obtained by measurements at the existing Kwinana and Muja Power Stations and from the Electric Power Plant Environmental Noise Guide (Bolt, Beranek and Newman Inc, 1978).

The major power station sound sources influencing noise levels at the nearest measuring position (MP3) were:

- o ID fan and stack;
- o FD and primary fan air inlets;
- o coal mills;
- o conveyors;
- o feed water pumps.

Mathematical modelling was carried out to produce a noise level contour map over an area of 56 km^2 surrounding the power station site. The modelling assumed the worst-case conditions for propagation of sound, namely calm night-time summer conditions with a thermal inversion. The results of modelling for a 600 MW power station shown on Figure 8.1, indicate a worst-case noise level of 40.4 dB(A) at Lot 4409, owned by a coal mining company and located 2.2 km south-east of the proposed power station site. Noise levels at other private landholdings within the survey area, under these worst-case conditions, were predicted to range from 22.2 dB(A) to 36.5 dB(A) (Table 8.3).

Under the Environmental Protection Act, 1986 (Noise Abatement Neighbourhood Annoyance Regulations, 1979 [amended in 1981 and 1982]), a night-time noise level of 30 dB(A) is assigned to rural areas with negligible transportation. This classification applies to those rural locations addressed in this survey.

In order to reduce power station noise to acceptable limits a variety of noise controls have been investigated for all significant sound sources. The predicted noise levels within the survey area under worst-case conditions with all these noise controls are shown on Figure 8.2 and summarized, for the residential locations, in Table 8.3. It can be seen that, if these noise controls are implemented, the assigned background noise level of 30 dB(A) will not be exceeded for any of the residential locations.

An acceptable situation may also be achieved through the purchase of a sufficiently large buffer zone. SECWA has recently purchased locations 1, 4 and 5 (refer to Table 8.3), as modelled noise levels were close to or above acceptable levels.

TABLE 8.3

PREDICTED COMMUNITY NOISE LEVELS*

LOCATION OR MEASURING POSITION NUMBER	DESCRIPTION (LAND OWNERSHIP)	NOISE LEVEL IN dB(A) WITHOUT NOISE CONTROL	WITH NOISE CONTROL
LOC 1	Lot 765 (purchased SECWA - 20/5/88)	20.0	19.1
LOC 2	Lot 786 (private)	22.2	14.2
LOC 3	Lot 785 (private)	23.0	13.7
LOC 4	Lot 1823 (purchased SECWA - 23/3/88)	36.1	24.4
LOC 5	Lot 1685 (purchased SECWA - 19/4/88)	36.5	24.6
LOC 6	Lot 4409 (Griffin Coal)	40.4	25.8
MP 1	Williams-Collie Road	24.3	11.4
MP 2	Williams-Collie Road	23.2	15.2
MP 3	Access track to Lot 1823	40.2	27.5

* Based on worst-case conditions - thermal inversion during summer, calm winds at night.

Furthermore, over a period of many years SECWA has purchased almost all private land within the modelled 35 dB(A) noise level contour as they became available on the free market . This will effectively provide a large buffer zone around the power station. The effectiveness of this buffer zone will also increase should SECWA re-establish forest vegetation around the perimeter of the buffer zone.

On commissioning of the power station SECWA will re-evaluate the situation based on actual noise level readings.

Should further action then be required, SECWA may achieve acceptable noise levels through:

(i) noise attenuation treatment of plant within the power station;

(ii) purchase of additional land to extend the buffer zone, and possible reafforestation of that land;

(iii) treatment of affected dwellings;

(iv) a combination of the above measures.

8.6 Traffic

The most recent traffic data for the Collie area were collected in 1984 in anticipation of an earlier commencement date for this project. Figure 8.3 indicates the results of the 1984 survey plus a correction factor for growth at 3% per annum. The data show that the highest traffic flows occur on Collie-Preston Road south of Throssell Street (Coalfields Road). Coalfields Road near the eastern side of Collie carries 2,000 vehicles per day whereas Coalfields Road west of Shotts Road South carries 1,400 vehicles per day. The Williams-Collie Road north of Palmer Street carries 400 vehicles per day.

It is estimated that during the peak of construction of the power station, there will be 1,660 vehicle trips during a working day including 550 trips during peak morning hours; as shown on Table 8.4. An estimated 72% of traffic produced by construction will be home based trips, with 28% non-home based trips. Sixteen per cent (265) of the daily trips will involve heavy commercial vehicles and buses.

Operation of the power station, once both units are commissioned, is expected to result in 215 vehicle trips during a weekday, including 70 trips during peak morning hours, as shown in Table 8.5.

The existing traffic and projected traffic volumes (including an allowance for growth plus the volumes due to power station construction) are well within the carrying capacities of the main roads under consideration. However, there are numerous structural and geometric deficiencies in these roads that require remedial action before increases, such as those projected, could be safely accommodated. These are detailed in engineering documents that are not strictly relevant here, but will be utilised by SECWA during project implementation.

All routes will be environmentally acceptable provided that the necessary upgrading and improvements are undertaken. The total costs of providing access, including upgrading of existing roads, were similar for each alternative. However, SECWA has marked preference for an access route that is completely separate from access to present and future mining areas and haulage routes. On this basis, the alternative route involving the Williams-Collie Road, has a significant safety benefit. Upgrading of the Williams-Collie Road will be required before this road could safely accommodate the construction traffic. SECWA will be prepared to negotiate this upgrading with the Collie Shire.

In 1984 ten percent of the daily traffic on Coalfields Road South, west of Shotts Road South, was heavy commercial traffic. This may have increased significantly as cartage contractors are currently trucking coal along this route, through the town to areas outside of Collie. The Shire has indicated that there have been no adverse impacts on the community from this heavy commercial traffic.

Two alternative transport routes between Collie and the new power station site have been considered and compared on the basis of:

- traffic and community safety.
- environmental impact,
- social impact with respect to the community and residences,
- compatibility with Collie Shire and Main Roads Department planning of new roads, and the town's growth, and
- cost of constructing new sections of road and upgrading existing section or road.

The two alternative routes considered are shown in Figure 8.4. Alternative route B is the preferred route for the construction and operations workforce, but not for coal delivery. Alternative route B is the preferred route because:

1. For traffic safety it is considered important to have general access to the power station site completely separate from access to coal haulage routes and mining areas. Using alternative route B for construction

and general access to the site will allow the new section of route A, or a similar route entering the South East corner of the site from Coalfields Road, to be used exclusively for coal delivery upon commissioning.

2. The general access route should only pass through locations free of all proposed coal mining operations. It is possible that, sometime in the future, coal mining may be extended across Coalfields Road. Should this occur the proposed Collie By-Pass Road would be constructed to provide a transport route to replace Coalfields Road. In this event the preferred route B will not be interrupted, and will actually benefit the town as most traffic will be directed around, not through, the centre of the town.

3. The preferred route B includes only existing gazetted roads, whereas route A would require access through State Forest.

4. The preferred route B is shorter.

The only disadvantage of the preferred route B is this route passes approximately 34 houses. However, once these roads are upgraded, including the provision of passing lanes, the roads will only be carrying approximately 25% of their traffic capacity. Thus traffic impact upon residences can be minimised by:

- Properly and completely sealing the road surface to reduce any possible dust generation by traffic,
- Upgrading roads and intersections, and providing passing lanes to improve safety and minimise congestion,
- Applying suitable traffic speed limits to enhance safety, and
- Planting of suitable vegetation along road verges where required to further reduce dust and noise impact.

8.7 Water Supplies

The use of water from coal mine dewatering has been selected as the preferred source of water supply for the power station. Environmental management of dewatering operations is the responsibility of the coal mining companies. The proposed new borefield will be used only for back-up supplies and will provide the security of supply that is necessary for operation of the power station. The location and layout of the proposed new borefield have been selected with the aim of minimizing the risk of interference with existing water supplies. It is unlikely, that occasional abstraction from the borefield will affect other users. The proposed expansions to the Collie Basin groundwater monitoring system should indicate any trends towards changing water tables so that the appropriate action can be taken.

In the event that mutual interference develops between the new borefield and, say, the Cardiff - South production bores, the new borefield may need to be extended to maintain the same production. In the event that shallow bores are affected, these bores may need to be deepened and additional pumping capacity may need to be provided.

8.8 Aesthetics- Exposure to Public View

Structures of the scale of the power station, particularly the larger structures, for example stacks, cooling towers, turbine hall and boilers, can not possibly be hidden from every viewpoint. However, as the power station site is located at a significant distance (3.5 km) from the nearest public road, the public visual impact will be negligible. From the Williams-Collie Road close to the junction with the access road there will be a limited view of the tops of the highest elements only. At 60 km/h this view would be exposed only for a few seconds, and would quite probably be missed altogether by the road user.

Those members of the public who have business at the station will see the major structures as they approach along the access road. Because of the low setting of the access road, the views of the station will be limited simply to those of the higher large scale components which are very much in scale with the landscape, and, properly treated, will be acceptable additions to it.

Only in the final stages of the approach will the smaller, less sightly elements be exposed. These smaller scale components can be effectively screened from the approach. Tree planting will be aimed at screening the coalyards and substation from view. Routing of the transmission lines will leave views of the major elements uncluttered when viewed from publicly accessible vantage points.

The power station and associated facilities will be major installations of impressive proportions and it can be expected that there will be considerable public interest in these facilities. In order to cater for public viewing, while avoiding the risk of interference to power station operations, a public lookout point will be established to the north of the Power Station. Viewed from this direction, the small scale components will tend to disappear in the background while the more impressive large scale elements will be well displayed.

TABLE 8.4

ANTICIPATED TRAFFIC PRODUCTION - COLLIE POWER STATION, PEAK CONSTRUCTION PHASE

TYPE OF TRAFFIC	DAILY TRAFFIC		MORNING PEAK HOUR TRAFFIC	
Home Based Trips	Number	Per cent	Number	Per cent
Site employees	1,100	66.5	480	87.3
Visitors	100	6.0	12	2.2
Sub-total	1,200	72.5	492	89.5
Non-Home Based Trips				
Regular site vehicles	260	15.5	38	6.9
Delivery vehicle	200	12.0	20	3.6
Sub-total	460	27.5	58	10.5
GRAND TOTAL	1,660	100.0	550	100.0

TABLE 8.5

ANTICIPATED TRAFFIC PRODUCTION - COLLIE POWER STATION, TWO GENERATING UNITS - OPERATIONS PHASE

TYPE OF TRAFFIC	DAILY TRAFFIC		MORNING PEAK HOUR TRAFFIC	
Home Based Trips	Number	Per cent	Number	Per cent
Site employees	180	83.7	63	92.9
Visitors	10	4.7	2	2.9
Sub-total	190	88.4	65	95.8
Non-Home Based Trips				
Regular site vehicles	25	11.6	3	4.2
GRAND TOTAL	215	100.0	68	100.0

9.0 ENVIRONMENTAL MANAGEMENT AND SAFEGUARDS

This section summarizes the environmental management programmes and the safeguards that will be implemented in the design, construction and operation of the project to avoid or alleviate adverse impacts on the surrounding environment. It also outlines the monitoring programmes that will be undertaken to measure the effects of the project, using as a baseline the environmental information collected for this ERMP.

9.1 General

9.1.1 The State Energy Commission's Environmental Policy

SECWA is committed to a policy of sound environmental management for all its power generation and transmission operations. Environmental staff are employed within its System Planning Branch and are specifically responsible for the environmental management and monitoring programmes applicable for each operation. In addition, scientific officers are attached to the Power Production Branch, where they are responsible for air and water quality monitoring programmes. Consultants are frequently appointed by SECWA to investigate and advise on environmental issues where SECWA itself does not have the necessary specialist expertise or enough permanent staff to meet the work load on hand.

SECWA has also co-operated with, and contributed to, joint planning and research programmes involving Government Departments and academic institutions. Examples are the Kwinana Air Modelling Study, the Bunbury Airshed Study and the Collie Basin Land Use Committee. SECWA has recently provided funding to Murdoch University to undertake research regarding:

(i) the efficacy of offsetting carbon dioxide emissions from power generation using coal, through a reforestation benefits study; and

(ii) the effects of SO_x on native vegetation and crops.

SECWA will continue to support co-operative programmes in the Collie region wherever they are relevant to its interests and environmental management responsibilities.

9.1.2 Greenhouse Gas Production

SECWA shares the growing community and political concern for the possible future effects of global warming as a result of the Greenhouse Effect.

SECWA also recognizes that while the implications of the increase in atmospheric concentrations of greenhouse gases are not fully or accurately known, it is prudent to adopt planning processes and engineering practices which will accommodate possible changes. Since any changes will occur slowly, there should be adequate time allowed to monitor these and to respond appropriately with changes in operation and development.

Estimates of CO_2 emissions expected from the power station have been made in an earlier section of this report. Load growth predictions, reviewed in Section 2.0, are sensitive to the Greenhouse Effect through the dependence of load on temperature, due to the electricity used for heating or cooling purposes. A general increase in mean temperature could result in greater air conditioning and water pumping peak loads in summer.

The management of power demand under varying seasonal circumstances would be required to maintain a balance between base load, intermediate and peak load plant to ensure that peak demands could also be met. This energy balance could be met while reducing carbon dioxide emissions by the following programmes:

(i) Studies continue into the methods of improving energy conversion efficiencies of boilers and turbines. Improvements to boiler/turbine efficiencies result in the consumption of less fuel and decreased CO_2 emission from power generation operation.

The use of combined cycle gas turbines is being investigated where an increase in overall plant efficiency (from approximately 31%-50%) would result in a decrease in CO_2 emission of approximately 36.5%.

The introduction of gas turbines to function in a peak lopping mode will enable coal-fired plant to be operated solely as base load stations. This will result in an energy utilization efficiency increase of 5 percentage points arising from the low fuel consumption during cold start-up of gas turbine plant compared to coal-fired boiler plant. There will also be a commensurate reduction in CO_2 generation for each coal-fired plant cold start-up that can be eliminated using gas turbine plant.

In the short term, increasing the loading on the higher efficiency plant presents an opportunity to increase overall energy conversion.

(ii) SECWA is presently examining the potential to establish cogeneration schemes within existing industry. By using gas turbine plant burning natural gas and generating steam from a waste-heat recovery boiler for use as low grade heat in industry, electricity can be generated at high conversion efficiency and with reduced CO_2 emissions for each unit of electricity generated. Opportunities to establish cogeneration in Western Australia are limited due to a lack of industries that could participate in such a scheme.

(iii) SECWA will continue to support research into the utilization of renewable energy resources, particularly wind energy and solar energy. SECWA has recently established a Renewable Energy Branch which will deal with all aspects of renewable and alternative energy use in SECWA's systems. Specifically, the Branch will be responsible for:

- o Obtaining and maintaining information on world trends in the application and use of renewable energy and the associated technology and techniques.

- o Representing SECWA on numerous renewable energy committees and Boards.

- o Investigating prospects for energy conservation and the improved management of energy use.

- o Undertaking and promoting research, development and demonstration projects relevant to energy conservation, energy management and the use of renewable energies.

- o Liaising with organizations outside SECWA about renewable energy issues.

- o Reducing SECWA's present losses from electricity systems in isolated country areas, through energy conservation, improved energy management and the use of renewable energy technologies.

(iv) In accordance with Government Policy and in recognition of fuel cost constraints, SECWA will continue to examine means by which natural gas can be used more extensively for electricity generation. Implicit in this will be a continuation of SECWA's willingness to purchase gas from new discoveries that is competitively priced for use in electricity generation.

(v) SECWA is committed to the efficient utilization of energy by consumers and has in place a broad based programme of information dissemination and education. Relevant aspects of this programme include:

- o Encouragement of natural gas installations in domestic residences to enable efficient direct use of energy for cooking and water heating.

- o Promotion of improvements to labelling of gas and electrical appliances to encourage efficient usage.

- o An energy Education Programme for schools involving the provision, by a full time education officer, of services and materials including:

  - An energy information pack in every school in the State (a comprehensive collection of publications on every energy-related subject).

  - A series of videotape productions available in Ministry of Education Audio Visual libraries.

  - Tours of SECWA installations - museum, power stations and wind turbines.

  - Guest speaker service on electrical safety and energy management in the home.

- Competitions on electrical safety and energy management.

- Deployment through the Marketing Branch of energy advisory officers to help new domestic users of energy choose the correct appliances. A very large showroom has been established to help people in this regard. SECWA officers also go out to builders, architects and developers to assist them.

(vi) Following the Greenhouse 1988 Conference held in Perth in November 1988, it was suggested that CO_2 offset targets could be met by the planting of trees and other appropriate vegetation to absorb the amount of CO_2 entering the atmosphere from new developments, such as power stations.

SECWA has recently provided funding to Murdoch University to determine the optimum approach to offsetting carbon dioxide generation. The outcome of these investigations may involve the planting of suitable vegetation in appropriate areas in the most cost effective manner, consistent with other Government environmental objectives.

It has been estimated that the carbon dioxide absorption rate of growing forest in southern Australia could vary widely from about 5-60 tonnes/ha/annum, depending on a range of factors including location soil type, species and cultivation factors. Therefore, for a tree planting programme to provide a substantial offset to carbon dioxide production from electricity generation, very large areas of plantation will need to be established.

A tree planting programme could be executed in many ways, from providing materials to interested groups, to professional tending of plantations. As the greatest CO_2 absorption occurs in the rapidly growing phase, new forests would need to be continually planted and mature forests could then be harvested for timber, thus locking away the CO_2 extracted from the atmosphere. If the timber produced were of commercial value, this might be sold to recoup some part of the initial costs and possibly return a profit.

9.1.3 Buffer Zone

The acquisition by SECWA of property surrounding the power station site will ensure that there is no encroachment of residential development within the zone of significant noise impact. The acceptable management of noise effects is discussed in section 9.2.5. Air dispersion modelling results indicate that ground level concentrations of gaseous emissions from the station will be within acceptable limits, even close to the station.

9.2 Design and Operations Planning

The design of plant and planning of the construction works will include a range of measures intended to reduce environmental impact. Limitation of the area requiring clearing or disturbance, control of dust, runoff and erosion, implementation of correct dieback hygiene procedures and minimization of all waste and process discharges to the environment are common goals in all areas of project management. Investigations of the potential to reduce greenhouse gas production through the improvement of operational efficiencies are also underway. The specific environmental management initiatives that will be implemented are summarized below.

9.2.1 Efficiency in Energy Production

Methods that are being examined by SECWA to enable improvements to the energy conversion efficiencies of electricity generation are discussed in Section 9.1.2 (i).

9.2.2 Removal of Particulates from Boiler Emissions

Electrostatic precipitators will be used to remove fly-ash from the boiler exhaust gases. This is expected to result in extraction of a minimum of 99.5% of ash from the boiler emissions, for subsequent discharge into the ash storage area. The remaining fraction, which will amount to approximately 1.4 tonnes per day, will be discharged, together with the gaseous combustion products, through the power station's stack. The plume from the station will be invisible except during short duration start-up periods when oil is used to fire the burners.

9.2.3 Dispersion of Gaseous Combustion Products

Ground level concentrations of contaminants within the boiler exhaust gases will be minimized by discharging the emissions from a 130 m stack. Dispersion modelling studies indicate that a stack of this height will be sufficient to ensure adequate dispersion of all emissions, and that no other controls are necessary.

9.2.4 Water Supply Bores and Pipelines

The corridors of land disturbance, necessary to implement the water supply and transmission system, require particular attention to clearing hygiene and future maintenance of access.

Appropriate management steps include:

- Liaison with the Department of CALM personnel to develop best practicable management techniques where protectable forest exists.

- Siting rights-of-way parallel with existing corridors where practicable.

- Limiting clearing activities to periods of dry soil conditions.

- Washdown of machinery before entry to dieback-free areas and on exit from infected areas. To minimize the need for washdowns, the contractor may choose to clear all protectable areas and all non-protectable areas separately.

- Ongoing inspections and maintenance confined to dry soil conditions wherever possible. Urgent repairs would be expected to occur infrequently.

9.2.5 Noise Control

Planning and design of the power station and infrastructure will aim to limit noise emissions beyond the power station property boundary to 40dB(A) at the nearest residence. Should the situation arise combination of measures will be implemented to limit noise nuisance at neighbouring residences. These will (or may) include:

- Attenuation of noise emissions from various items of plant. Attenuation will be achieved by such means as acoustic lagging or enclosures, fitting of silencers and preferential selection of low noise equipment.

- Provision of an exclusion zone to preclude encroachment of new residences.

- Treatment of individual residences to limit annoyance.

9.2.6 Ash Disposal

Investigations have determined that the disposal of ash produced by the power station will be conducted by high density slurry disposal or dry/moisture conditioned ash disposal. These methods have the following environmental advantages compared to alternatives:

(i) lower process water requirement than alternatives;
(ii) lower requirement for land due to higher stacking density;
(iii) lower leachate generation potential;
(iv) greater ease of rehabilitation of disposal areas.

Current studies indicate that on-site disposal using high density slurry may prove to be the most appropriate method in terms of operational efficiency and environmental management. SECWA is firmly committed to rehabilitation of the ash storage area. Management of the area will continue beyond the date of retirement of the station until such time as the storage can be left without risk of inundation, erosion or exposure of unneutralized ash.

Rehabilitation will be conducted progressively and will involve the following steps subject to refinement during the course of operational experience:

(i) Placement of a clay capping layer overlain by a suitable thickness of topsoil.

(ii) Establishment of surface and subsurface drainage so that ponding does not occur following winter rainfall, thus preventing waterlogging at the surface and minimizing infiltration.

(iii) Planting of appropriate vegetation.

Once the surface has dried sufficiently, no difficulties are envisaged with establishment of vegetation. Disused ash storage areas at Kwinana and South Fremantle have been successfully revegetated with both pasture species and native vegetation. The selection between pasture species and native vegetation for rehabilitation of the ash disposal site will depend on plans for the power station site once the station itself has been retired. Assuming that the site will continue to be used for some type of public purpose, revegetation with native species would be preferred as this would require less maintenance.

9.2.7 Management of Wastewater

The need to minimize the discharge of saline water to the Wellington Dam catchment will be a primary consideration in the selection of the wastewater management scheme for the power station. The wastewater management system will be designed to meet water quality objectives for the catchment that have been defined by the Water Authority of WA.

Environmental management criteria that will be incorporated, as appropriate, in the design of the wastewater management system will include:

(i) Maximum re-use of process water

(ii) Appropriate engineering design and site work to reduce leakage from storage ponds that may be constructed.

(iii) Permanent containment on-site of salt imported to the power station in process water and coal, using evaporative concentration and secure storage in a pond with minimized leachate potential.

(iv) Monitoring of the containment performance of wastewater ponds that may be constructed using a monitor bore network.

(v) Alternatively, salts imported to the power station may be exported from the Collie Basin to environmentally acceptable ocean disposal.

(vi) Treatment by appropriate processes of all excess water prior to removal from the power station to disposal.

Any highly toxic wastes such as reagents from the chemical laboratory will be removed to an approved site for disposal if required. Quantities of hazardous wastes are expected to be very small.

9.2.8 Forest Hygiene

Forest hygiene practices set down and supervised by the Department of CALM are used to guide activities in forest where there is a risk of spreading jarrah dieback disease. Through past construction of power stations, transmission lines, pipelines and roads within State forest, SECWA has developed experience in the implementation of these hygiene practices.

Hygiene practices include:

- Consultation with Department of CALM personnel during initial planning stages to avoid, where practicable, sites and routes that involve a high risk of the spread of dieback into previously unaffected areas.

- Regulation of clearing activities in high risk forest.

- Avoidance of forest clearing activities during the winter and spring months when the risk of spreading the disease is highest. Forest clearing activities during summer and autumn are temporarily discontinued in the event of rainfall exceeding 7 mm.

- Washdown of vehicles prior to site entry. Once on-site, large earthmoving machinery will normally remain within the work area.

- Vehicles leaving areas infected by dieback are thoroughly washed using a weak copper sulphate solution to remove disease-infected soil prior to entering die back-free areas. These provisions are written into all SECWA's construction contracts affecting areas of State forest (SECWA, 1987).

- Site entry and exit limited to one sealed access route which will become the final Power Station Access Road.

While forest hygiene measures are appropriate throughout this project, there will be variations in emphasis depending on the nature of the activity. Power station, ash pond and water storage construction will necessitate intensive activity over a high proportion of a limited area. On the other hand, road and pipeline construction are extensive by nature but involve only a very small proportion of any given region. They therefore have the potential to infect large areas, if hygiene practices are not effective.

9.2.9 Measures to Minimize Visual Impact

(i) Construction

A landscape architect will be engaged by SECWA to develop appropriate site planning strategies, by which the visual impact of the project can be minimized by setting the development into the landscape rather than imposing upon it. Cost savings in earthworks and land clearance occur as an additional incentive to the aesthetic benefits.

During earthworks, the existing landscape will not be unduly disturbed, unless it is necessary for the construction and proper functioning of the power station. The less the landscape is disturbed, the better the integration of the development with the landscape. Retention of existing trees, shrubs and pasture will reduce post construction landscaping and erosion control; thus clearing will be limited to the minimum area required for construction.

The following criteria will be implemented to achieve minimum disturbance:

- Clearance of vegetation and topsoil will be limited to those areas where such clearance is necessary.

- Where practicable, temporary works areas such as construction offices and laydown areas will occupy space which has to be cleared for permanent construction.

- Access for construction purposes will follow the permanent access road alignment at the outset. A temporary surface may suffice during the construction period, but no other new temporary roads or tracks will be permitted.

- o Topsoil which is necessarily stripped will be stored and re-spread as soon as possible over areas to be rehabilitated such as batter slopes and road verges.

- o Screen planting, where required, will be undertaken at an early stage. Some areas may be identified where a vegetation screen could be planted even before construction commences. In this way considerable growth can be achieved by the time the station is commissioned and subject to public access.

- o Detailed management strategies will be formulated prior to construction, incorporating the above criteria and addressing the long term management of the surrounding land.

(ii) Vehicle Movement and Parking Areas

As both workers and visitors will gain access to the power station site along the same access road, the location of parking facilities will be planned to provide the users with clear directions. Design criteria for car parks will include provision of trees for shade and screening.

(iii) Transmission Lines and Substations

These associated facilities are amongst the most important for landscape consideration. The substation, to be located 3 km north-east of the power station, will require tie-in transmission lines from the station. A detailed programme of screen plantings and other landscape treatments will be developed for these facilities.

(iv) Coalyards

The coal handling area is to be located on the southern boundary of the power station site. A programme of earthworks and vegetation screening will be developed in conjunction with plans for the access road into the site.

(v) Ash Disposal Area

The ash storage will be naturally screened from major viewpoints, except from the ridges to the north. All external batters will be vegetated with pasture species so that the embankment will blend in with the surrounding valley slopes.

(vi) Access Road

The route of the access road on its final approach into the power station site will be carefully selected and appropriate screening or visual improvements formulated to reduce the adverse impacts of the less sightly elements of the power station.

9.3 Construction Phase

The primary environmental management task during the construction phase will be the supervision and implementation of management initiatives outlined in the previous section.

During periods of dry weather, dust control will be achieved using traditional water spray methods in areas of heavy traffic or soil storage areas.

Earthworks construction contracts will include provisions for control of drainage to minimize erosion by surface runoff. Diversion channels above and below batters and around the perimeter of cleared areas will assist erosion control and allow turbid runoff to be directed to sediment traps.

Where possible, cleared areas will either be sheeted with gravel, sealed with asphalt or rehabilitated with vegetation as soon as possible following completion of earthworks. Contractor's laydown, delivery, parking and office areas will all be located within the boundaries of the initial site preparation activities.

There are no ethnographic sites known within the project area that require protection. Any archaeological sites that are revealed during construction will be reported to the WA Museum with a request for prompt advice and, if appropriate, permission to proceed with construction.

9.4 Stabilization, Restoration and Rehabilitation of Disturbed Areas

9.4.1 General

Minimization of ongoing dust potential, erosion, and visual impacts will require all areas that are disturbed during construction to be stabilized or restored as soon as possible either during construction or at completion of activities.

Preparative measures to assist the implementation and success of this work have been described in previous sections, and can be summarized as follows:

(i) Minimization of the areas of disturbance will reduce the requirement for restoration.

(ii) Proper storage and management of topsoil recovered from construction sites or operations areas will optimize the results of its use in restoration work.

(iii) Cut and fill batters will be benched to facilitate retention of returned topsoil.

(iv) Replanting of disturbed areas will utilize species appropriate to the future use of the land.

Grass and pasture species will be utilized for areas cleared for future extensions, with appropriate landscaping using natural trees and shrubs.

(v) Particular attention will be paid to areas of cut and filled outslopes around the perimeter of the power station area. Slopes will be graded to 1 in 3 or flatter and berms will be constructed on the batters at vertical intervals not exceeding 2 m. Topsoil will then be applied to the graded batters. Planting will be with a mixture of native shrub and groundcover species or with grass and pasture species, depending on the existing vegetation of the particular location.

Water and ash storage embankments will be similarly treated except that revegetation will utilize grass and pasture species similar to those already in use on the site. Hydro-seeding or haymulching will best provide rapid stabilization of such slopes.

9.4.2 Revegetation of Road and Water Supply Easements

SECWA will apply its Environmental Specifications for Transmission Lines to road and water supply easements, as appropriate (SECWA, 1987). These specifications will be suitably modified to incorporate currently accepted practices adopted by other authorities involved in similar works. The access road will extend 4.7 km from the existing Williams-Collie Road to the plant site.

Water collection pipes throughout the borefield will be installed underground, while transfer pipes will be above ground. There will be approximately 16 km of collection pipes and 17 km of transfer pipes.

SECWA has specific recent experience with the revegetation of the Dampier to Perth gas pipeline. Guidelines to be applied to water transfer pipelines will include:

(i) Clearing will be kept to the minimum practical requirement - normally 10 m for pipelines and as governed by site conditions for the access road.

(ii) Underground collection pipes will be installed by stripping topsoil to a windrow, trenching and backfilling, followed by topsoil return.

(iii) Seed of native or pasture species, as appropriate to the surrounding vegetation, will be sown.

(iv) A single lane access track will be maintained along all easements, with appropriate diversion bars to direct runoff from the track onto stable vegetation.

(v) Above ground transfer pipes will be installed on a levelled and graded strip of a maximum width of 5 m, from which all trees, undergrowth, scrub, stumps and large rocks have been removed. Natural regeneration from the topsoil will be retained, with the exception of trees and shrubs which may become large enough to interfere with the pipeline. These will be removed periodically.

(vi) The advice of the Landscaping Section of the Main Roads Department (MRD) will be sought on road verge regeneration.

(vii) Good quality topsoil from beneath native vegetation will be windrowed for return to completed verges.

9.4.3 Reforestation Programme

SECWA recognizes its statutory obligation to revegetate and stabilize temporarily disturbed areas and to contribute to the reforestation of Wellington Dam catchment.

Legislation passed in 1976 under the Country Areas Water Supply Act requires reforestation of previously cleared land to offset new land clearing. Under this programme SECWA has purchased a total of 712 ha of cleared land, mainly to the east of Collie township. Approximately 503 ha of this land has already been planted, and planting of the remaining 209 ha is currently in progress. SECWA will undertake further planting of Eucalyptus trees over an area equivalent to the area within Wellington Dam catchment which is cleared for the power station project, which includes the power station site, borefield, pipelines, tracks and transmission lines. It is expected that the total area will be less than 250 ha.

Considerable expertise in reforestation is available from the Department of CALM, based on previous experience on farmland, minesites and other disturbed land in the jarrah forest environment. This expertise will be used in the formulation of the reforestation prescriptions for offset replanting of the farmland owned by SECWA. Standard replanting techniques comprise:

(i) Ripping of planting lines to a depth of 300 mm along the contours at approximately 4 m spacing.

(ii) Elimination of pasture plants from the planting lines using herbicide spray.

(iii) Planting of tree seedlings at 4 m spacing in June/July. Species will be those recommended by the Department of CALM.

(iv) Hand fertilization of each seedling with granulated fertilizer containing major and minor essential nutrients.

(v) Winter establishment which will obviate the need for any follow-up watering.

9.5 Operations Phase

Environmental management will be a routine ongoing component of the operational works conducted at the power station. The primary environmental management works will be conducted in two programmes:

(i) Monitoring and inspection of waste handling facilities and waste disposal areas will be routinely conducted to ensure they are operating correctly and efficiently at all times. Methods of improving waste handling and disposal that become apparent as a result of operational experience will be implemented where practical and economic.

(ii) Monitoring of the surrounding environment will also be conducted on a routine basis. A number of monitoring programmes will be implemented as appropriate, including those described in following sections.

9.5.1 Air Quality

As discussed in Sections 4.6 and 7.2.1 the use of electrostatic precipitators for removal of fly-ash, and construction of a chimney stack to ensure dispersion of gaseous emissions, are expected to maintain the concentrations of airborne particulates well within acceptable limits.

A stack emissions and ambient air quality monitoring programme will be undertaken to confirm model predictions for ground level and air quality.

Prior to commissioning of the first unit, an automated monitoring base station will be established in a location which could be expected to experience relatively high ground level concentrations of plume constituents. The base station will be equipped with a continuous sulphur dioxide monitor and high volume sampler to measure particulate concentrations. Meteorological instruments will continue to be maintained at the base station and in the vicinity of the power station. Stack emission monitoring will also be undertaken for sulphur dioxide, nitrogen oxides and particulates.

Since the concentration measured at the base station will be strongly dependent on wind direction, there will be no difficulty in identifying contributions from the various sources (i.e. Muja, Worsley Alumina or the new station). The purpose of the monitoring programme will be to provide a data base for validation of the computer model predictions, particularly for morning situations where the plume is penetrating through, or being trapped under, temperature inversions.

The management of greenhouse gases that will be produced by the power station is a further major area of environmental investigation and management (see Section 9.1.2). SECWA has recently provided funding to Murdoch University to determine the optimum approach to offsetting carbon dioxide generation from power production through the establishment of reforestation programmes. The findings of this research will be incorporated as appropriate in SECWA's overall environmental management operations. Further air quality monitoring programmes that will be supported by SECWA are discussed in Section 9.5.5 (i).

9.5.2 Groundwater

(i) Power Station Site

Networks of groundwater observation bores will be established around the ash disposal pond and the evaporation pond.

Monitoring will commence prior to commissioning of the station to ensure background concentrations are known. Results will be provided to the relevant licensing authority. Groundwater in these bores will be tested for pH and conductivity at monthly intervals. Biannually, and at other times if pH or conductivity values are anomalous, a range of cations and anions will be measured, including: mercury, sodium, potassium, calcium, magnesium, cadmium, iron, manganese, lead, copper, cobalt, chromium, zinc, sulphate, chloride, nitrate, phosphate.

(ii) Collie Coal Basin

For monitoring the effects of groundwater abstraction, SECWA has access to over 100 observation bores in the Collie Basin. The majority of these bores were developed by SECWA during an extensive study of the Collie Basin groundwater resources. Some of these bores have been used to monitor water levels since 1977. The monitoring programme is aimed at providing data to enable a better understanding of the hydrology of the basin and for assessment of the effects of the existing borefields.

SECWA is currently reviewing the existing water monitoring programme with the licensing authority, the Water Authority. Before the new borefield is developed the monitoring network will be extended as required to ensure that groundwater levels are monitored in those areas which have been identified as being at risk from declining water tables.

Groundwater levels in observation bores in the Collie Basin aquifer subcrop areas will be monitored on a quarterly basis or as otherwise agreed with the licensing authority.

9.5.3 Management of Water Supplies

The over-riding consideration in management of power station water supplies will be the maintenance of water quality, particularly ensuring that the pH and levels of iron, sulphate, aluminium and silica remain within acceptable limits.

All water storage and wastewater storage ponds at the power station will be sampled at monthly intervals and the samples analysed for pH, TDS and a range of cations and anions.

However, wherever it is consistent with these quality requirements, priority will be given to use of water from mine dewatering.

The power station's water and wastewater system will allow for considerable flexibility in storage and disposal of the various supply and effluent streams.

Water streams will be monitored regularly for dissolved salts, pH and contaminants. Levels of the storages will also be monitored to ensure that there is no interruption to supply and to ensure that there is no avoidable wastage by overflow from storage.

9.5.4 Flora and Fauna

Two programmes of vegetation monitoring are proposed.

(i) Forest Eucalypt Monitoring

Research conducted recently at Murdoch University (Murray and Wilson 1988a, 1988b, 1988c) has examined the effects of sulphur dioxide and hydrogen fluoride exposure on the important forest tree species Eucalyptus marginata (jarrah) and Eucalyptus calophylla (marri). The commercial crop plants wheat and barley were also examined in this context. The investigations utilized measurements of the surface area and weight of both immature and mature eucalyptus leaves under various conditions of exposure to sulphur dioxide and hydrogen fluoride. It is proposed to establish a monitoring programme to measure the effects of emission of these gases from the power station on the surrounding forest. The programme will have the benefit of existing cause and effect measurements specific to common forest eucalypt species. The objective of monitoring will be to confirm the findings of atmosphere dispersion modelling, which indicates ground level concentrations of these gases should not impair the biological viability of State forest areas surrounding the station.

(ii) Wetland Vegetation

Monitoring transects and reference quadrats will be established in areas identified as being most at risk from groundwater drawdown and secure from disturbance by mining activities and intentional human activities. These areas will be inspected biannually in late summer and late winter, when assessments will be made of changes in vegetation density and species composition. Should this monitoring and the groundwater observation programme indicate that changes are occurring, consideration will be given to modification of the groundwater abstraction programme in the light of the results.

9.5.5 Noise

Following commissioning of the power station, a noise survey will be carried out to measure noise levels within and around the power station site. This survey will show whether or not the noise levels around the site are within the predicted levels and will identify any plant items which are generating noise above the specified levels. If this survey indicates that noise levels are excessive, further noise controls or other remedial action will be implemented.

9.5.6 Social

During construction and continuing into the first years of operation, SECWA will consult closely with personnel from the Shire of Collie to assist in identification and resolution of any conflicts that may arise due to the influx of non-local workers into the community. A social monitoring programme will be implemented to assist in assimilation of the non-local workers into the local community. One of SECWA's officers will be appointed to co-ordinate meetings with the Deputy Premier's Department Social Impact Unit, South West Development Authority, Collie Shire Council and social welfare groups to advise on and assist in the resolution of any housing, education and social welfare issues that arise.

9.5.7 Reporting

SECWA will prepare an annual report comprising all the monitoring data obtained in the various programmes described above. It will assess the adequacy of the programmes and outline any changes necessary to ensure all environmental commitments are achieved.

All necessary reporting of monitoring data in relation to groundwater, surface water, air quality and wetland vegetation condition will be reported as required to appropriate regulatory authorities.

9.6 Summary of Environmental Management Commitments

General Commitments

1. The proponent will adhere to the proposal as assessed by the Environmental Protection Authority and will fulfil the commitments made below.

2. The power station will be constructed and operated according to relevant Government statutes and agencies' requirements, including those of the following:

    - Environmental Protection Authority;
    - Water Authority of W.A.;
    - Department of Conservation and Land Management;
    - Department of Occupational Health Safety and Welfare;
    - Shire of Collie.

Design and Planning

The proponent is committed to:

1. the removal of all fly-ash particulate matter in excess of $0.08g/m^3$, which is a National Health and Medical Research Council (NH&MRC) Guideline for New Plant (1985), from the boiler exhaust gases by the use of electrostatic precipitators, to the satisfaction of the Environmental Protection Authority.

2. the design of the power station boiler to limit nitrogen oxide (NOx) emissions to $0.8g/m^3$, which is the NH&MRC Guideline for New Plant (1985), to the satisfaction of the Environmental Protection Authority.

3. the design of the power station and a suitably constructed chimney stack to limit the ground level concentrations of sulphur dioxide (SO_2) to comply with Victorian Environmental Protection Authority's Acceptable level of $486\mu g/m^3$, one hour average; NH&MRC's ambient air quality goal of $60\mu g/m^3$, twenty four hour average.

4. planning and design of the power station to limit noise emissions beyond the power station property boundary to 40dB(A) at the nearest residence, to the satisfaction of the Environmental Protection Authority.

5. the design of a coal ash disposal method which will meet the environmental management requirements established in the licence conditions set by the Water Authority of Western Australia for the Wellington Dam Catchment.

6a. the design of a wastewater management process which will meet effluent discharge quality criteria consistent with achieving the water quality objectives for the Wellington Reservoir which have been defined in the Draft Water Resources Management Strategy for the Collie Coal Basin. These criteria will allow no discharges with salinity in excess of 550mg/L TDS to be discharged into the surface waters of the coal basin, to the satisfaction of the Water Authority of Western Australia.

6b. should an ocean pipeline be identified as a means of removing from the Collie Basin saline wastewater produced by power generation, the proponent shall seek full environmental approvals for the proposal, to the satisfaction of the Environmental Protection Authority.

7. minimising the visual impact of the power station by the engagement of a landscape architect early in the design phase and prior to commencement of construction.

8. taking account during design stages, of forest hygiene requirements, to avoid, where practicable, sites and routes that involve a high risk of the spread of dieback into previously unaffected areas, by early consultation with, and to the satisfaction of, the Department of Conservation and Land Management.

<u>Construction Phase</u>

The proponent is committed to:

9. conducting a social monitoring programme during the construction and operations phase and liaising with the Deputy Premier's

Department Social Impact Unit, South West Development Authority, Collie Shire Council and social welfare groups to assist in the resolution of any housing, education and social welfare issues that arise from this proposal to the satisfaction of the Local Authority and the Environmental Protection Authority.

10. controlling dust nuisance by water application via sprinkler or truck in areas of heavy traffic or soil storage, to the satisfaction of the Environmental Protection Authority.

    In the event of complaint relating to nuisance dust from construction activities, the proponent will investigate and take appropriate remedial action to the satisfaction of the Local Authority and the Environmental Protection Authority.

11. minimising water erosion due to surface runoff during earthworks by ensuring that earthworks construction contracts will include provision for control of drainage. Diversion channels above and below batters and around the perimeter of cleared areas will assist erosion control and allow turbid runoff to be diverted to sediment traps to the satisfaction of the Environmental Protection Authority.

12. minimising ongoing dust potential, erosion and visual impact by stabilisation or restoration of disturbed areas as soon as possible following construction, to the satisfaction of the Environmental Protection Authority and other relevant authorities.

Measures implemented will include:

- (i) Minimisation of the areas of disturbance.
- (ii) Proper storage and management of recovered and returned topsoil.
- (iii) Replanting of disturbed areas with appropriate species.

13. initiating investigations and issuing a report to the Western Australian Museum in the event that any archaeological sites are revealed during construction. If appropriate, permission to proceed will be obtained before construction commences.

14. revegetating and stabilising temporarily disturbed areas, and contributing to reforestation of the Wellington Dam Catchment, in accordance with its obligation under the Country Areas Water Supply Act, 1976, to the satisfaction of the Water Authority of W.A.

15. the incorporation of dieback hygiene procedures within all earthworks construction specifications in areas of dieback infection, and protectable forest in accordance with and to the satisfaction of the Department of Conservation and Land Management.

Operations Phase

The proponent is committed to:

16. an emissions and ambient air monitoring programme.

    The emissions monitoring programme will confirm that stack emission specifications for particulates and nitrogen oxides (NOx) comply with the relevant guidelines as expressed under commitments 2 and 3. Measured levels of SO_2 will also be taken at the stack.

    The ambient air monitoring programme will be affected by the establishment of an automated monitoring station equipped with a continuous sulphur dioxide monitor and high volume sampler to measure particulate concentrations.

    The resulting levels of sulphur dioxide and particulates measured will be used to validate computer model predictions of ambient air quality for sulphur dioxide and particulates.

    The above monitoring programme will be to the satisfaction of the Environmental Protection Authority. In the event that relevant guidelines for ambient air quality are not complied with, the proponent will develop operational strategies to mitigate unacceptable air quality events to the satisfaction of the Environmental Protection Authority.

17. installing networks of groundwater observation bores around the ash disposal pond and storage ponds containing saline water. Monitoring

will be conducted at intervals agreed to by the Water Authority of W.A. In the event that monitoring indicated leakages that could have significant environmental impact, remedial strategies will be formulated and implemented to the satisfaction of the Water Authority of W.A. and the Environmental Protection Authority.

18. extending the existing network of regional groundwater observation bores in the Collie Basin as necessary to cater for the proposed new borefield and to ensure groundwater levels are monitored in those areas that have been identified as being at risk from drawdown. The monitoring programme and reporting of results will be to the satisfaction of the Water Authority of W.A. In the event that monitoring indicated drawdown is occurring to the detriment of either existing groundwater users or to local wetlands, remedial strategies will be developed by SECWA to the satisfaction of the Water Authority of W.A. and the Environmental Protection Authority.

19. establishing monitoring transects and reference quadrats in wetland areas identified to be at most risk from drawdown and assessed at appropriate intervals to determine whether changes to species composition or structure are occurring. Should significant detrimental changes to wetland vegetation be indicated by monitoring remedial strategies will be formulated by SECWA to the satisfaction of the Department of Conservation and Land Management and the Environmental Protection Authority.

20. developing a vegetation monitoring programme to measure the effects of atmospheric emissions from the power station on the surrounding forest. In the event that monitoring identifies unacceptable detrimental effects, remedial strategies will be formulated by SECWA and implemented to the satisfaction of the Department of Conservation and Land Management and the Environmental Protection Authority.

21. controlling dust nuisance from the on-site coal storage and crushed coal stockpiles by the use of water sprays.

22. maintaining an annual audit of the greenhouse gas, carbon dioxide which results from the burning of Collie coal, to the satisfaction of the Environmental Protection Authority.

23. implementing a noise survey following commissioning of the power station to confirm model predictions of noise levels established at various locations outside the SECWA property boundary. If the survey indicates that noise levels are excessive, remedial strategies will be formulated and implemented to the satisfaction of the Environmental Protection Authority.

Decommissioning

24. The usual life expectancy for a coal-fired power station is 30-40 years. Once decommissioned the power station will be used for public purposes which have yet to be determined. Rehabilitation of the site including appropriate management of solid and liquid wastes will be a pre-requisite to future use of the area and will be carried out to the satisfaction of the Environmental Protection Authority.

10.0 BIBLIOGRAPHY

AUSTRALIAN BUREAU OF STATISTICS (1983). Australian Year Book. Australian Government Publishing Service, Canberra.

AUSTRALIAN BUREAU OF STATISTICS (1986). Census 86 - Small Area Data. Australian Government Publishing Service, Canberra.

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED (1983). South West Power Station - Raw Water Supply Borefield - Report No. 1016. Prepared for State Energy Commission, October 1984.

BOHN, H.L., B.L. McNEAL and G.A. O'CONNOR (1979). Soil Chemistry. John Wiley and Sons, New York.

BOLT, BERANEK and NEWMAN INC. (1978). Electric Power Plant Environmental Noise Guide, Volume 1, Eddison Electric Institute. 50 Moulton Street, Cambridge, MA.02138. Report 3637.

DELL, B., J.R. BARTLE and W.H. TACEY (1983). Root occupation and root channel of jarrah forest subsoils. Aust. J. Bot 31, 615-627.

DEPARTMENT OF HEALTH (1980). Desirable Quality for Drinking Water in Australia.

DEPARTMENT OF RESOURCES DEVELOPMENT (1985). Community Needs Study, A Socio-Economic and Social Impact Assessment of the Proposed Kemerton Aluminium Smelter.

ELECTRIC POWER RESEARCH INSTITUTE (1982). Scrubbers; The Technology Nobody Wanted. EPRI Journal, October 1982.

ELECTRICITY SUPPLY ASSOCIATION OF AUSTRALIA (1989). Environmental Committee Survey "Emissions of Greenhouse Gases 1986/87 to 1996/97.

ENVIRONMENTAL PROTECTION AUTHORITY (1988). Proposed Harvey-Kwinana 330 kV Transmission Line State Energy Commission of WA. Report and Recommendations of the Environmental Protection Authority. Bulletin 338. Perth WA.

HART, B.T. (1974). A Compilation of Australian Water Quality Criteria. Department of the Environment & Conservation, Australian Water Resources Council, Technical Paper No. 7, Australian Government Publishing Service, Canberra.

HAVEL, J.J. (1975a). Site-Vegetation mapping in the Northern Jarrah Forest (Darling Range) I. Definition of Site-Vegetation Types. Forests Department Western Australia Bull. No. 86.

HAVEL, J.J. (1975b). Site-Vegetation mapping in the Northern Jarrah Forest (Darling Range) II. Location and Mapping of Site-Vegetation Types. Forests Department Western Australia Bull. No. 87.

INTERNATIONAL RADIATION PROTECTION ASSOCIATION (1989). Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields.

KAMS (1982). The Kwinana Air Modelling Study. Report No. 10, Department of Conservation and Environment, Perth, WA.

KEEPIN, B., and KATS, G. (1988). Greenhouse Warming - Comparative Analysis of Nuclear and Efficiency Abatement Strategies. Energy Policy. December 1988 pp 538-561.

McKINNELL, F.H. (1981). Review of the Dieback Disease Situation 1981. Forests Department Research Paper No. 64.

MURRAY, F. and S. WILSON (1988a). Effects of Sulphur Dioxide, Hydrogen Fluoride and their Combination on Three Eucalypt Species. Environmental Pollution 52, pp. 265-279.

MURRAY, F., and S. WILSON (1988b). The Joint Action of Sulphur Dioxide and Hydrogen Fluoride on the Yield and Quality of Wheat and Barley. Environmental Pollution 55 pp. 239-249.

MURRAY, F., and S. WILSON (1988c). Joint Action of Sulphur Dioxide and Hydrogen Fluoride on Growth of Eucalyptus tereticornis. Environmental Experimental Botany. Vol. 28, No. 4 pp. 343-399.

NATIONAL HEALTH and MEDICAL RESEARCH COUNCIL (1985). National Guidelines for Control of Emission of Air Pollutants from New Stationary Sources. Australian Government Publishing Service. Canberra 1986.

NEW SOUTH WALES COAL ASSOCIATION (1989). Newsletter, April Edition.

SCOTT and FURPHY (1987). Review of High Voltage ELF Transmission Line Field and Human Health Effects. A report to the Environmental Protection Authority.

SMITH, R.L. (1972). Elements of Ecology and Field Biology. Harper & Row, New York.

STATE ELECTRICITY COMMISSION OF VICTORIA (1989). SEC and the Greenhouse Effect, Melbourne Victoria.

STATE ENERGY COMMISSION OF WESTERN AUSTRALIA (1983). Energy for Western Australia and Gas Pipeline Project. Issued by Hon. P.M'C. Dowding (Minister for Fuel & Energy), October 1983.

STATE ENERGY COMMISSION OF WESTERN AUSTRALIA (1985). Proposed Transmission Line Interconnections for Proposed Aluminium Plant (Kemerton). Public Environmental Report. Report No. SD88, March 1985. Prepared by Dames Moore.

STATE ENERGY COMMISSION OF WESTERN AUSTRALIA (1987). Environmental Specifications for Transmission Lines.

STATE ENERGY COMMISSION OF WESTERN AUSTRALIA (1988). Proposed Harvey-Kwinana 330 kV Transmission Line Public Environment Report. Report No. S.D. 233 February 1988. Prepared by Dames Moore.

STATE ENERGY COMMISSION OF WESTERN AUSTRALIA (1989). Air Emissions from Power Generation and Effects on the Collie Area. Internal Report.

STATE GOVERNMENT OF WESTERN AUSTRALIA (1989). Energy Policy Options for Western Australia. A Green Paper.

THE INSTITUTION OF ENGINEERS, AUSTRALIA (1989). The Impact of Energy Use on the Greenhouse Effect - A Position Paper.

UNDERWOOD, R.J., and P.E.S. CHRISTENSEN (1983). Forest Fire Management in Western Australia. Forests Department Special Focus No. 1.

UNITED STATES ENVIRONMENTAL PROTECTION AUTHORITY (1977). Quality Assurance Handbook for Air Pollution Measurement Systems, Volume 11. Ambient Air Specific Methods, Environmental Protection Agency; Research Triangle. Ark, North Carolina.

VICTORIAN ENVIRONMENT PROTECTION AUTHORITY (1984). User Manuals for use with the Plume Calculation Procedure, Environmental Protection Authority, Victoria.

VICTORIAN ENVIRONMENT PROTECTION AUTHORITY (1981). State Environmental Protection Authority - The Air Environment. Victorian Government Gazette No. 63. AG P S, Melbourne.

WHO (1979). Sulphur Oxides and Suspended Matter - Environmental Health Criteria. WHO Geneva.

WHO (1982). Air Quality Guidelines for Europe. Regional Office for Europe, Denmark.

WHO (1984). World Health Organization. Environmental Health Criteria 35. Extremely Low Frequency (ELF) Fields. Geneva.

WHO (1987). Environmental Health Criteria 69 "Magnetic Fields". Geneva.

WOODRUFF, D. (1976). Understanding fire in the Forest. Ecos., 7 (1976):3-12.

11.0 ABBREVIATIONS

General

AHD	Australian Height Datum
CALM	Conservation and Land Management
DISPMOD	Dispersion Model (Gaussian Plume)
EPA	Environmental Protection Authority
ERMP	Environmental Review and Management Programme
HDPE	High Density Polyethylene
ISCST	Industrial Complex Model Short-Term
KAMS	Kwinana Air Modelling Study
LOC	Residential Location
MP	Measuring Position
MRD	Main Roads Department
NHMRC	National Health and Medical Research Council
PER	Public Environmental Report
RAC	Royal Automobile Club
SECWA	State Energy Commission of Western Australia
TAFE	Technical and Further Education
TDS	Total Dissolved Solids
US EPA	United States Environmental Protection Agency
VEPA	Victorian Environment Protection Authority
Water Authority	Water Authority of Western Australia
WHO	World Health Organization

11.0 ABBREVIATIONS (CONT'D)

Technical

C	Celsius
cm	centimetre
m^3	cubic metre
g	gram
ha	hectare
kg	kilogram
km	kilometre
kV	kilovolt
L	litre
MW	megawatt
ug/l	micrograms per litre
mg/L	milligrams per litre
mm	millimetre
NO_x	Nitrogen Oxides
%	percentage
s	second
km^2	square kilometre
SO_2	Sulphur Dioxide
TDS	total dissolved solids
t	tonne
a	annual

12.0 GLOSSARY OF TERMS

Anion	A negatively charged ion (e.g. Cl^-).
Aquicludes	Separate layers of water above the main aquifer.
Aquifer	A geological formation capable of receiving, storing and transmitting significant quantities of water.
Archaeology	Study of antiquities, especially of the prehistoric period.
Attenuation	(Applied to sound) reduction or tapering off.
Base Load	An industry term that refers to the portion of the total electricity requirement which is effectively constant throughout the year.
Biota	The totality of plants and animals of a specified area.
Buffer Zone	An area surrounding a development that aims to minimize the adverse impacts of the development on the surrounding environment.
Cation	A positively charged ion (e.g. Na^+)
Capacity Factor	Measure of the energy production of a generating plant during a period compared to the total energy production if the plant had operated continuously at full output during the period.
Cogeneration	The generation of electrical energy as part of some other process such as the supply of low pressure steam to a chemical plant or the recovery of waste heat and gases from a blast furnace.
Conservation	The efficient use of energy, either by forsaking energy needs or by using more efficient systems and appliances.
Demand	The instantaneous requirement for electricity that the system has to meet, the usual units being megawatts (MW) or gigawatts (GW).
Ecology	The study of the interrelationships of plants and animals and their environments. Also, the totality of pattern of these interrelationships within a specified area, community or ecosystem.
Ecosystem	An interacting set of plants, animals and non-biotic components of their habitat and their interactions. An ecosystem is usually defined by its dominant vegetation

	(e.g. forests) and plant species or by the habitat in which it occurs (e.g. riverine).
Emission Control	Controls that are installed to maintain the emissions from the development at acceptable levels.
Energy	A measure of the amount of electricity used over a period of time. Units used are gigawatt-hours (GWh), megawatt-hours (MWh) or kilowatt-hours (kWh) depending on the power and time scale involved. The kWh is the familiar unit used to measure customer electricity consumption. 1 GWh = 1000 MWh 1 MWh = 1000 kWh
Environment	All aspects of the surroundings of man including the physical, economic, cultural and social aspects. This includes the complex of habitat factors, both biotic and abiotic, that do, or will, impinge or have impinged upon a plant or animal or groups of plants and animals.
Ethnography	The scientific description of races of men.
Flora	The totality of plant species of a specified area.
Gas Turbine	A generating unit in which an air/fuel mixture is burnt and the resulting hot air/gas mixture used to drive a turbine. This turbine drives a generator to produce electrical energy. A steam boiler is not required.
Gravity Model	A spatial interaction model which weighs a particular variable according to the size of the population centre and the distance between the centres. It allows the analyst to predict the size of a workforce which can be expected from a particular sized centre and at a particular distance from that centre.
Greenhouse Gas	A family of gases that contributes to the Greenhouse Effect. Greenhouse gases are transparent to short wavelength incoming solar radiation, which passes through the atmosphere, is absorbed at the earth's surface and is re-emitted as long wave heat radiation. Greenhouse gases absorby long wave heat radiation and thus trap heat in the atmosphere. The concentration of these gases is increasing, so a greater amount of re-emitted heat is being trapped in the atmosphere, producing a slight rise in global average temperature. This phenomenon is known as the "greenhouse effect". Carbon dioxide accounts for about half of the

greenhouse effect whilst methane, nitrous oxide and chlorofluorcarbons account for the balance.

Groundwater Surface or Water Table	That surface within the saturated zone at which the pressure is atmospheric. Level at which water stands in uncased or screened shallow well in unconfined aquifer. A perched water table is one which occurs above an impermeable zone, which is underlain by unsaturated materials.
Habitat	The place where species or populations of plants or animals live. A habitat contains a system of components that satisfies the requirements of an animal, essential to the continued survival of the species, such as food, shelter and adequate territory. The habitat components of an animal include both living (e.g. vegetation) and non-living features.
Heavy Metals	Metallic elements with high molecular weights (for example, mercury, cadmium, lead, arsenic) which, in low concentrations, are generally toxic to plant and animal life.
Infrastructure	Systems of services and utilities within a community; e.g. physical (water, sewerage, electrical, transport) and social (health, education, safety, communications).
Intermediate Load	That part of power demand falling between the highly fluctuating peak loads and the steady base load component. Plant supplying intermediate loads typically operates during weekdays and is shut down or off-loaded overnight and on weekends. This plant would generally operate at an annual capacity factor of between 30% and 60%.
Jarrah Dieback Disease	An exotic plant disease caused by the root-rotting fungus Phytophthora cinnamomi.
Modifiers	Parameters that have changed the ecology of an area over a period of time (e.g. clearing, reforestation, logging, fire).
Multiplier, Employment	A number used to calculate the amount of direct and indirect employment generated as a consequence of project construction and operation.
Peak Load	That portion of the total electricity requirement which exceeds base load, which occurs over relatively short periods and is characterized by fluctuating but high energy demand.

Peak Lopping	Additional generation required to meet short term peak energy demand.
pH	A measure of acidity or alkalinity of a liquid (on a scale of 1 to 14 - pH 7 is neutral; pH less than 7 is acidic and a pH more than 7 is alkaline).
Protectable Areas	Areas of State forest that have been designated to be free from jarrah dieback; and upslope from known areas of dieback.
Non-Protectable Areas	Areas of State forest (either non-quarantined or quarantined) that are downslope of known dieback areas; these areas may be either low or high potential risk zones.
Rehabilitation	The process necessary to return disturbed land to a predetermined surface, land use or productivity.
Renewable Energy Source	Energy sources that are capable of being reused (solar, biomass conversion, wind generation, hydro-electric generation).
Reserve Plant Margin	The total plant capacity available less the actual maximum demand for electricity in a particular year expressed as a percentage of the maximum demand.
Species Diversity	A number which relates the density of organisms of each species present in a habitat.
Trophic Level	The energy levels of a food-chain, usually totalling three or four levels.
Unconfined Aquifer	An aquifer which is either filled with water and/or has no impermeable or semi-impermeable layer preventing a rise in the water table. It contains groundwater which is not subjected to any pressure other than its own weight.
Vegetation Complex	The plant cover of a specified area. It is described primarily in terms of form and structure.
Vegetation	A collective group of plants with characteristic form, structure and dominant species.
Wetlands	Lakes, pools, rivers, streams and swamps and their associated moist margins.

POWER AND ENERGY UNITS

Electricity **Power (or capacity)**

watt	(W)				
kilowatt	(kW)	=	1000 W		
megawatt	(MW)	=	1000 kW	=	10^6 W
gigawatt	(GW)	=	1000 MW	=	10^9 W

Energy

kilowatt hour	(kWh)		
megawatt hour	(MWh)	=	10^3 or 1000 kWh
gigawatt hour	(GWh)	=	10^6 or 1 000 000 kWh

General **Energy**

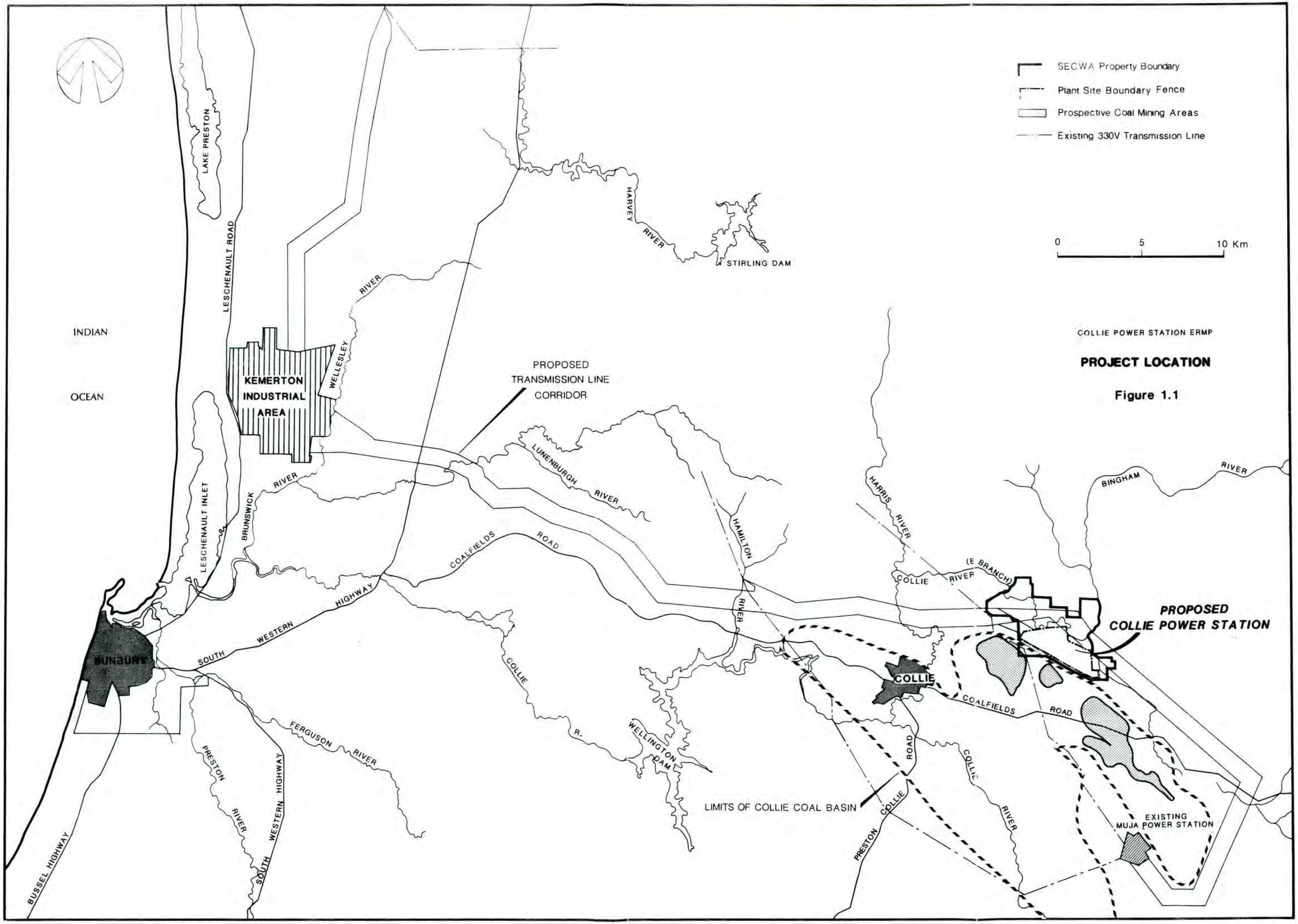
joule	(J)				
kilojoule	(kJ)	=	1000 J		
megajoule	(MJ)	=	1000kJ	=	10^6 J
gigajoule	(GJ)	=	1000 MJ	=	10^9 J
terajoule	(TJ)	=	1000 GJ	=	10^{12} J
petajoule	(PJ)	=	1000 TJ	=	10^{15} J

Conversion Factors

1 kWh	=	3 600 000 J	=	3.6 MJ
1 GWh	=	3 600 000 MJ	=	3.6 TJ
1 GJ	=	277.8 kWh		
1 PJ	=	277.8 GWh		

FIGURES

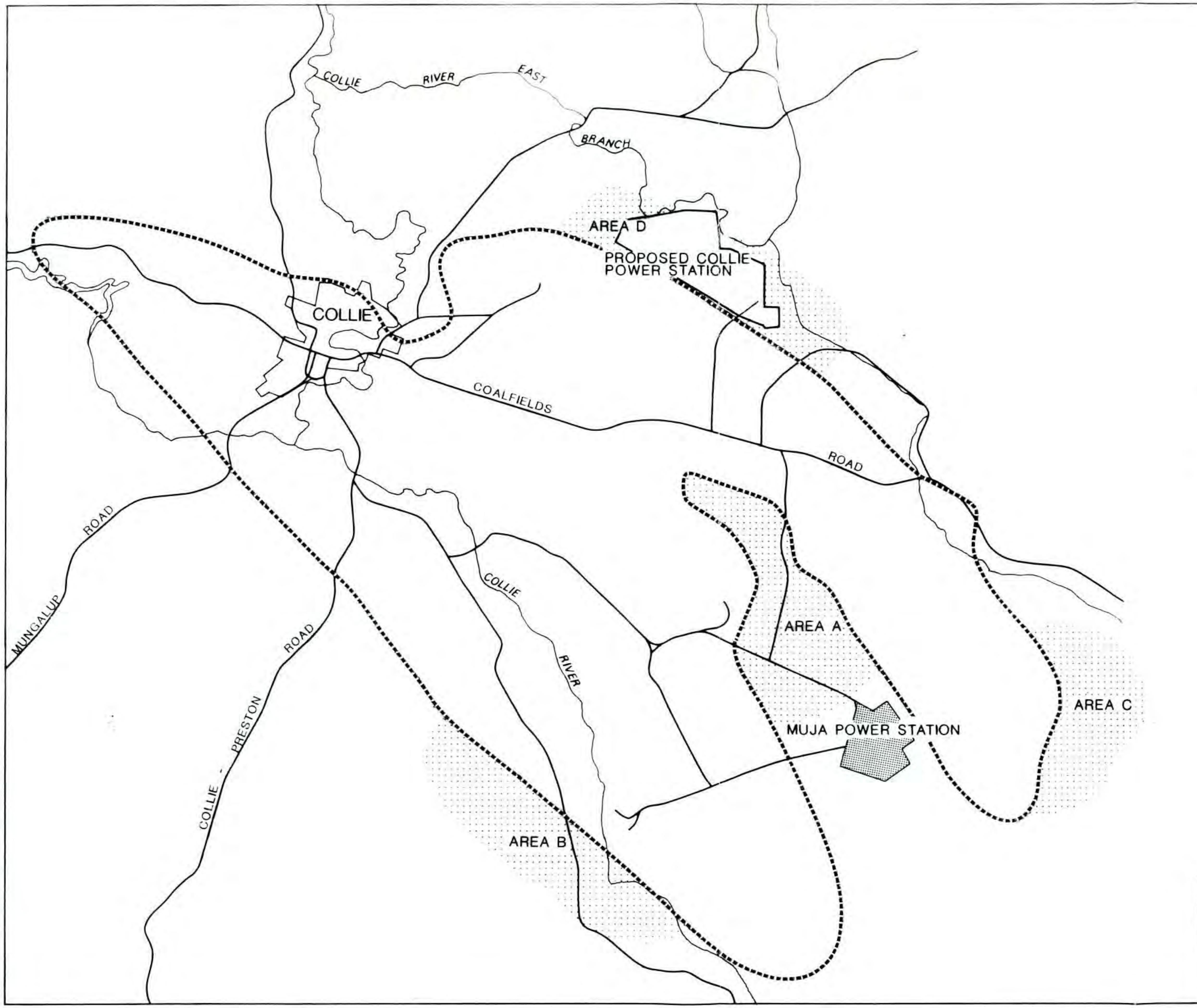
LIST OF FIGURES



COLLIE POWER STATION ERMP

PROJECT LOCATION

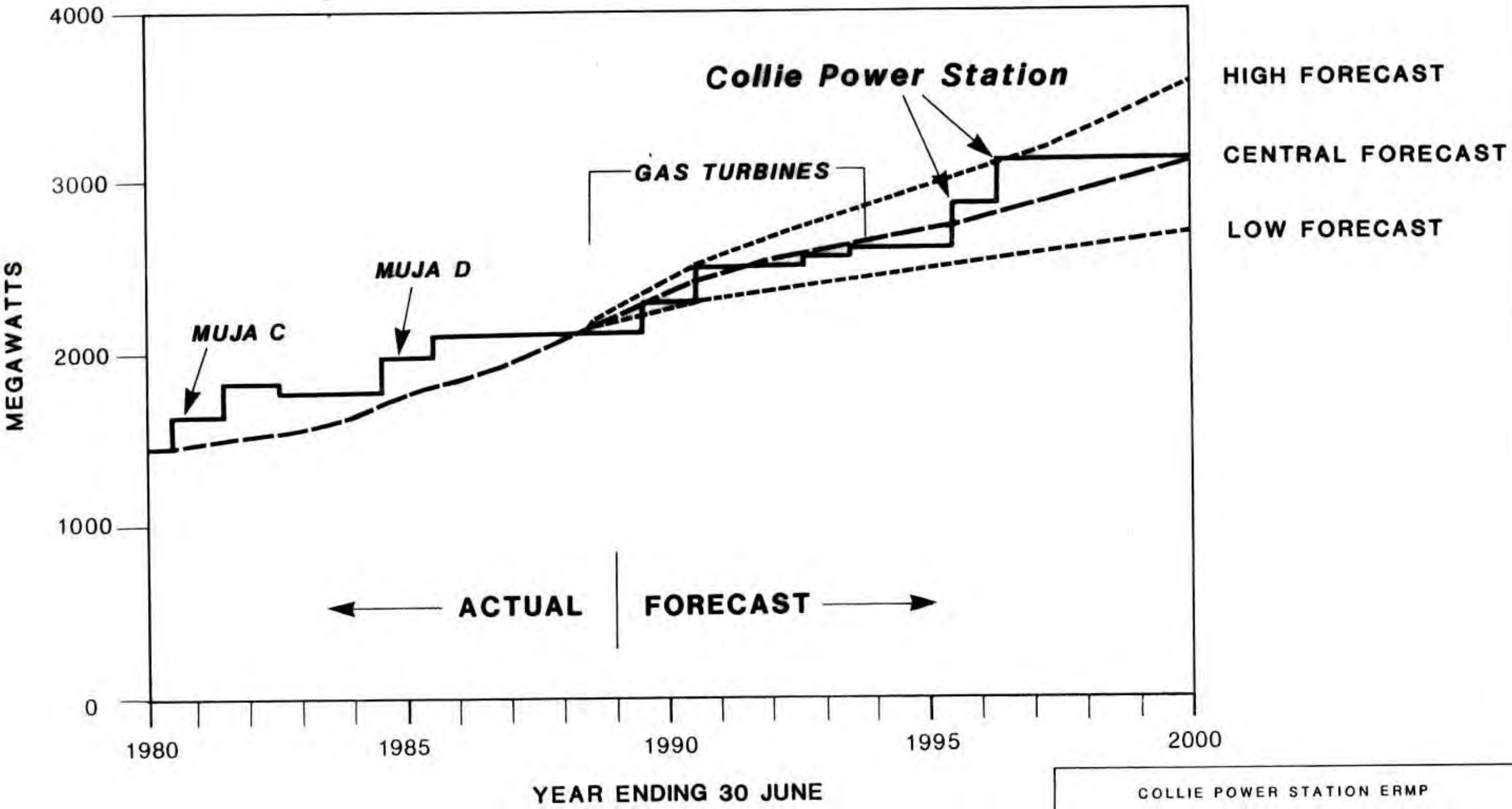
Figure 1.1



COLLIE POWER STATION ERMP

ALTERNATIVE POWER STATION LOCATIONS COLLIE BASIN SURROUNDS

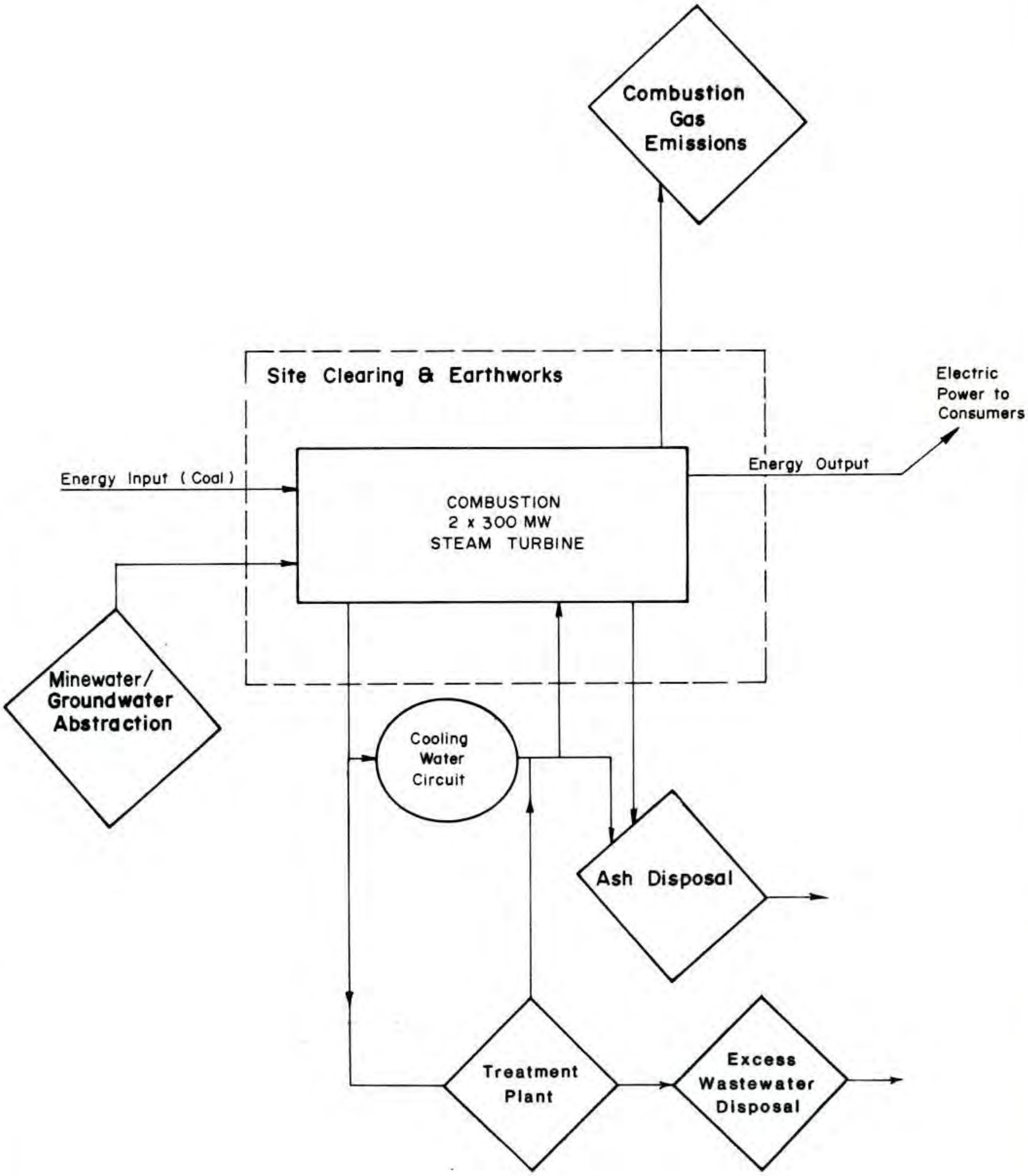
Figure 3.1



COLLIE POWER STATION ERMP

SECWA GENERATING PLANT REQUIREMENTS & INSTALLATION PROGRAMME

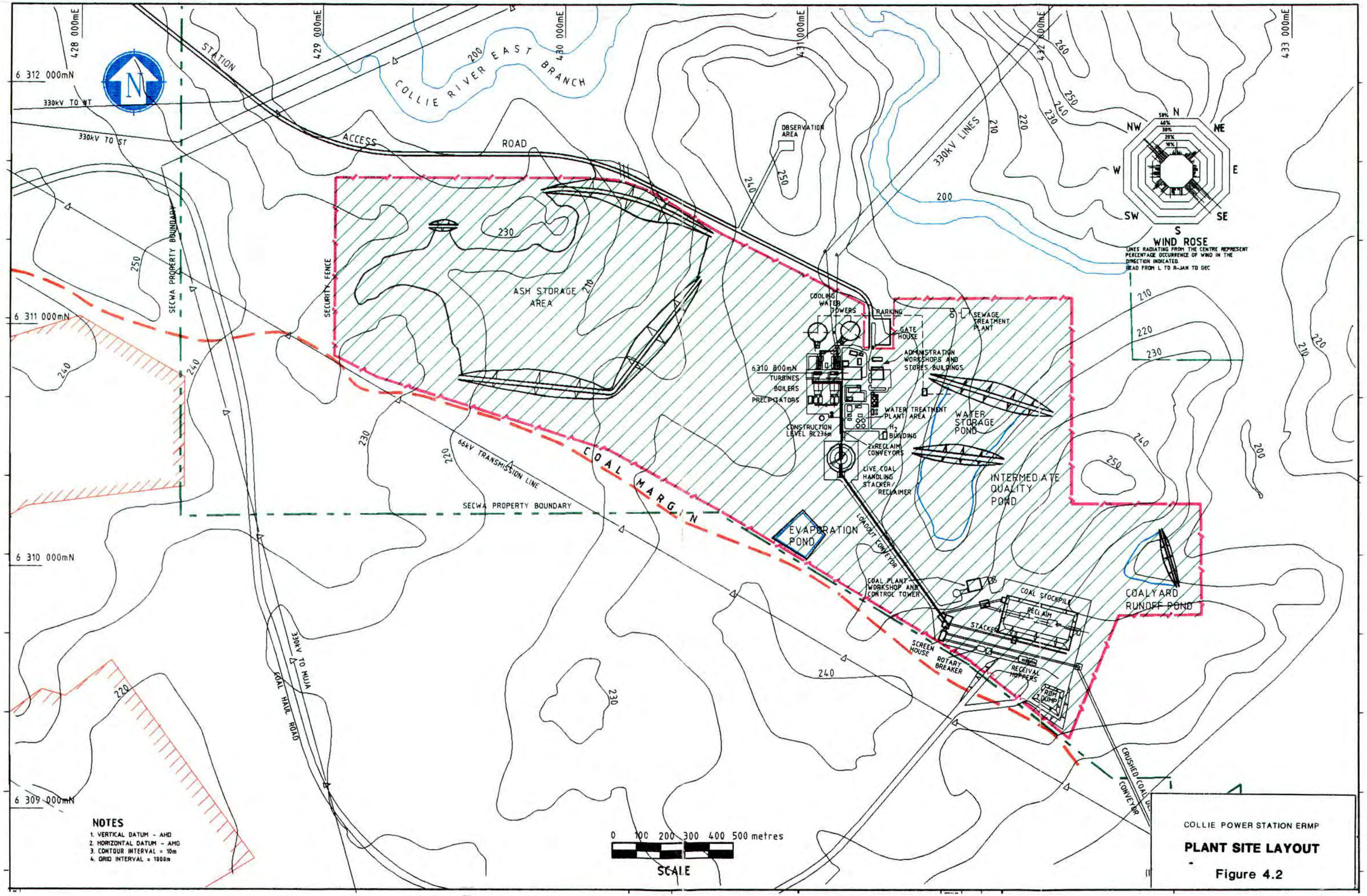
Figure 3.2



COLLIE POWER STATION ERMP

CONCEPTUAL DIAGRAM OF POWER STATION SHOWING PRINCIPAL COMPONENTS

Figure 4.1



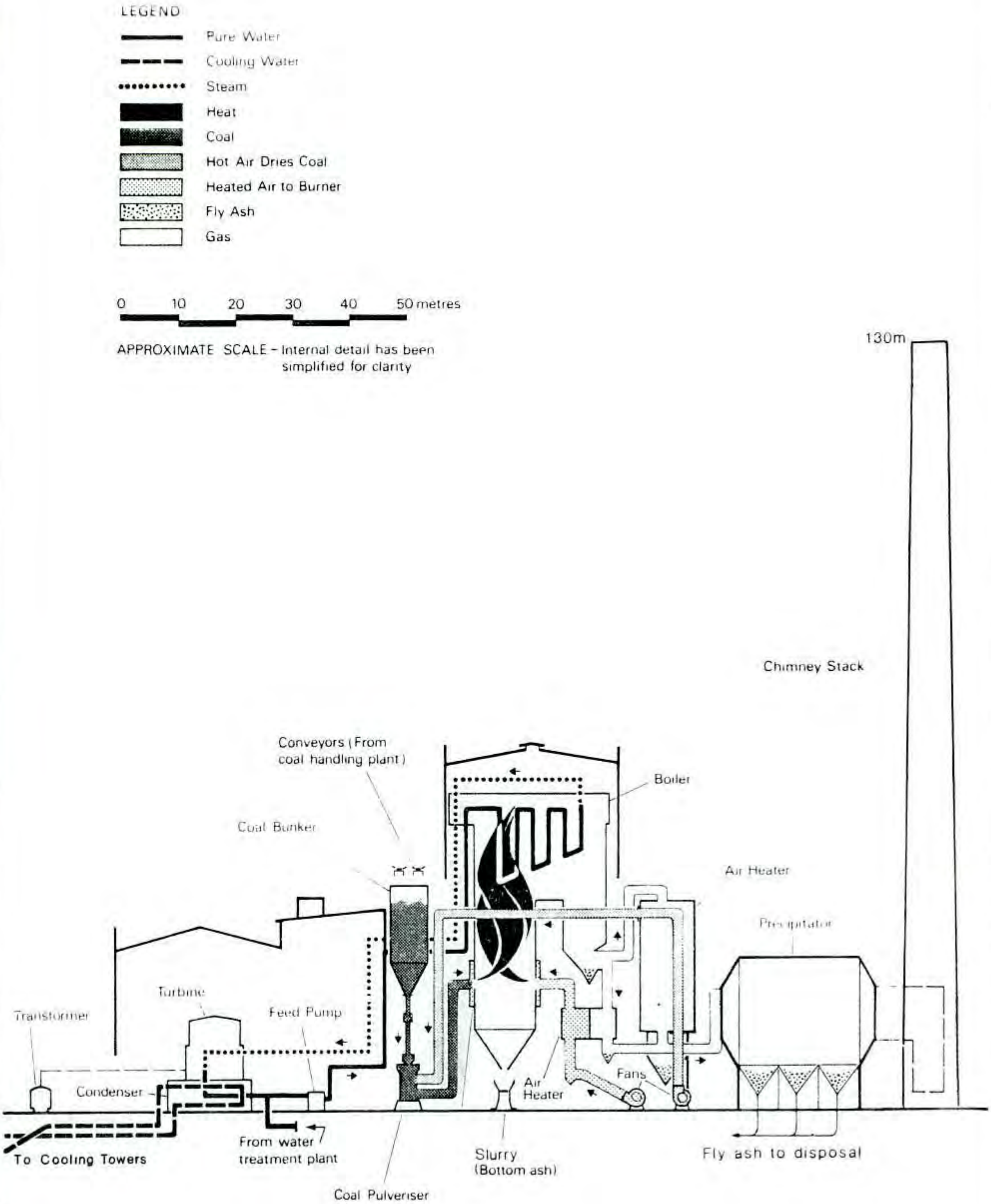
NOTES

1. VERTICAL DATUM - AHD
2. HORIZONTAL DATUM - AMG
3. CONTOUR INTERVAL = 10m
4. GRID INTERVAL = 1000m

COLLIE POWER STATION ERMP

PLANT SITE LAYOUT

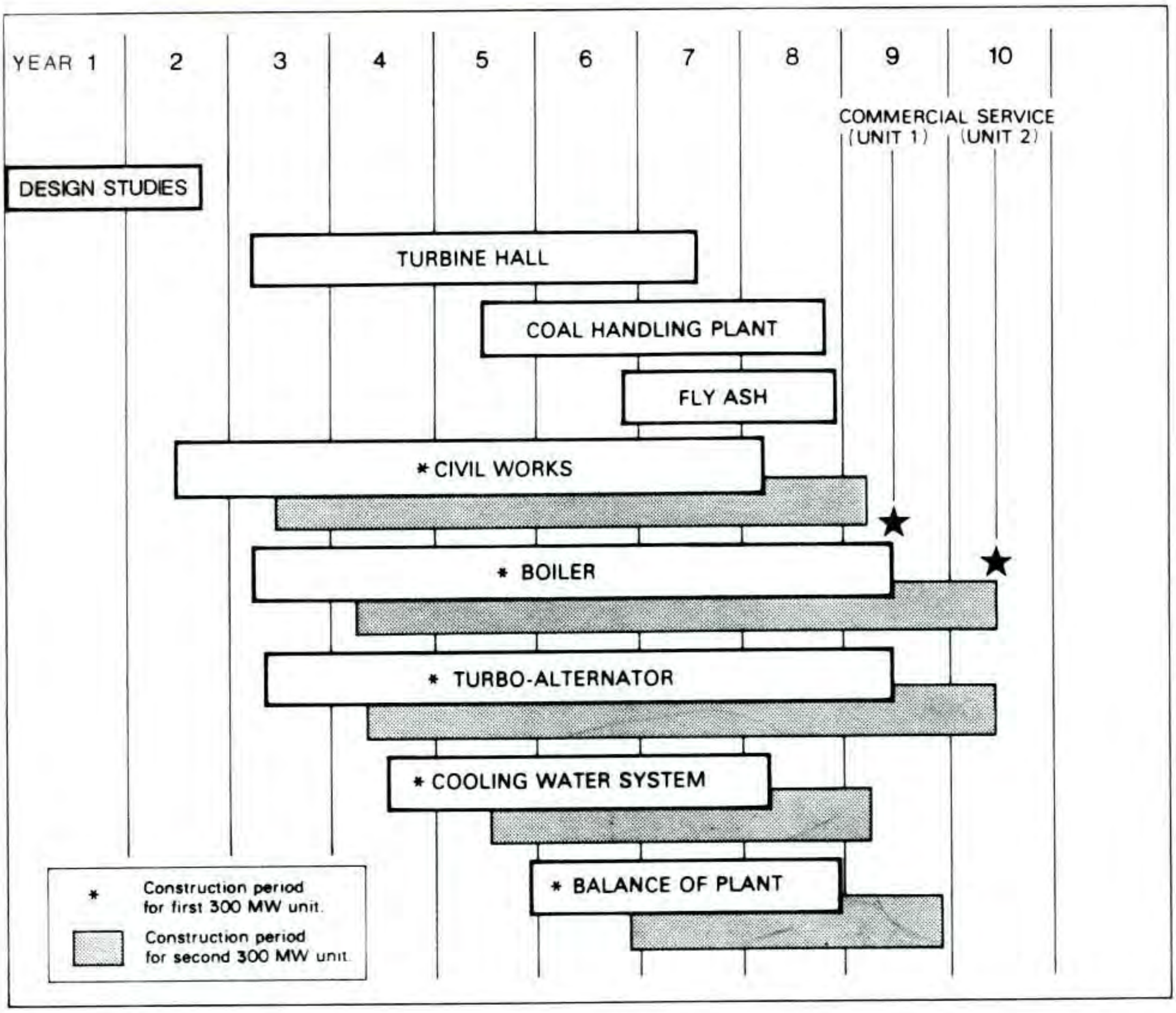
Figure 4.2



COLLIE POWER STATION ERMP

CROSS SECTION THROUGH POWER STATION

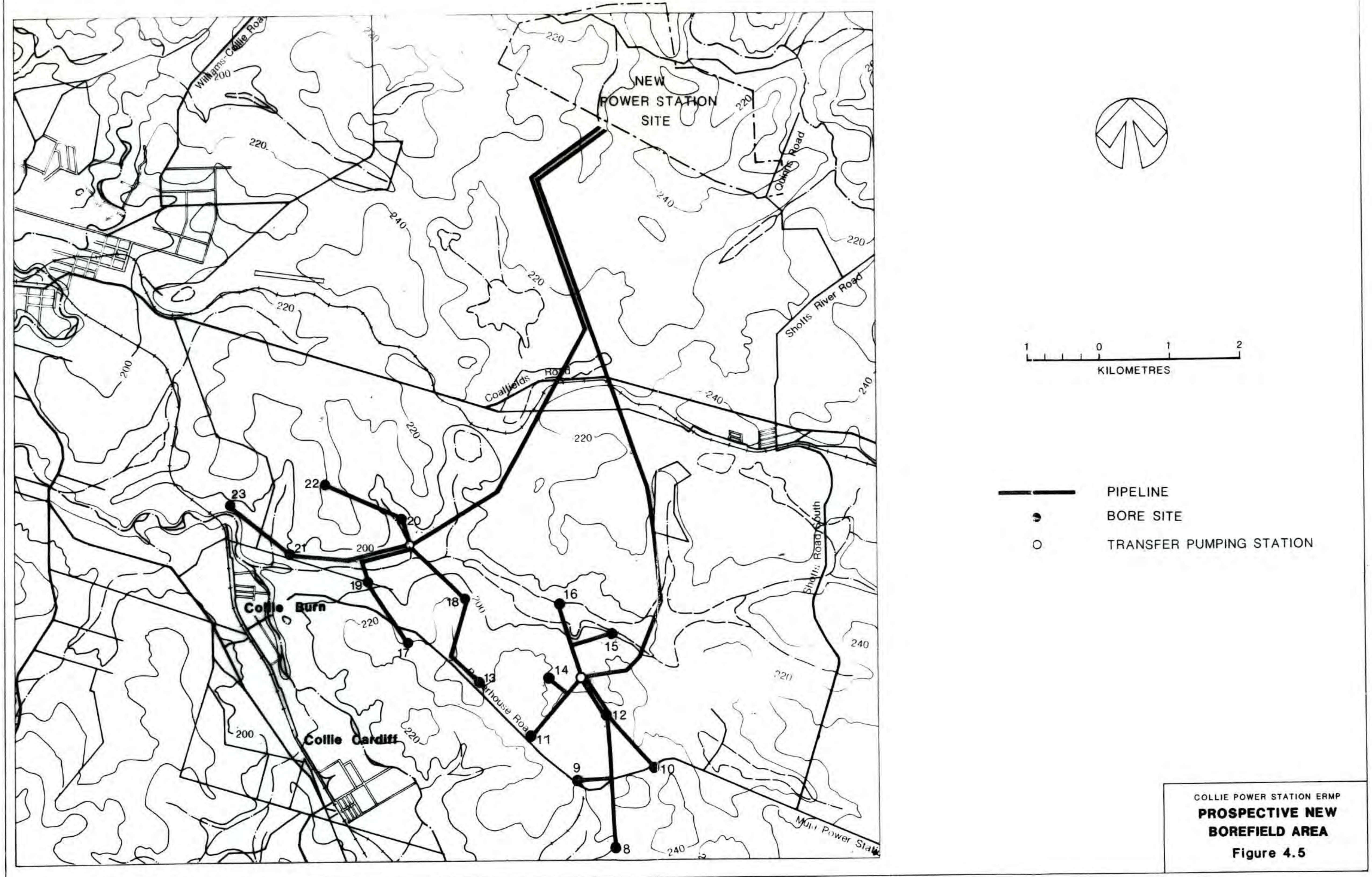
Figure 4.3



COLLIE POWER STATION ERMP

PROJECT SCHEDULE

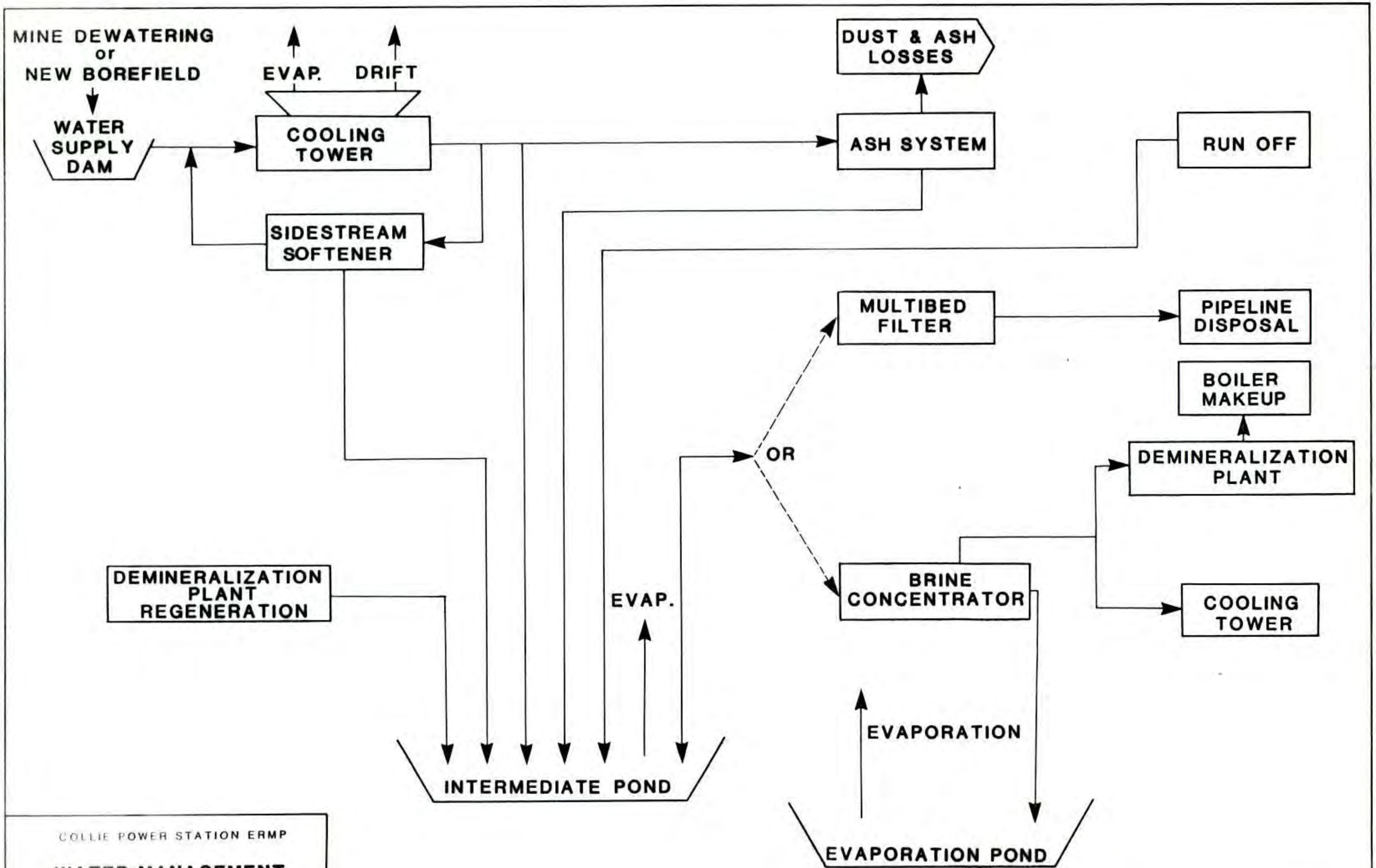
Figure 4.4



COLLIE POWER STATION ERMP

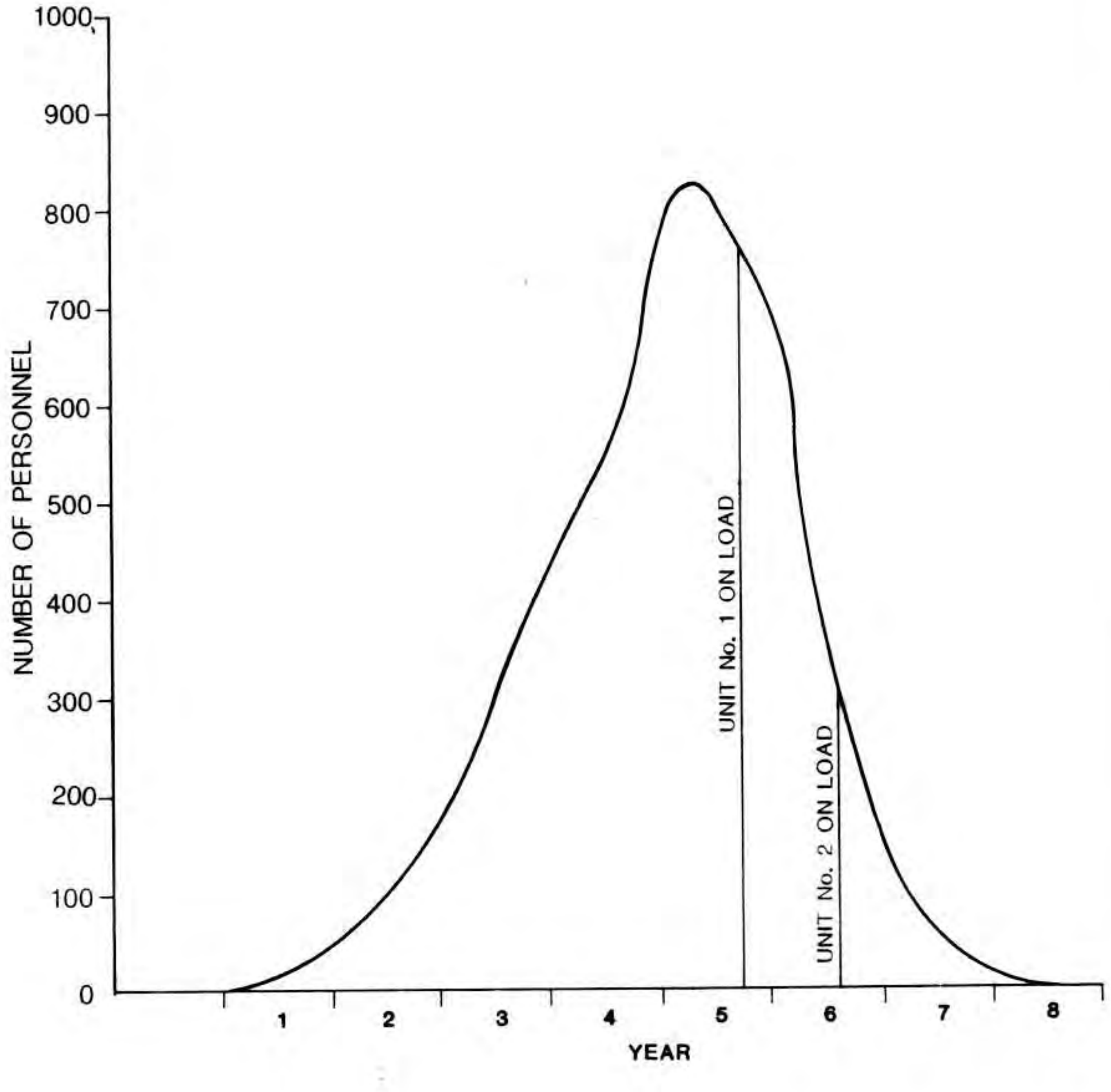
PROSPECTIVE NEW BOREFIELD AREA

Figure 4.5



COLLIE POWER STATION ERMP

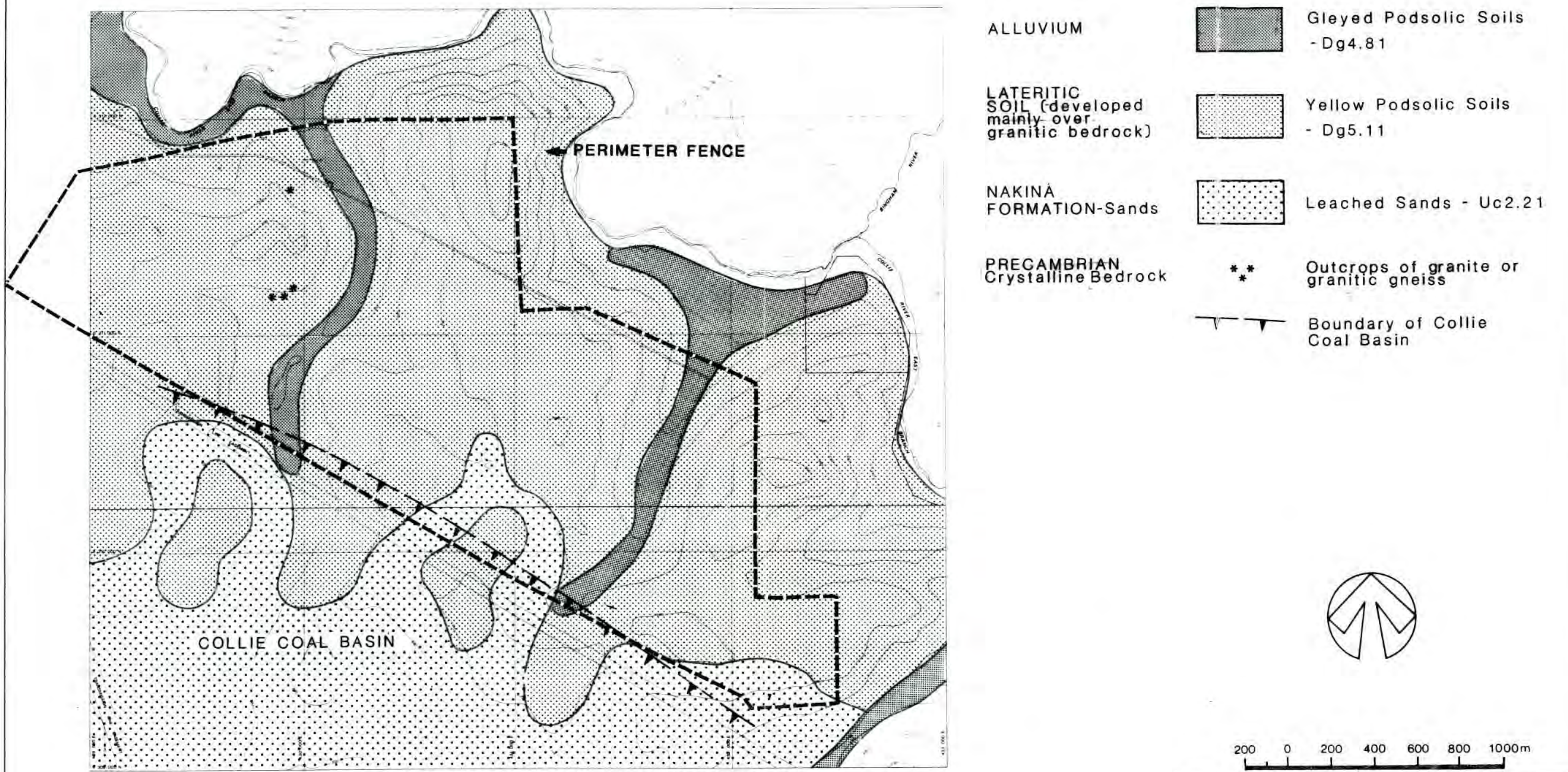
WATER MANAGEMENT
Figure 4.6



COLLIE POWER STATION ERMP

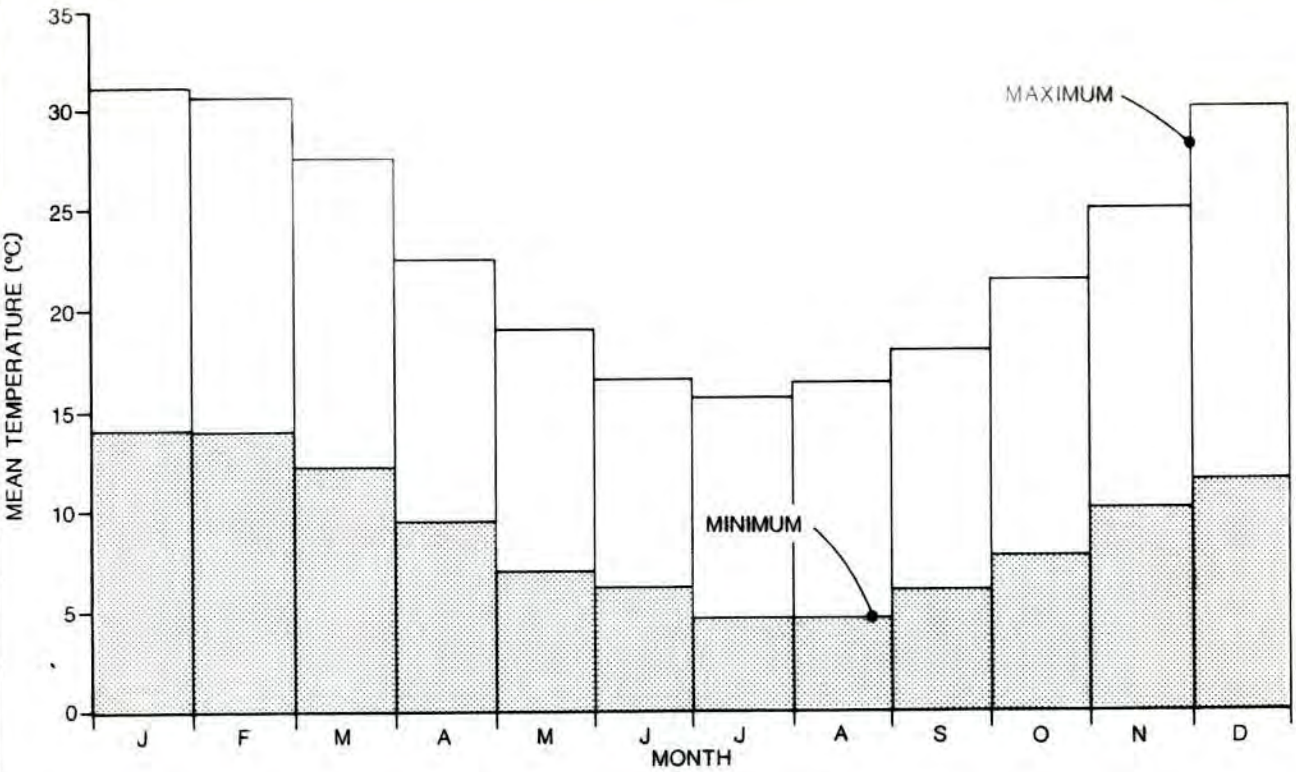
SITE CONSTRUCTION WORKFORCE PREDICTIONS - COLLIE POWER STATION (2 x 300 MW UNITS)

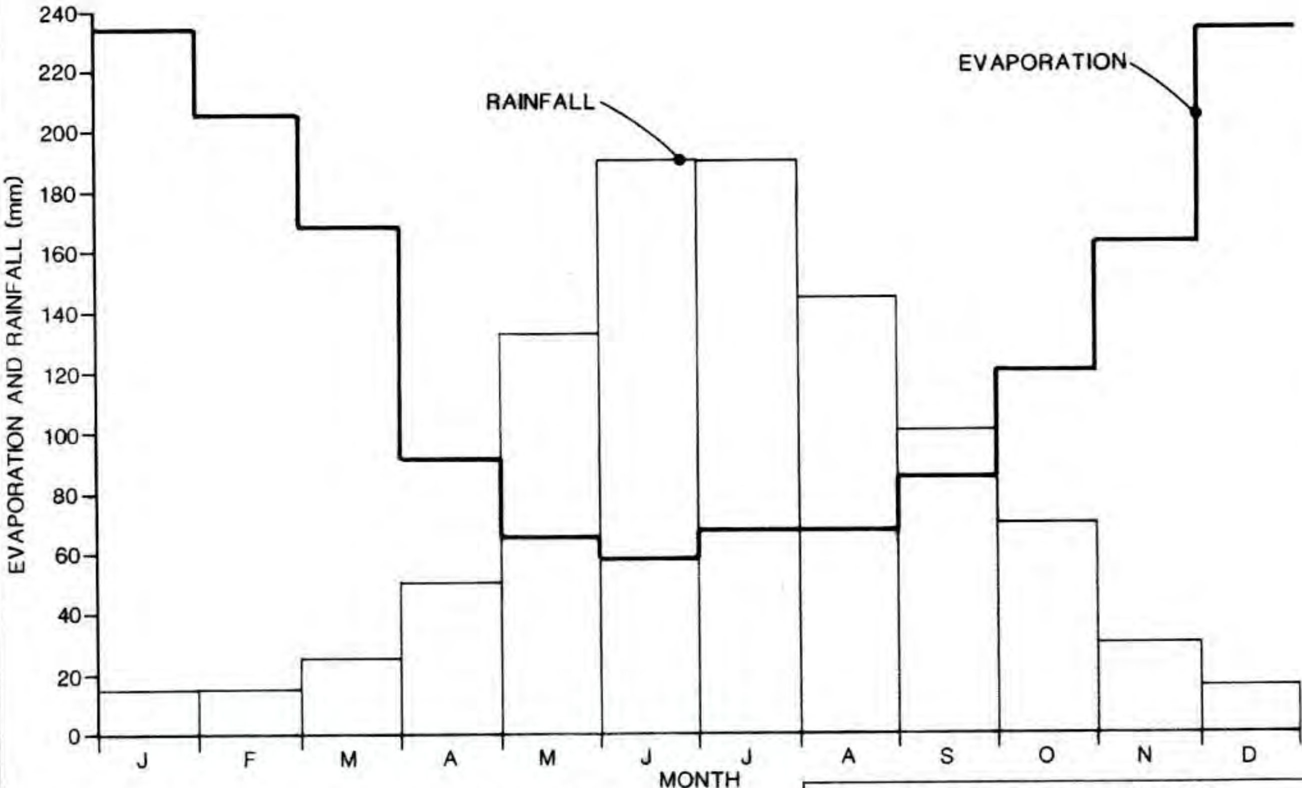
Figure 4.7



COLLIE POWER STATION ERMP

POWER STATION SITE
SURFACE GEOLOGY AND SOILS
Figure 5.1





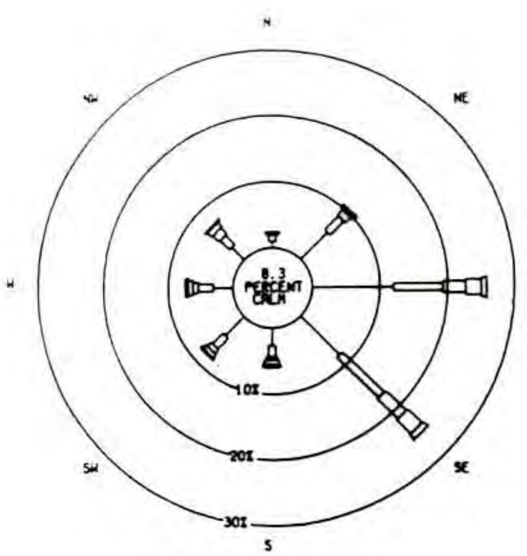
NOTE: Rainfall and Temperature quantities from Collie Post Office.
Average Evaporation figures from Dwellingup Post Office.

SOURCE: Bureau of Meteorology

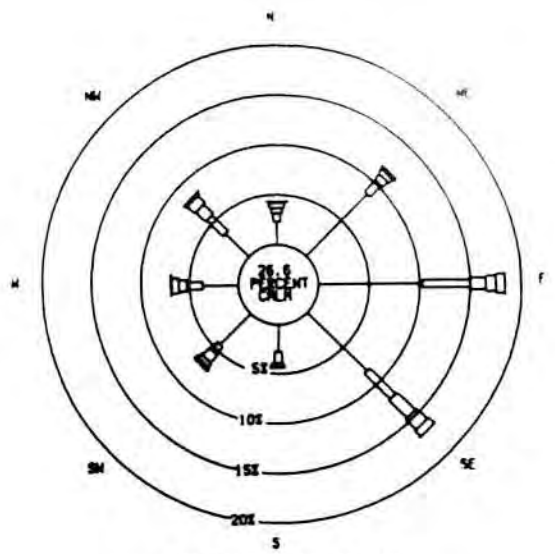
COLLIE POWER STATION ERMP

MONTHLY TEMPERATURE, RAINFALL AND EVAPORATION

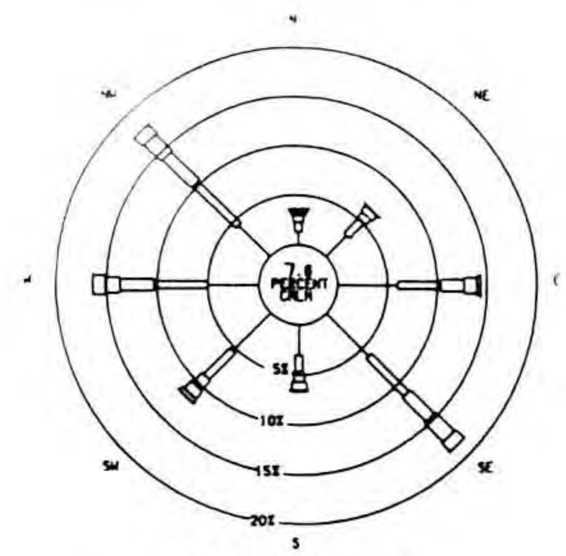
Figure 5.2



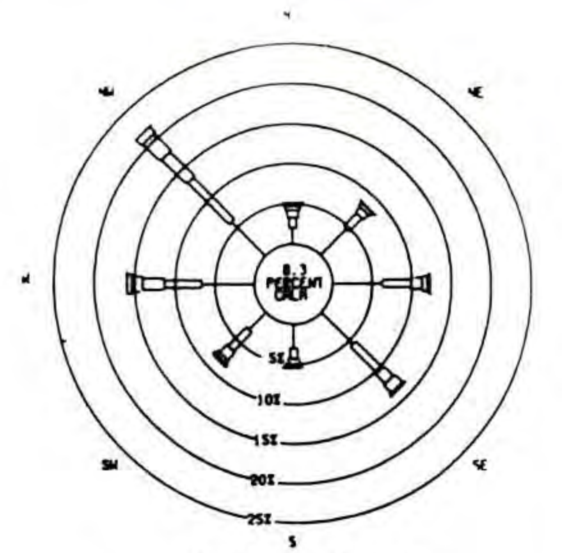
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
COLLIE WINDS SUMMER 9 AM



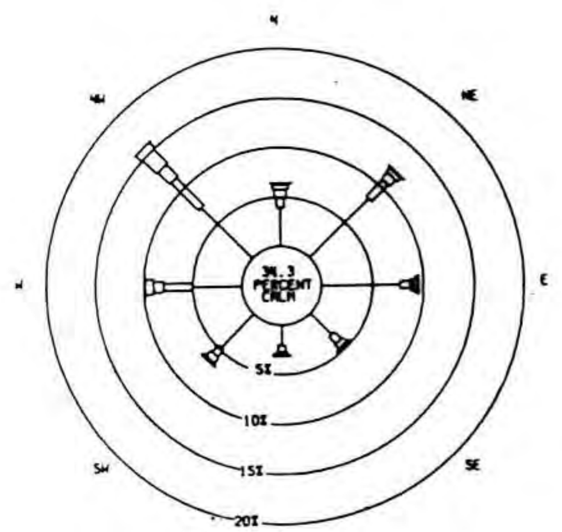
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
COLLIE WINDS AUTUMN 9 AM



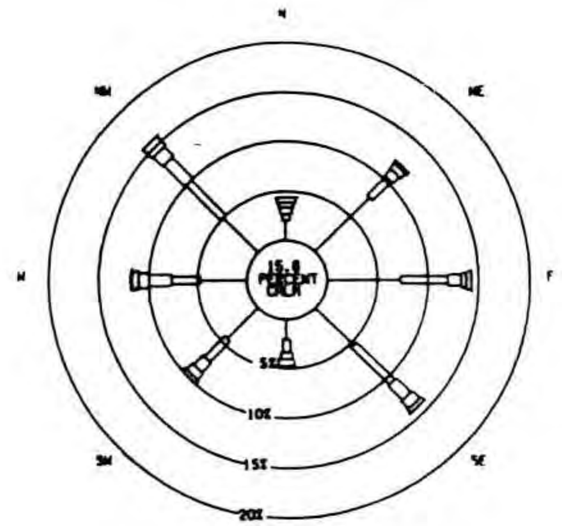
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
COLLIE WINDS SUMMER 3 PM



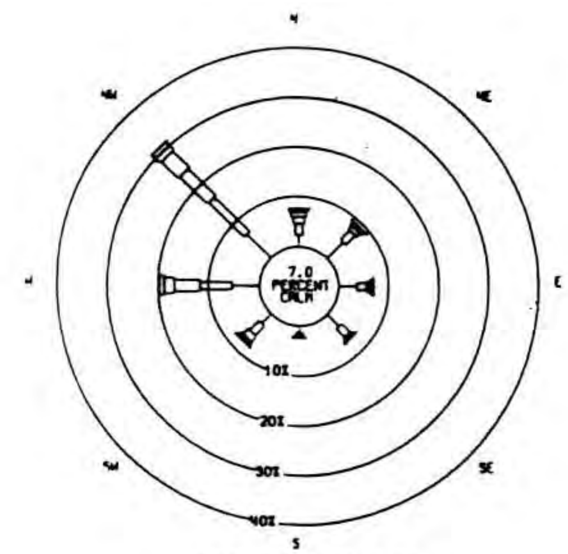
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
COLLIE WINDS AUTUMN 3 PM



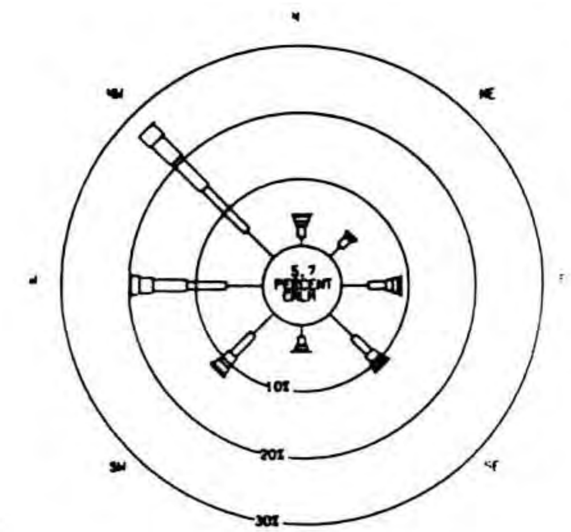
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
COLLIE WINDS WINTER 9 AM



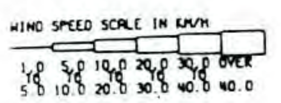
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
COLLIE WIND SPRING 9 AM



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
COLLIE WINDS WINTER 3 PM



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
COLLIE WINDS SPRING 3 PM

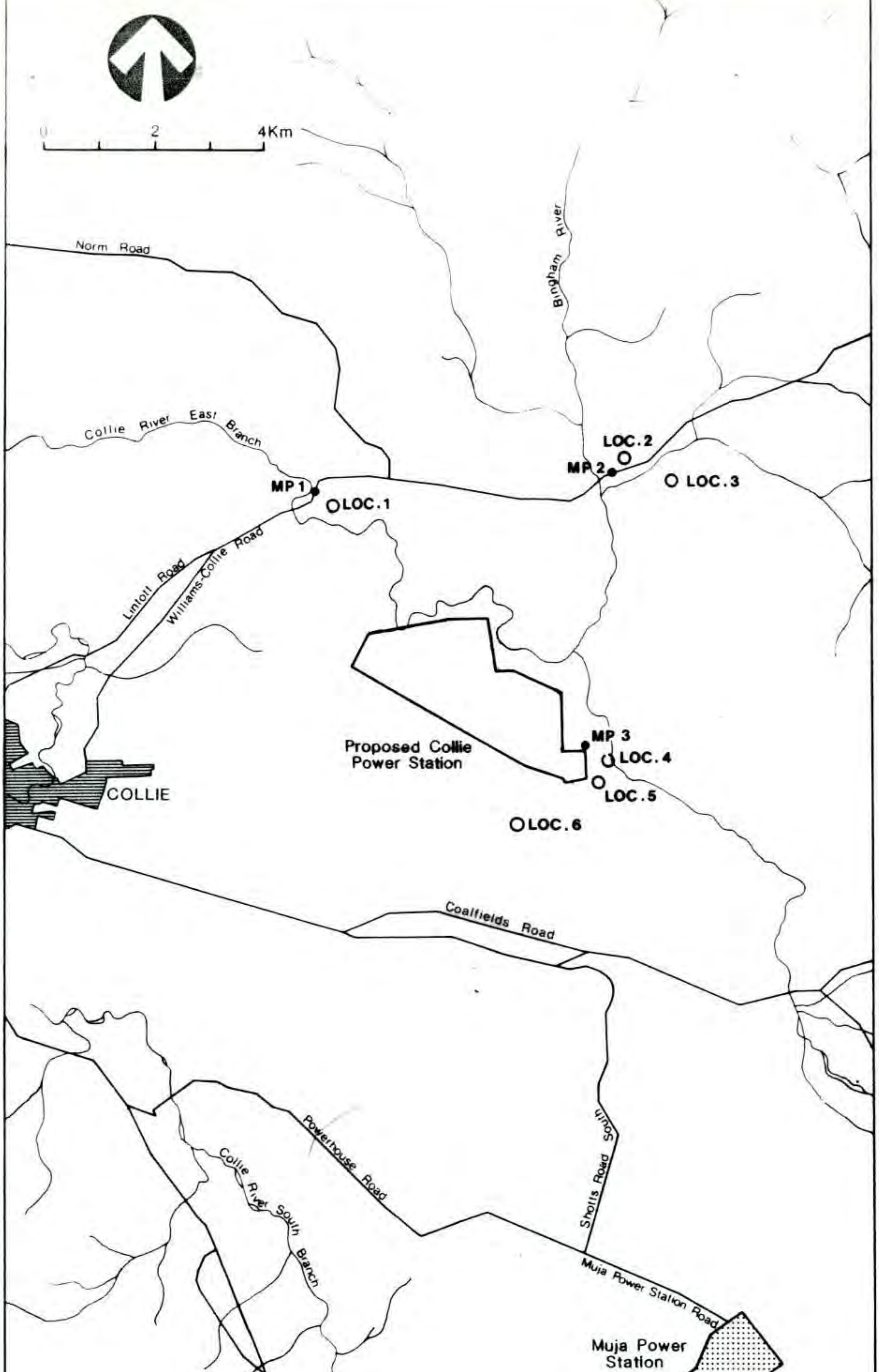


COLLIE POWER STATION ERMP

SEASONAL WIND ROSES FOR COLLIE

9 AM AND 3 PM

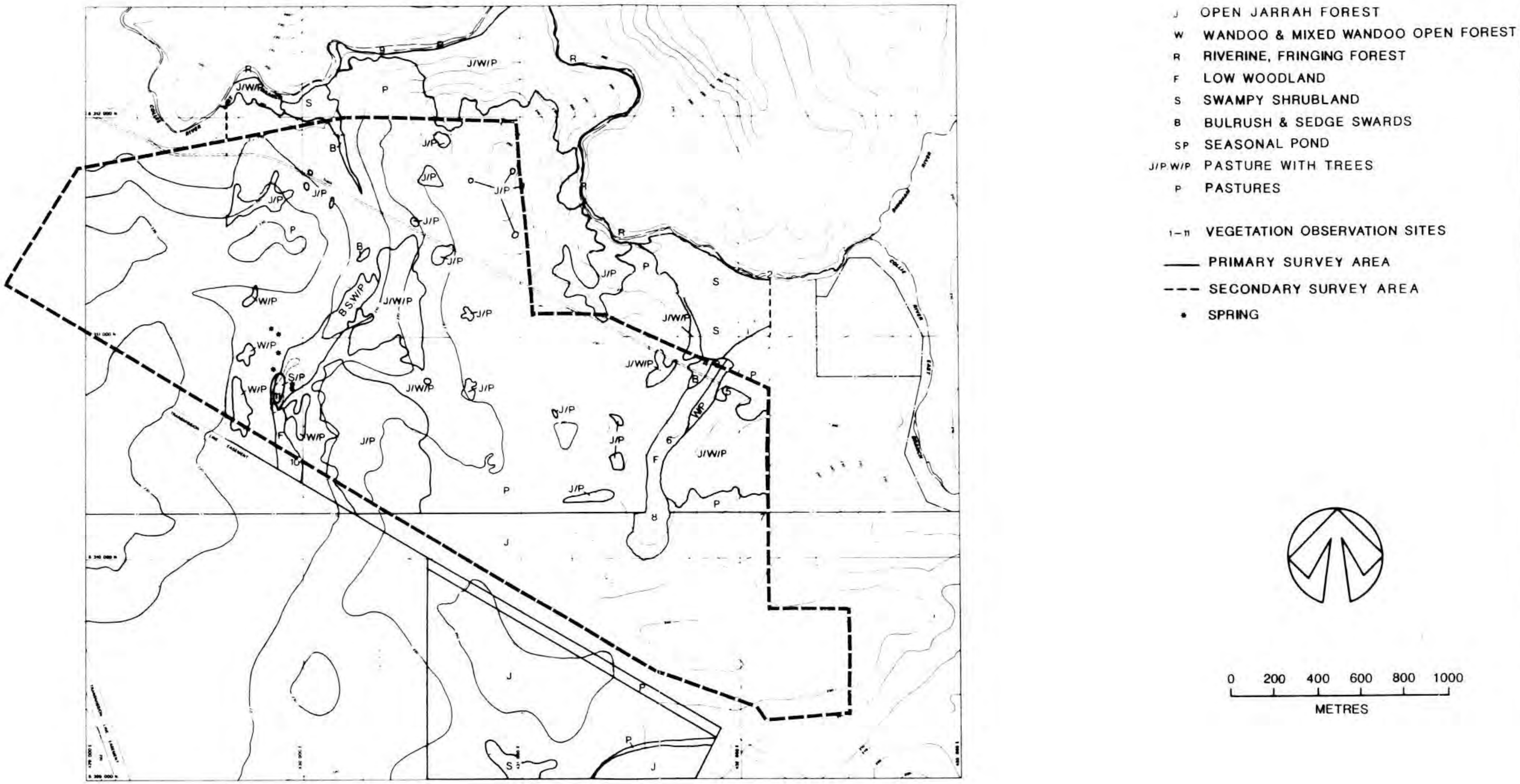
Figure 5.3



COLLIE POWER STATION ERMP

NOISE MEASURING POSITIONS (MP) AND RESIDUAL LOCATIONS (LOC)

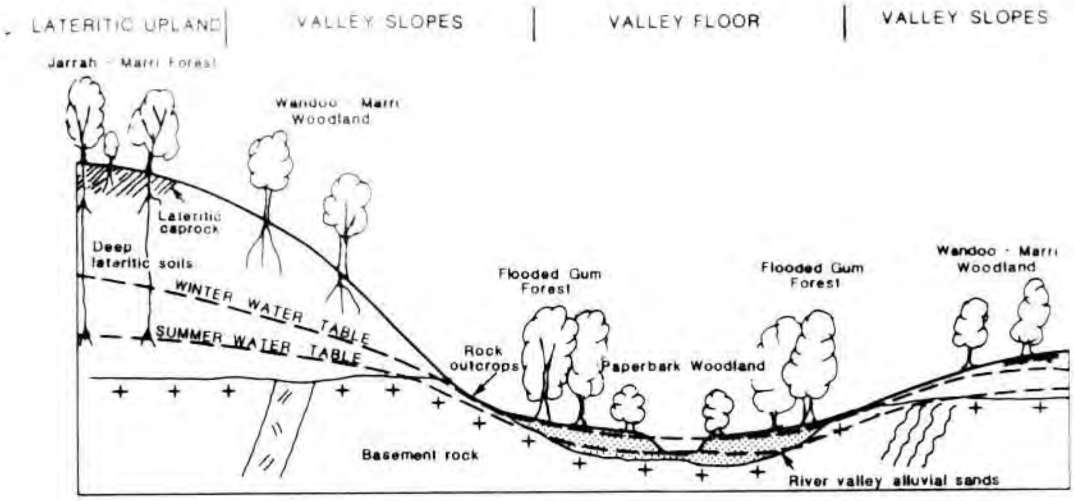
Figure 5.4



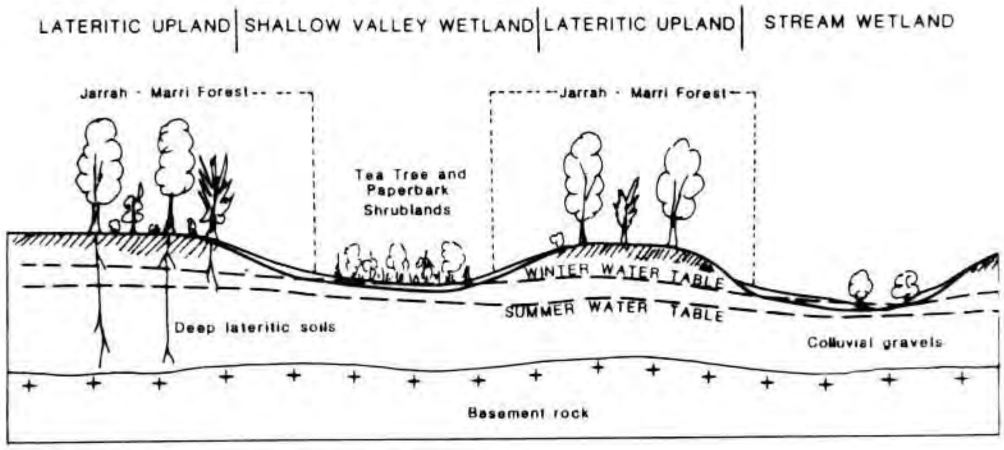
COLLIE POWER STATION ERMP

VEGETATION TYPES

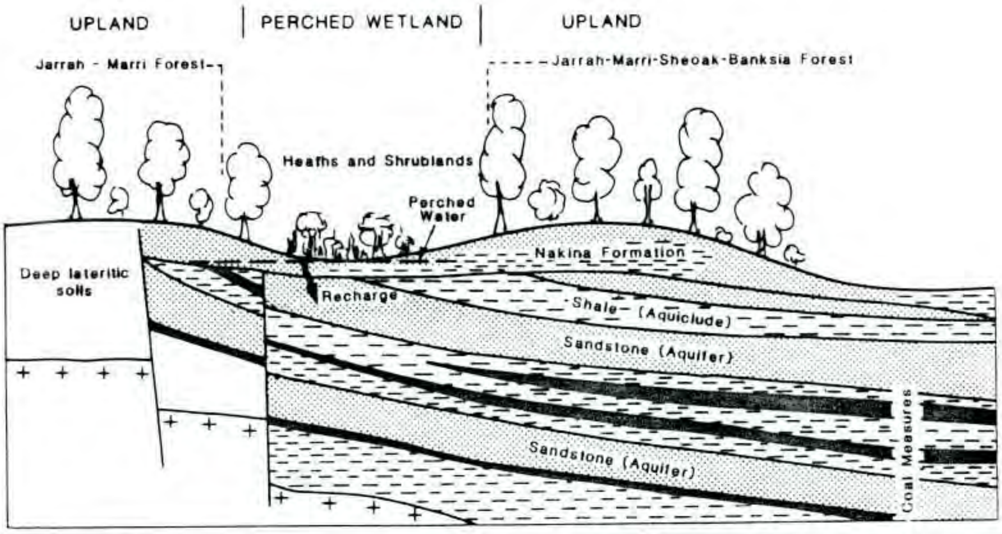
Figure 5.5



1. MAJOR RIVERS



2. UPLAND - ON BASEMENT ROCKS

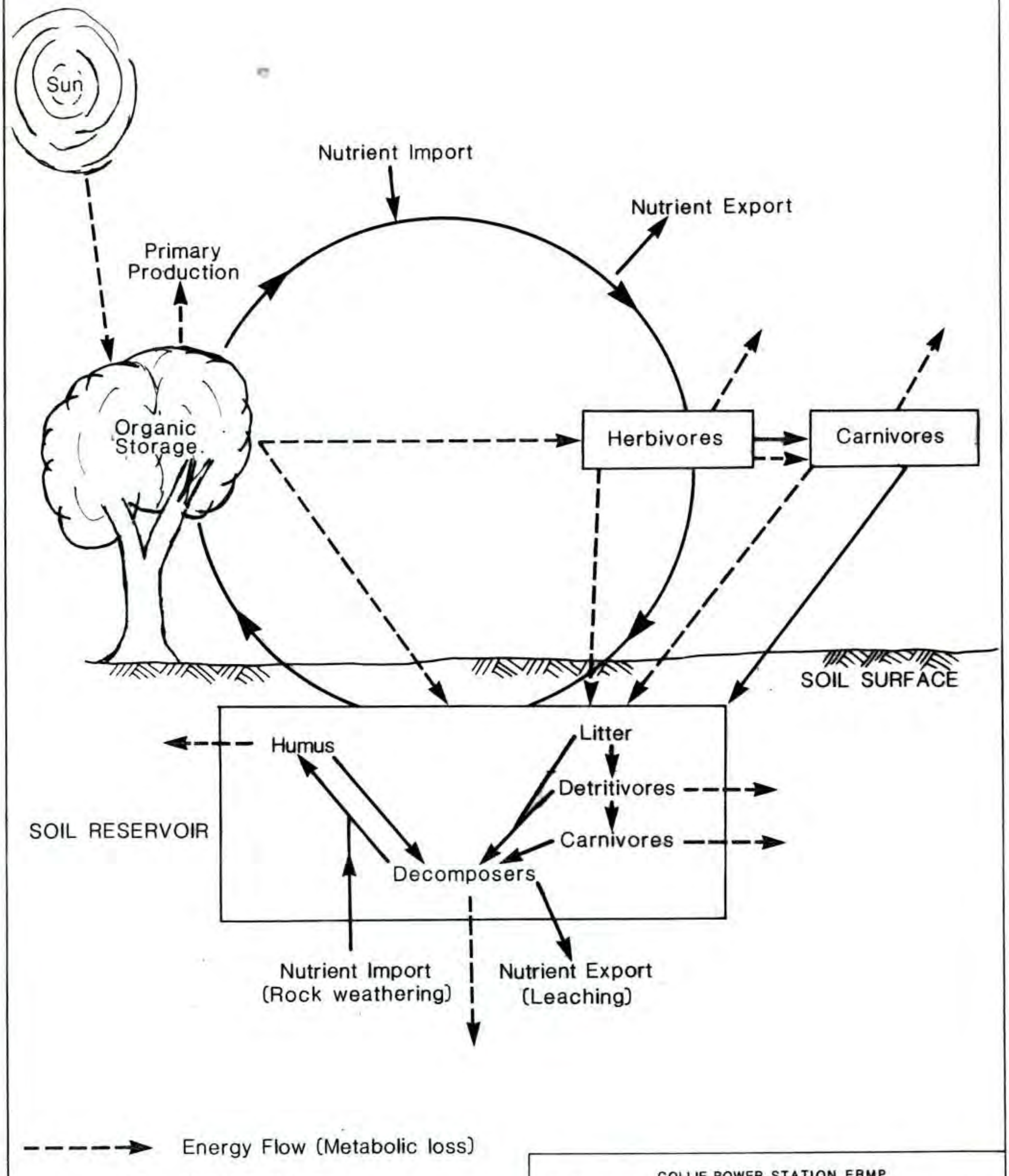


3. UPLAND - ON COLLIE COAL BASIN

COLLIE POWER STATION ERMP

LANDSCAPE RELATIONSHIPS

Figure 5.6

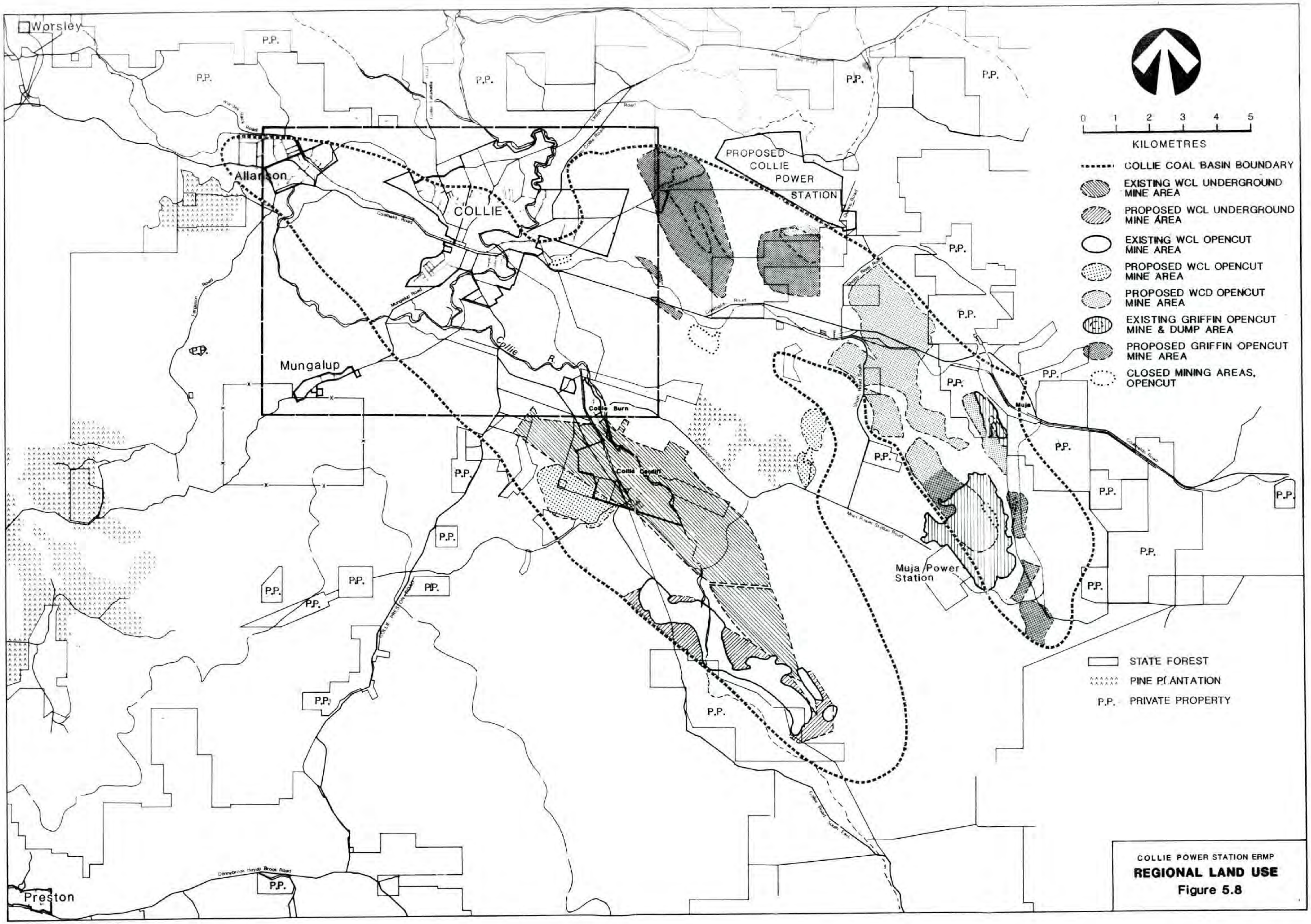


SOURCE: Modified from Smith (1972)

COLLIE POWER STATION ERMP

NUTRIENT CYCLES AND ENERGY FLOW WITHIN NORTHERN JARRAH FOREST

Figure 5.7



COLLIE POWER STATION ERMP

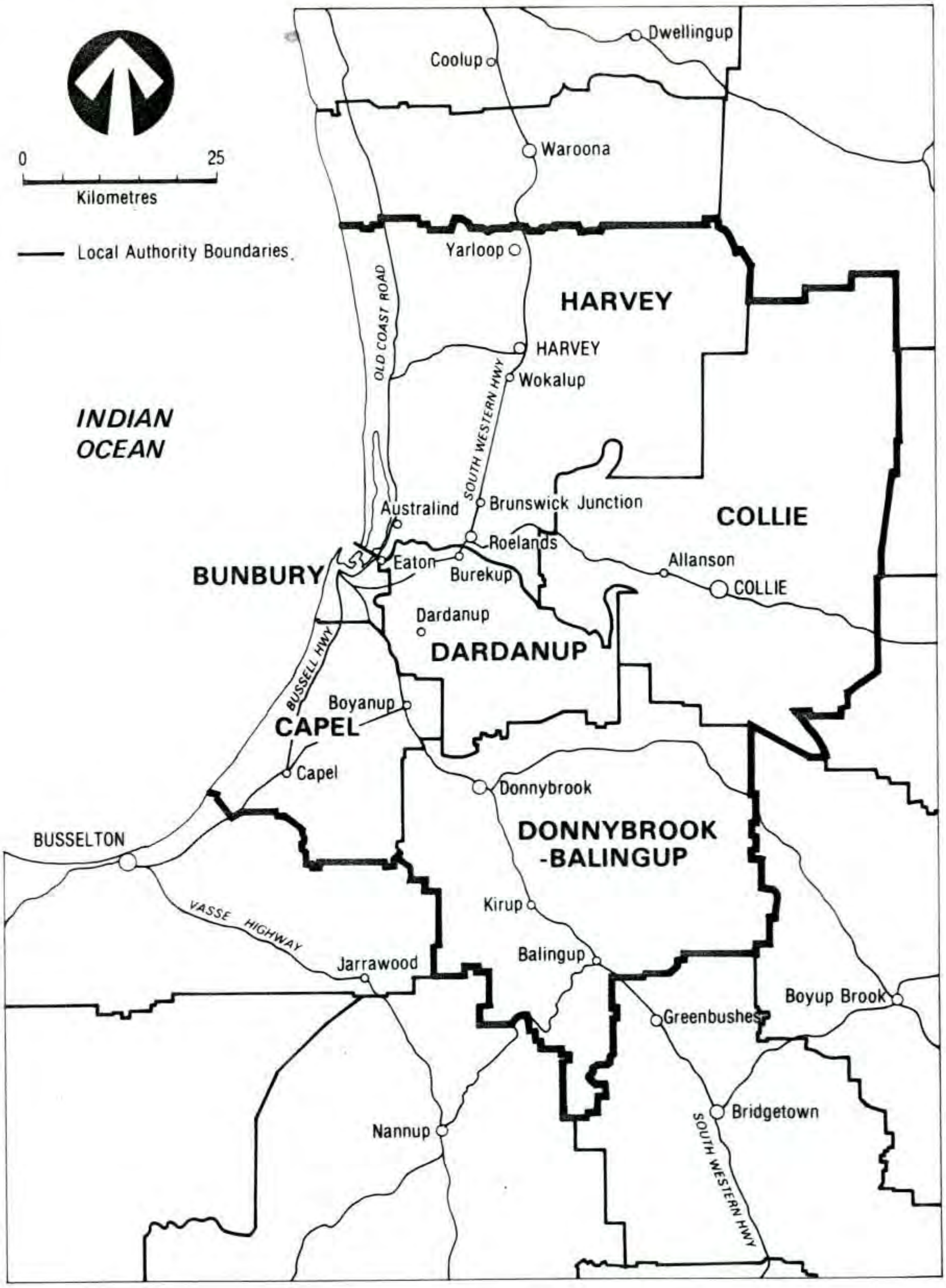
REGIONAL LAND USE

Figure 5.8

COLLIE POWER STATION ERMP

LAND USE COLLIE

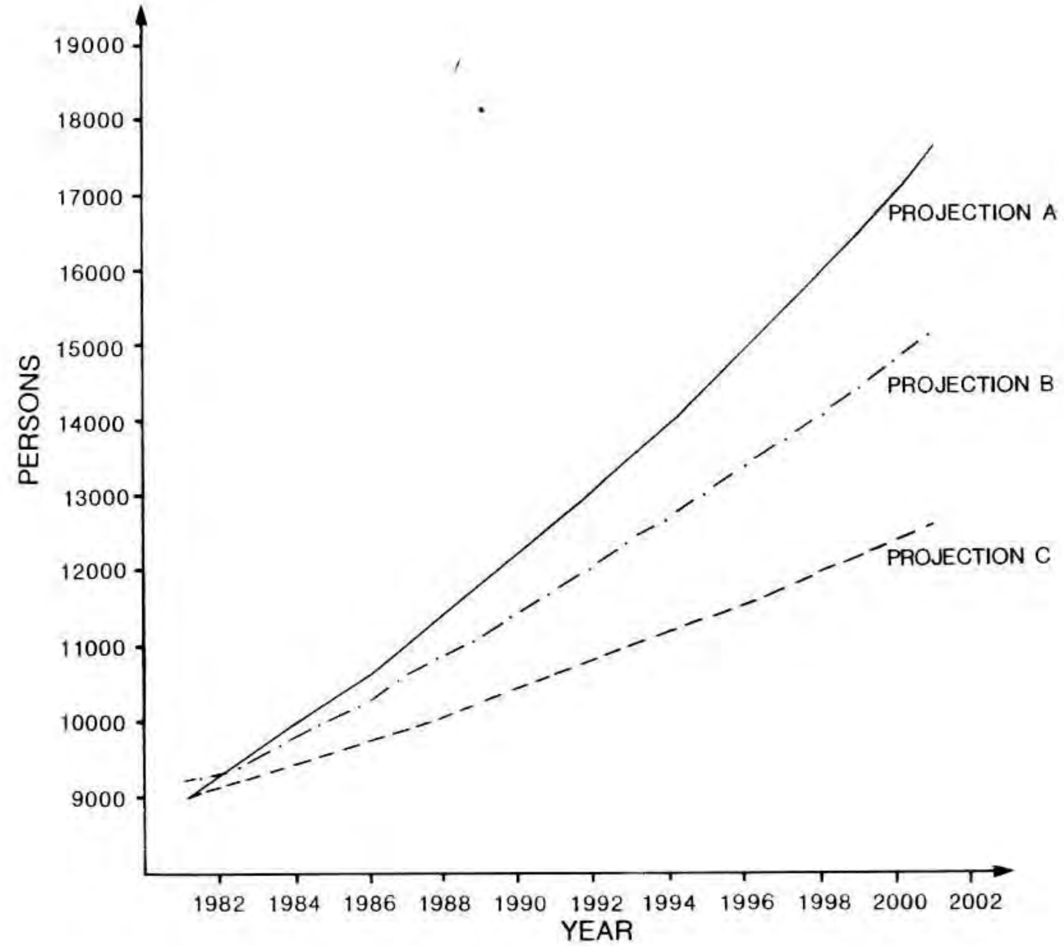
Figure 5.9



COLLIE POWER STATION ERMP

SOCIAL ENVIRONMENT STUDY AREA

Figure 6.1



——— ACTUAL CENSUS COUNT, A.A.G.R. 1976-1981 3.48%.

—·—·—·— ESTIMATED RESIDENT POPULATION, A.A.G.R. 1976-1981 2.67%.

– – – – – – ACTUAL CENSUS COUNT A.A.G.R. 1971-1981 1.73%.

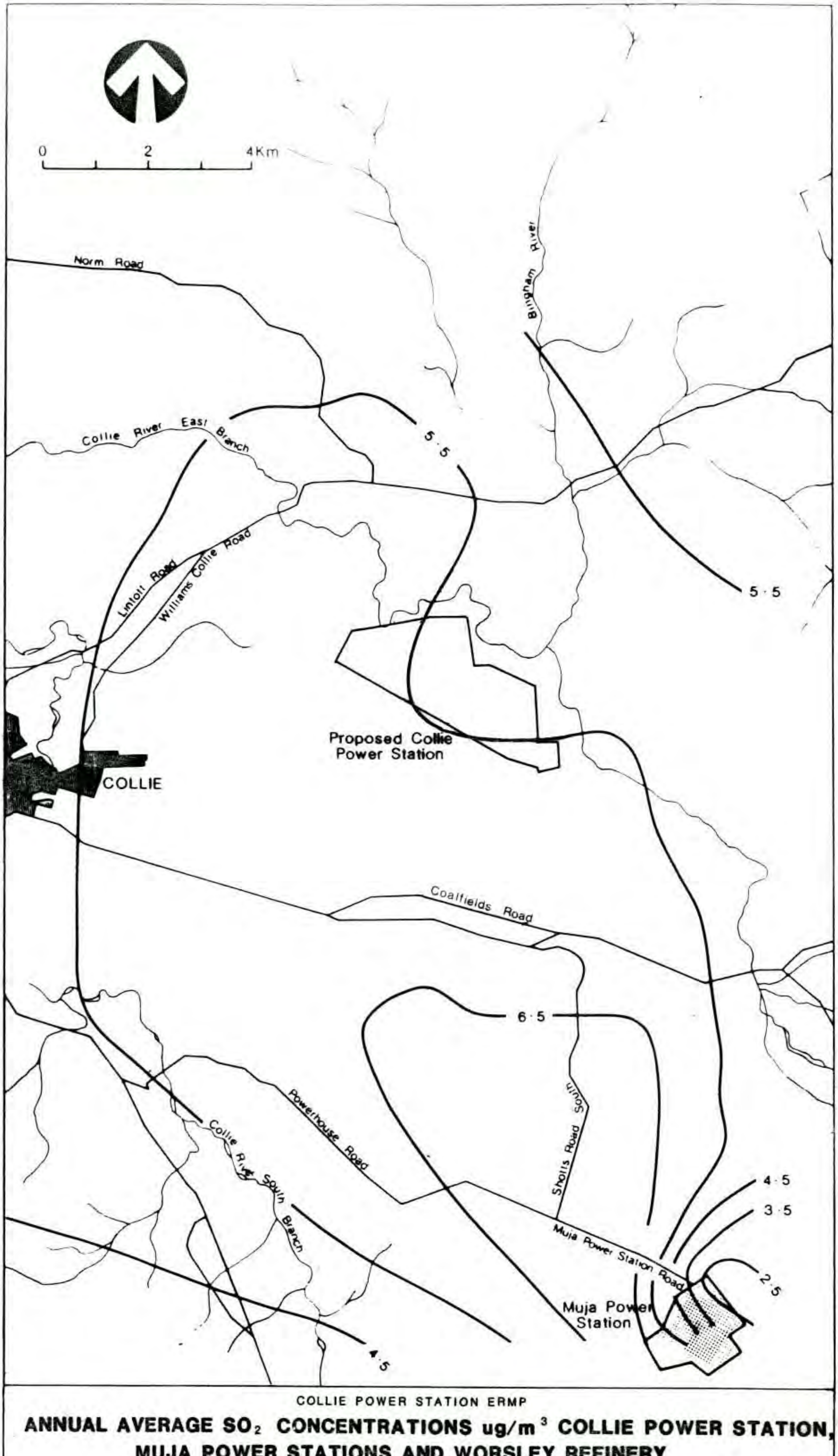
NOTE: A.A.G.R. denotes Annual Average Growth Rate.

SOURCE: South West Development Authority, October 1983

COLLIE POWER STATION ERMP

POPULATION PROJECTIONS TO YEAR 2001 FOR COLLIE SHIRE

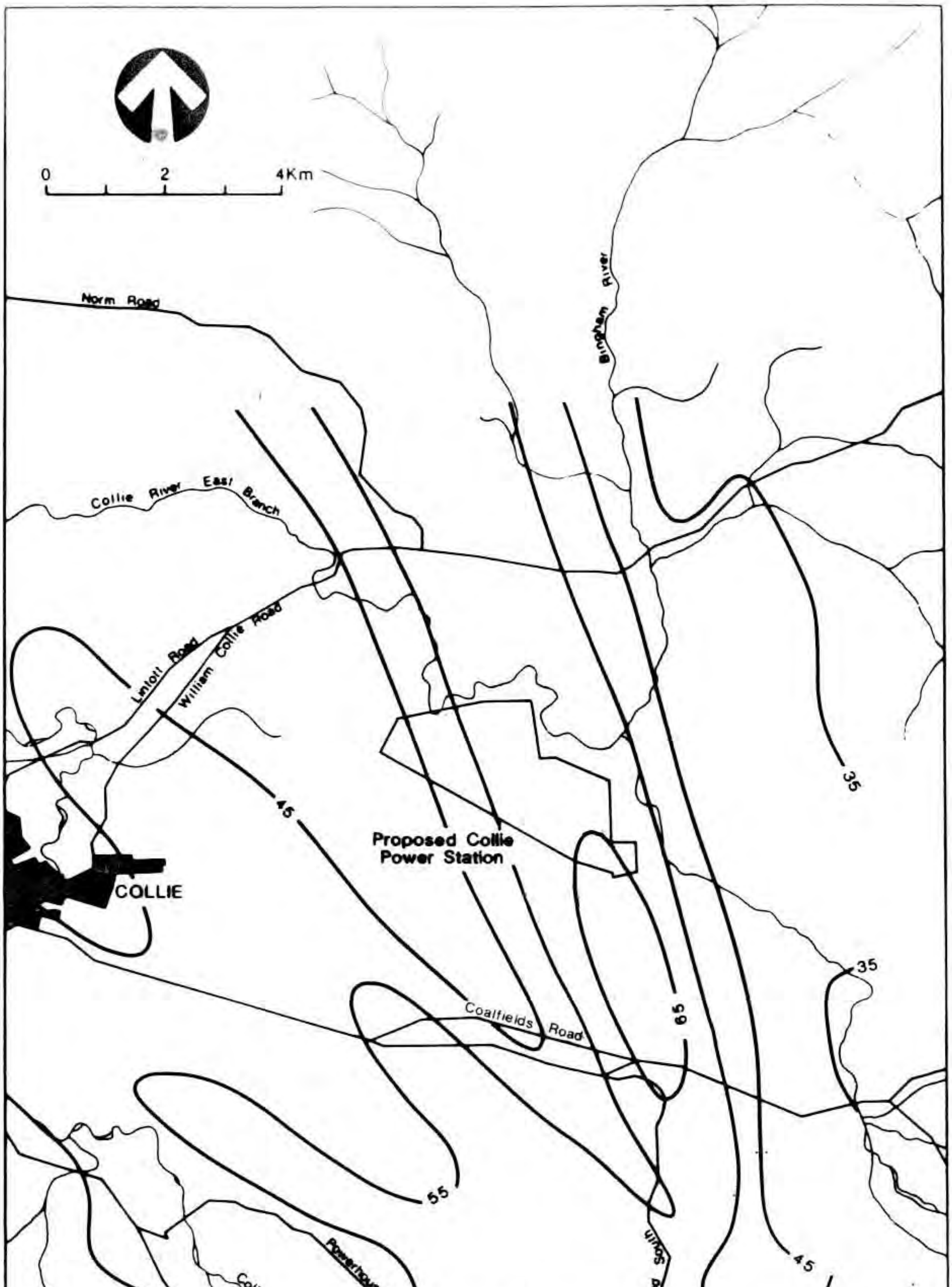
Figure 6.2



COLLIE POWER STATION ERMP

ANNUAL AVERAGE SO_2 CONCENTRATIONS ug/m^3 COLLIE POWER STATION, MUJA POWER STATIONS AND WORSLEY REFINERY

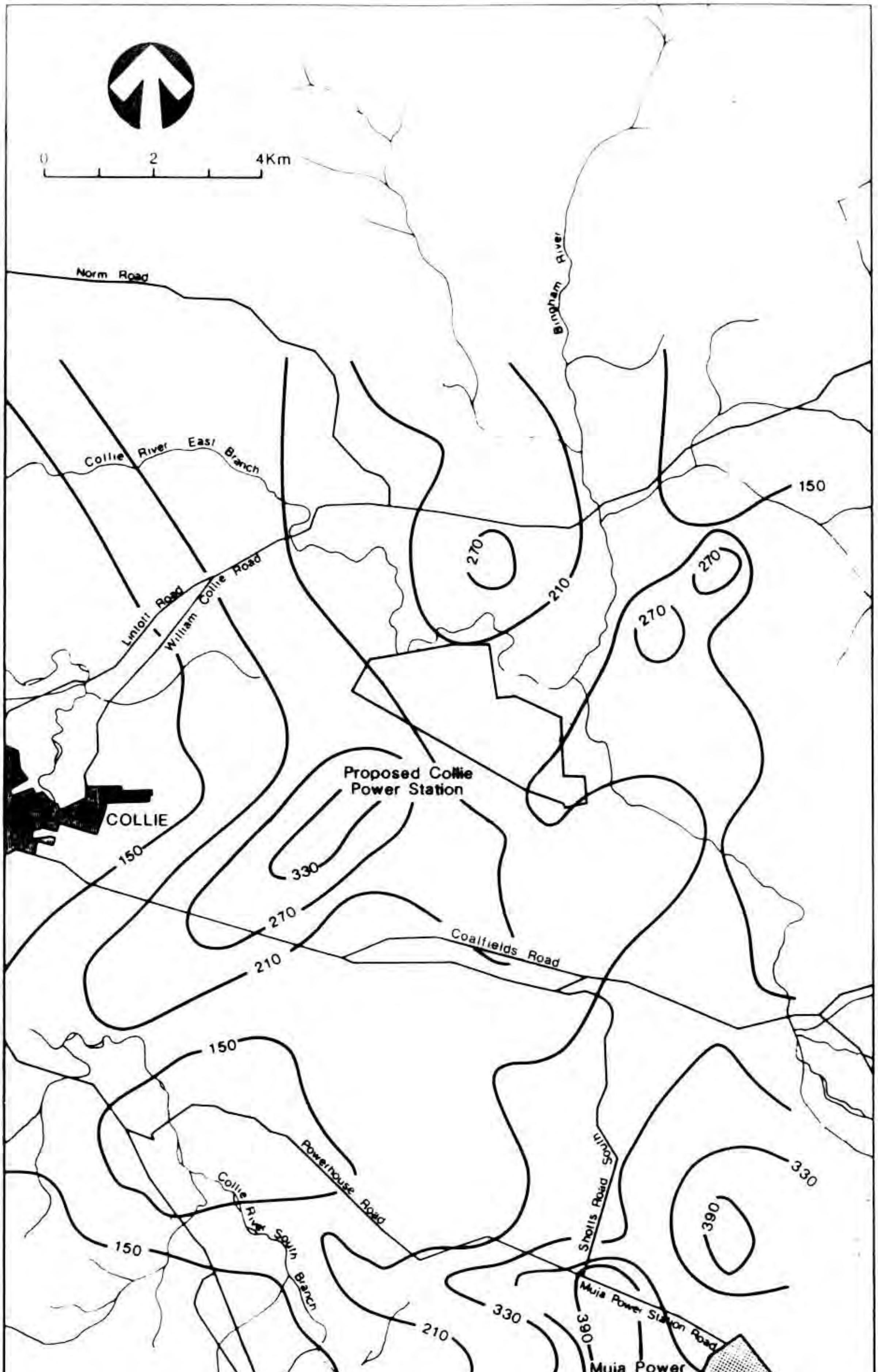
Figure 7.1



COLLIE POWER STATION ERMP

MAXIMUM 24-HOUR SO_2 CONCENTRATIONS ug/m^3 COLLIE POWER STATION, MUJA POWER STATIONS AND WORSLEY REFINERY

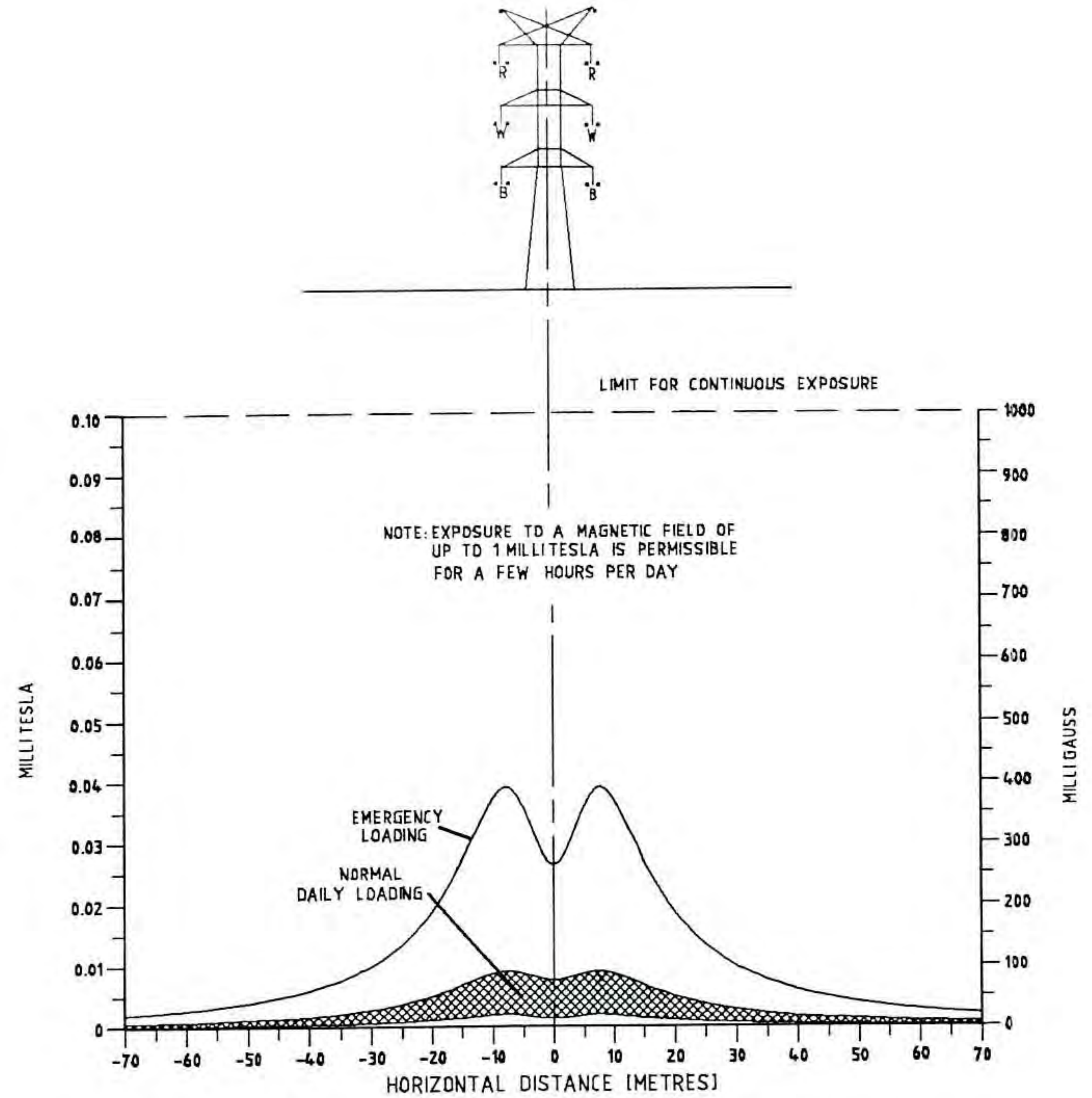
Figure 7.2



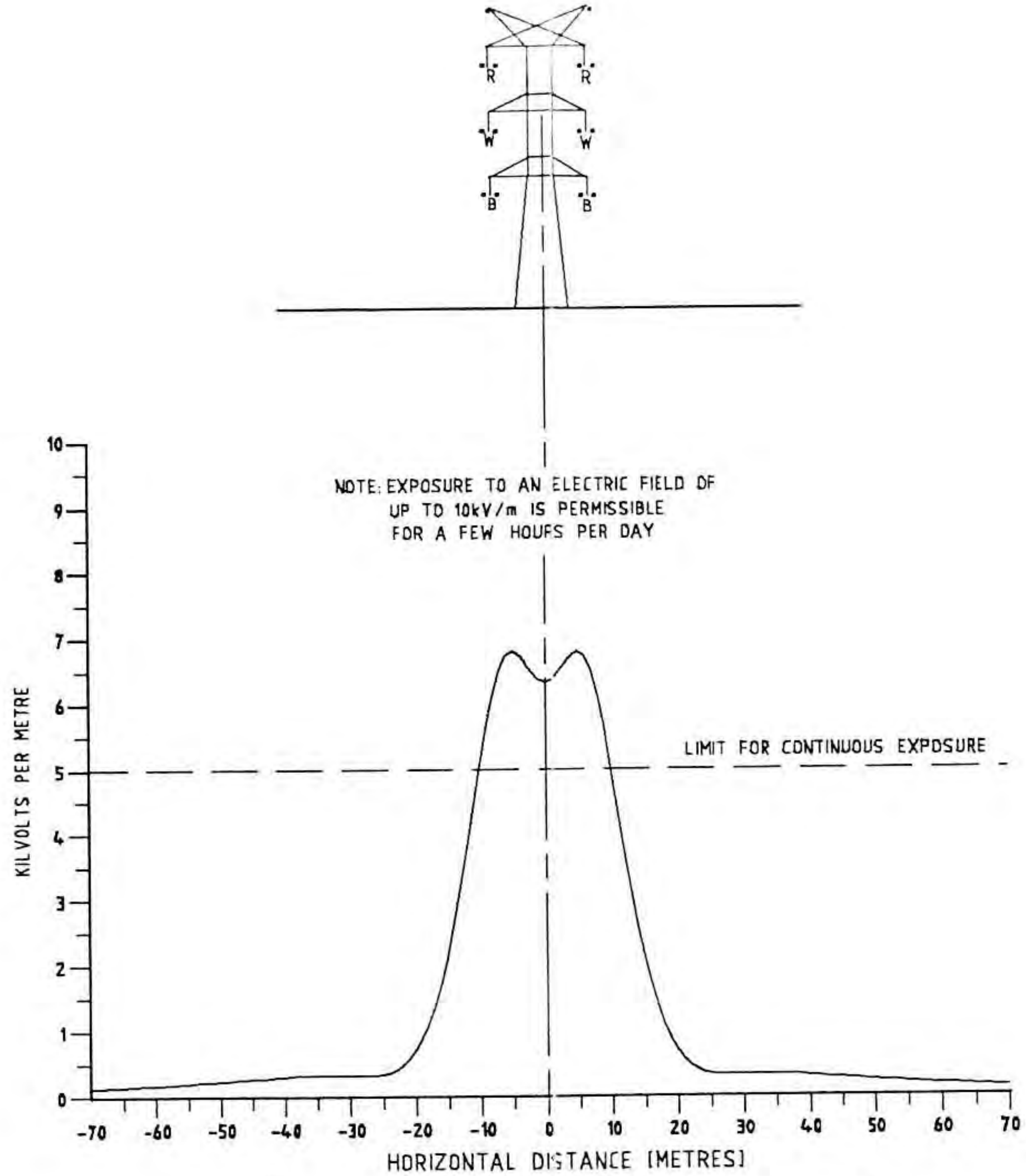
COLLIE POWER STATION ERMP

MAXIMUM 1-HOUR SO_2 CONCENTRATIONS ug/m^3 COLLIE POWER STATION, MUJA POWER STATIONS AND WORSLEY REFINERY

Figure 7.3



MAGNETIC FIELD INTENSITY DISTRIBUTION



ELECTRIC FIELD INTENSITY DISTRIBUTION

NOTES:-

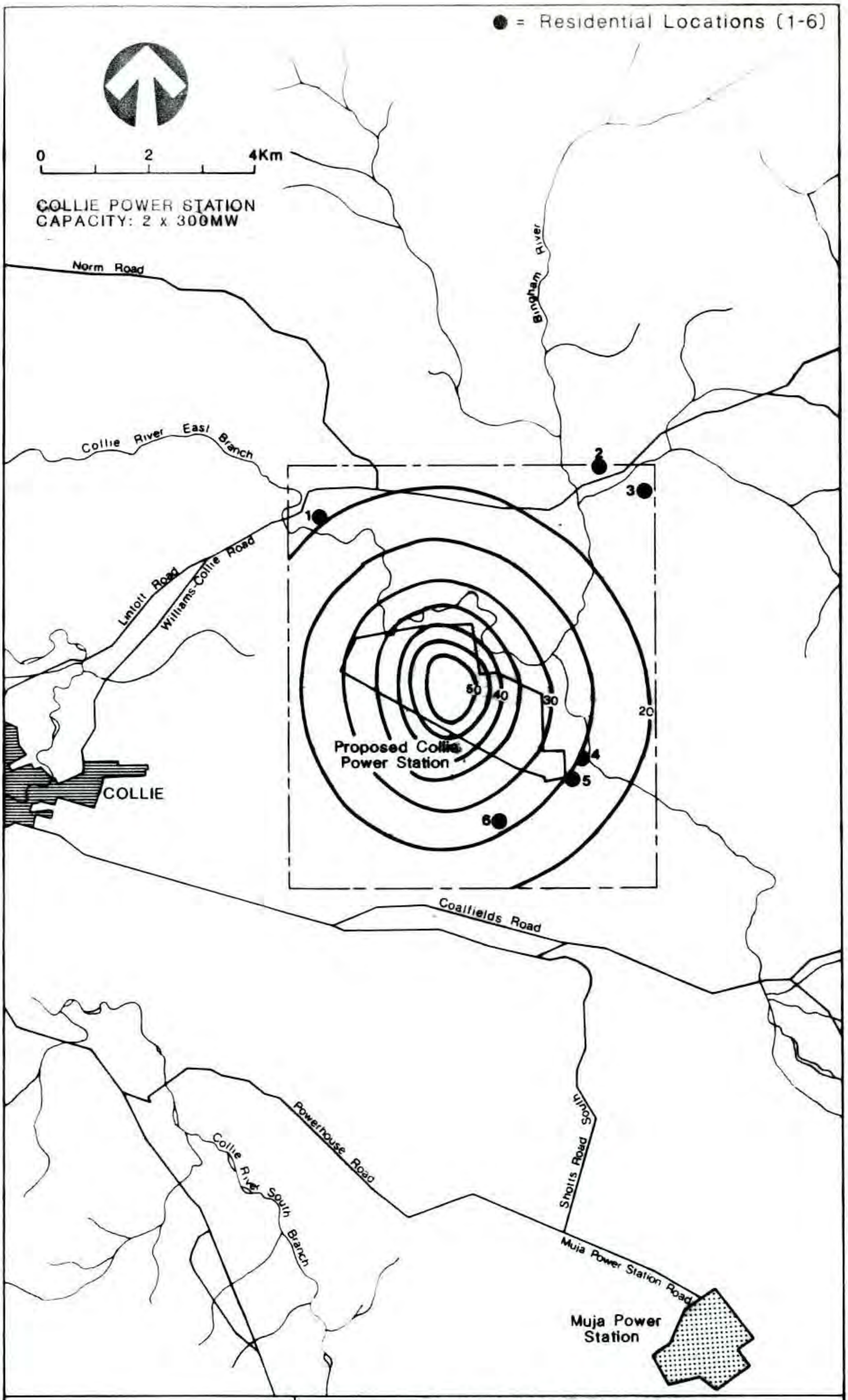
1. THE EXPOSURE LIMITS SHOWN ARE IN ACCORDANCE WITH THE GUIDELINES APPROVED BY THE INTERNATIONAL RADIATION PROTECTION ASSOCIATION IN MAY 1989 FOR AREAS WITH PUBLIC ACCESS

2. THE FIELD INTENSITIES ARE MEASURED 1m ABOVE GROUND LEVEL AT MID-SPAN (i.e. MIDWAY BETWEEN TOWERS), WHICH IS THE WORST CASE.

COLLIE POWER STATION ERMP

ELECTRIC AND MAGNETIC FIELD DISTRIBUTION BELOW THE TRANSMISSION LINES FOR SINGLE TOWER DOUBLE CIRCUIT CONFIGURATION

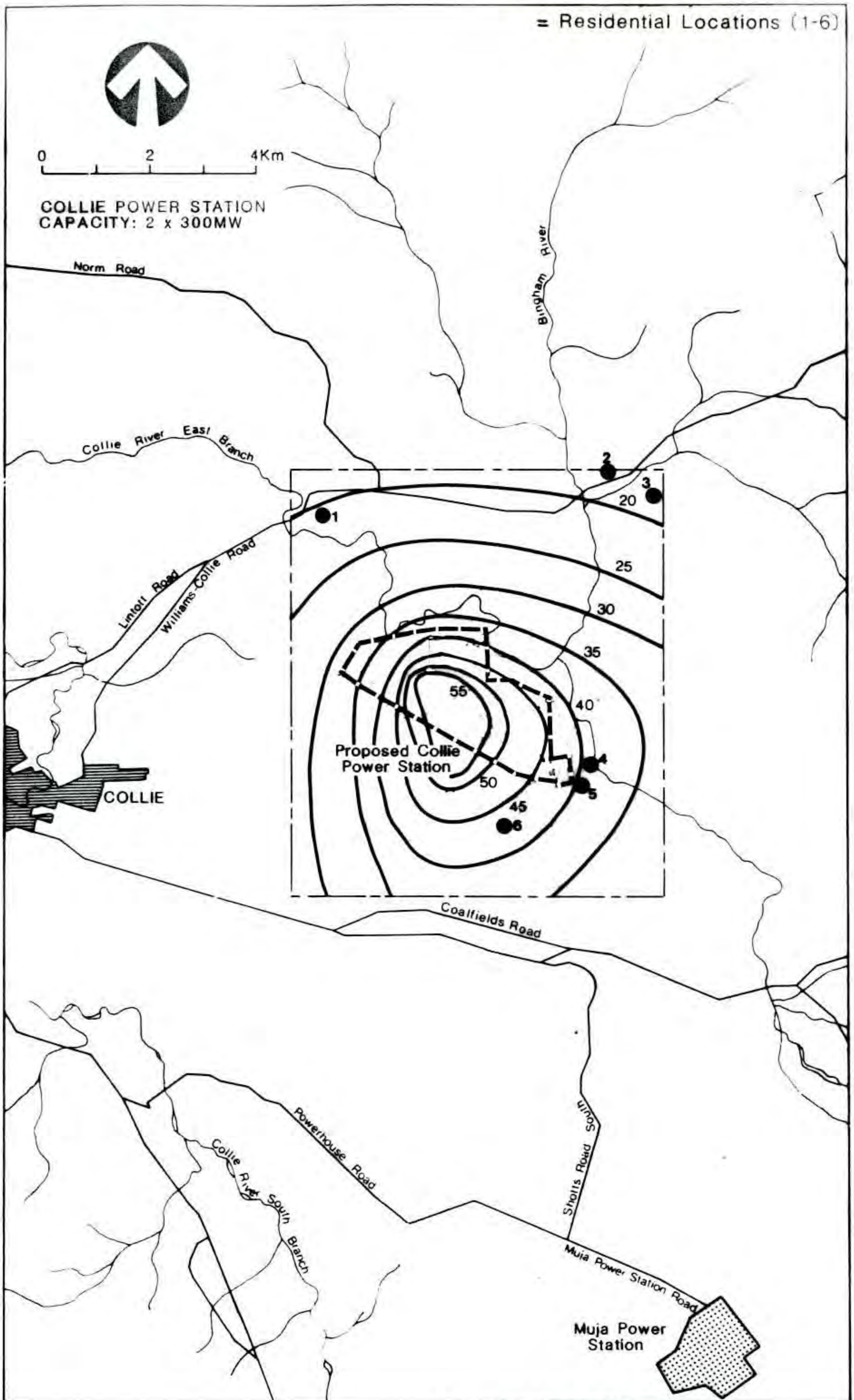
Figure 7.4



COLLIE POWER STATION ERMP

PREDICTED WORST CASE CONTOURS IN dB(A) WITH PLANT NOISE CONTROL ON ALL SOURCES

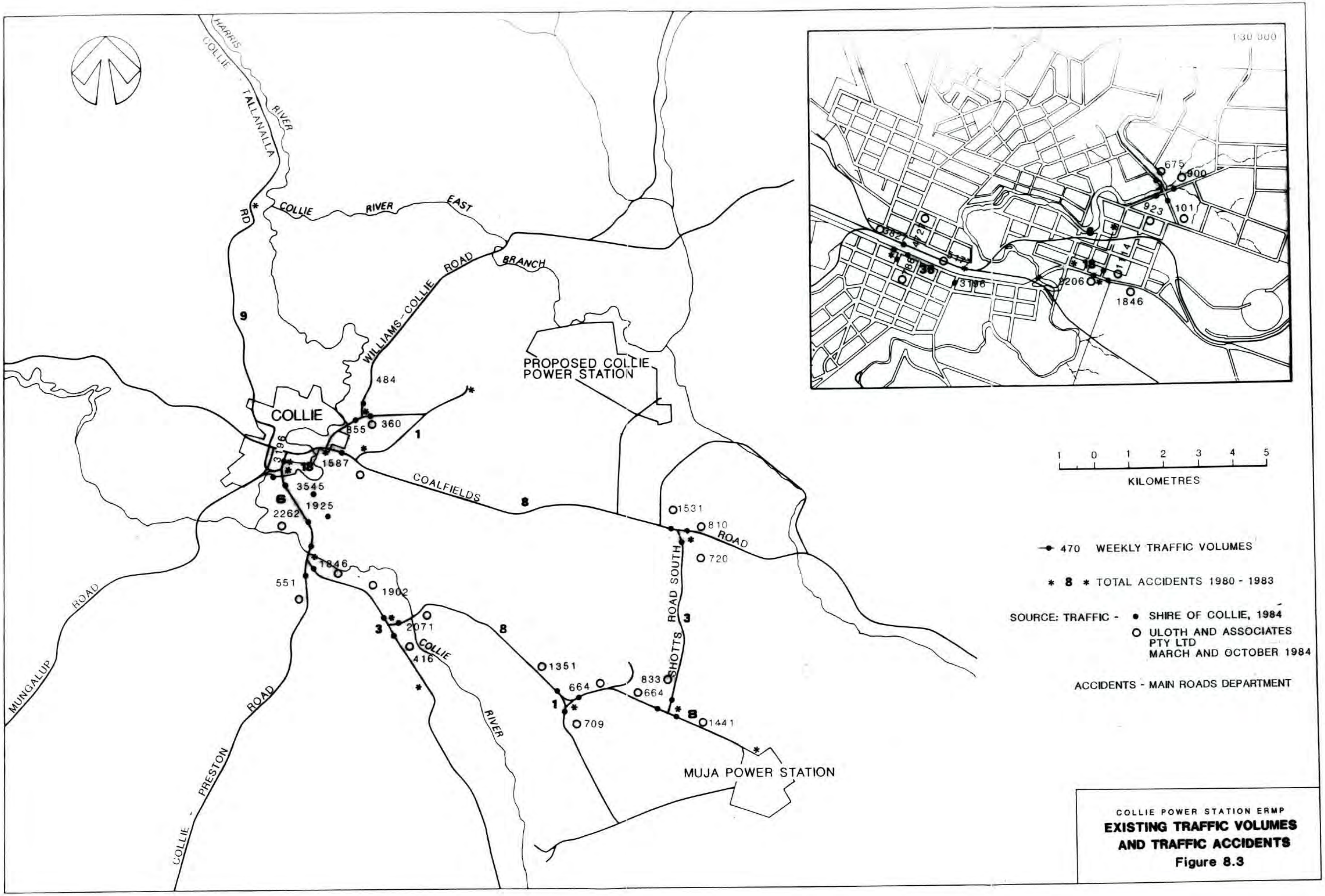
Figure 8.2



COLLIE POWER STATION ERMP

PREDICTED WORST CASE CONTOURS IN dB(A) WITHOUT PLANT NOISE CONTROL

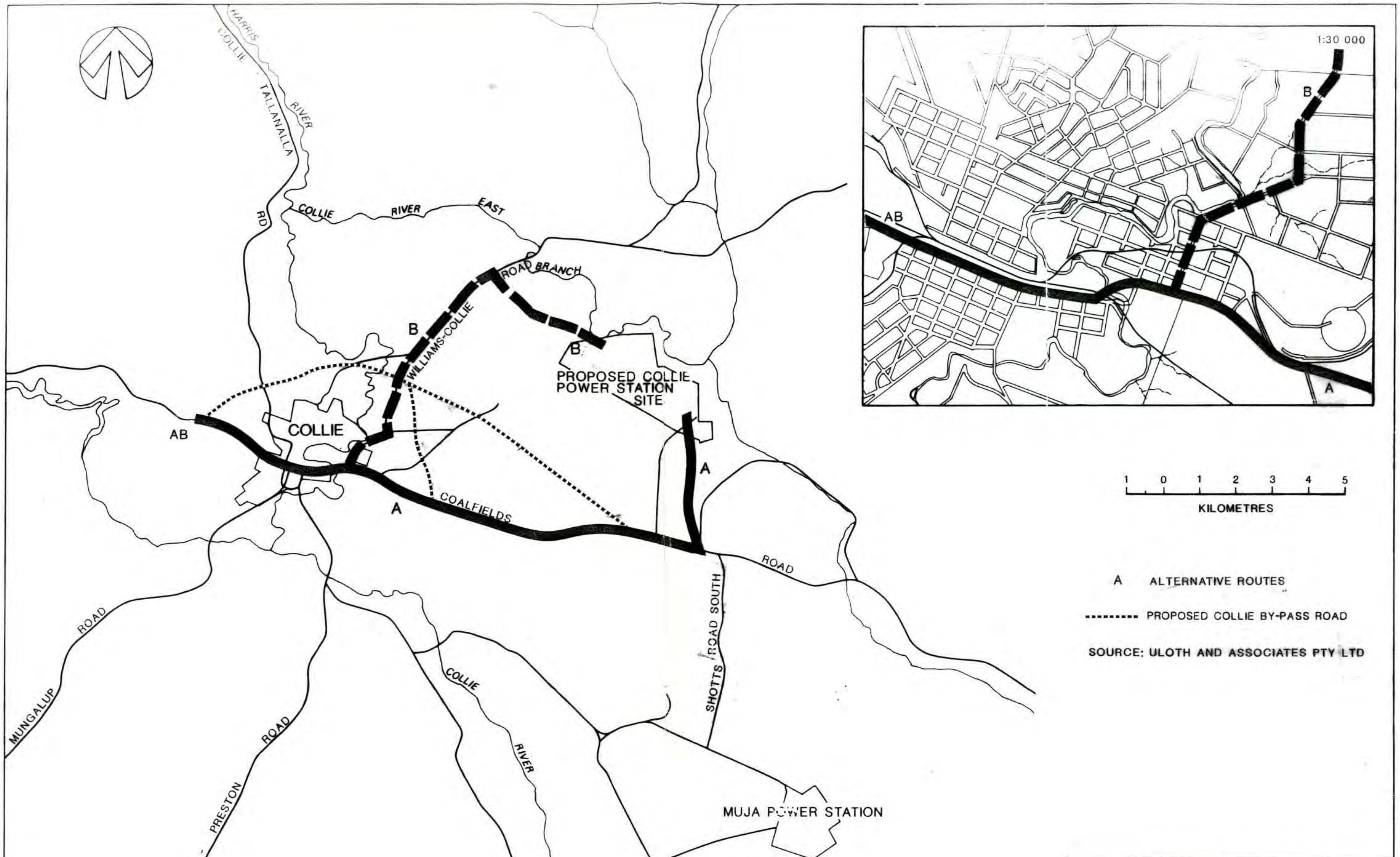
Figure 8.1



COLLIE POWER STATION ERMP

EXISTING TRAFFIC VOLUMES AND TRAFFIC ACCIDENTS

Figure 8.3



COLLIE POWER STATION ERMP

ALTERNATIVE ROUTES TO STATION SITE

Figure 8.4

APPENDIX A

STATE ENERGY COMMISSION OF WESTERN AUSTRALIA

COLLIE POWER STATION
ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

April 1990

APPENDIX A

AIR QUALITY ASSESSMENT

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LIST OF TABLES

1.0 INTRODUCTION

This document provides a detailed description of the air quality assessment conducted for the proposed Collie Power Station and is intended as supporting information for the Environmental Review and Management Programme. (ERMP).

In discussing the air quality aspects of the project, the following topics are considered:

- the dispersion meteorology of the area;
- the existing air quality;
- the modelling approach used in the impact assessment, and
- the likely long and short-term ground level concentrations of sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and particulates.

2.0 DISPERSION METEOROLOGY OF THE COLLLIE AREA

2.1 Existing Meteorological Monitoring Programmes

The Bureau of Meteorology operate a climatic station at Collie Post Office and make observations of 9 am and 3 pm winds, temperature (both wet and dry bulb) and cloud cover. In addition, maximum and minimum temperatures and daily rainfall are recorded. Some relevant statistical data from these long-term records have been summarised in the ERMP. However these data are of little relevance to the air dispersion studies which are the subject of this report. The principal deficiency in the Bureau of Meteorology's data from the point of view of air dispersion studies (as opposed to climatic studies) is the lack of continuity of the wind data i.e. 9 am and 3 pm observations only, whereas knowledge of wind conditions for continuous 24 hour periods is required in line with the continuous operation of the proposed power station. In addition, air dispersion studies require precise quantitative data on parameters not recorded by the Bureau of Meteorology programmes. The main value in the data lies in the length of the available records, which allow comparison with data from intensive short-term, monitoring programmes to ensure that they are representative.

Worsley Alumina Pty. Ltd. operate a meteorological station as part of their environmental monitoring programme for the Refinery. This station, which is located approximately 22 km west of the proposed power station site, provides hourly average (or shorter intervals) data on wind speed, wind direction, temperature and humidity (all at 30 m) and solar radiation, evaporation and rainfall measurements using ground based instruments. Some upper air data (24 radiosonde profiles) and additional wind data from three wind recorders located within 8 km of the refinery are also available. These data are summarised in a report prepared by Worsley Alumina (1983).

A meteorological monitoring station was established specifically to gather data for the power station project and is referred to herein as the Base Station (Figure 1). This station recorded the following parameters:

- wind speed at 12, 15, 22, and 28 m,
- wind speed and wind direction at 37 m,
- sigma-theta at 37 m (the standard deviation of horizontal wind direction with a time constant of 180 s, measured using a wind vane with a nominal damping ratio of 0.6),
- temperature lapse rate over the height interval 22 to 37 m,
- long wave radiation,
- global radiation,
- dew point temperature at 22 m,
- air temperature at 22m,
- rainfall, and
- barometric pressure.

The data are available in computer compatible form and have been processed to provide a data file containing the required information for air dispersion calculations at ten minute intervals. The details of the data processing and the application of the data in the dispersion model are discussed in Section 5.

2.2 Surface Winds and Atmospheric Stability

The prevailing winds are largely the result of synoptic scale driving forces interacting with local topography. The site is elevated and lies approximately 240 m above sea level, the surrounding topography is gently undulating with the maximum height differences within a 10 km radius of the site being no more than 120 m (from 200 to 320 m above sea level).

Thus, topography is not expected to be a significant factor affecting the dispersion of high level stack emissions.

In calm nocturnal conditions, one could expect a slow (1-2 m/sec) drift over the site, perhaps fifty metres deep at most, associated with drainage of cold air down the surrounding slopes (P. Mannins, CSIRO, Div. of Atmospheric Sciences, Pers. Comm. 1984). Since the power station plume will be released from 130 metres above the ground, and rise probably 300 metres more in calm conditions, the details of topographic drainage flow are of no relevance to the air quality patterns. Under these conditions, the plume material will not reach ground level for many kilometres downstream and will be dispersed over a wide area when it finally does.

Figure 2 shows four wind roses prepared from approximately 12 months of data (346 days) for winds associated with three different stability conditions, namely, unstable, neutral and stable (that is, Pasquill-Gifford stability classes A to C, D, and E to F) and for all winds independent of stability class. It is clear that stable conditions are most likely to be associated with winds from the north and south-east. Winds associated with unstable classes are most likely to come from the west through to south (in an anticlockwise direction). Winds associated with neutral stabilities have highest frequencies of occurrence from the east-south-east and south-east. If stability is not considered, the most common winds are from the southeast.

Table 1 shows the frequency of occurrence of different stability categories from the analysis of the available 346 days of data. The method of assigning stability categories for this study is discussed in Section 5.

The sea breeze plays an important role in the dispersion of pollutants in coastal areas of Western Australia. However the proposed site is approximately 50 km from the coast, and although sea breezes will occasionally reach the area, the limited mixing and fumigation phenomena experienced at the coast will not be relevant, because the longer overland trajectory will have increased the depth of the thermal and mechanical mixed layers beyond the critical values experienced on the coast.

TABLE 1

PERCENTAGE OCCURRENCE OF PASQUILL-GIFFORD STABILITY CATEGORIES

STABILITY CATEGORY	A	B	C	D	E	F
PERCENTAGE OCCURRENCE	3.4	4.5	9.3	42.5	12.9	27.3

2.3 Mixing Height

Mixing height has been determined from the analysis or records made by a monostatic acoustic sounder (see Figure 1 for location). Since the maximum range of this instrument was 1,000 m, all occasions when mixing height was greater than 1,000 m have been conservatively set equal to 1,000m.

Table 2 summarises the year's (8,163 hours) data showing the frequency of occurrence of mixing height for different height intervals at different times of day. The table shows that daytime mixing heights are often above the 1,000 m height level, which is the range limit of the acoustic sounder.

Temperature lapse rates data measured between 22 and 37 m levels on the Base Station tower indicated that strong surface inversions were not common, and the rapid rate at which mixing height was observed to grow after sunrise (as shown by the acoustic sounder records) supported this observation. This was presumably a result of the extensive areas of forest which grow on the undeveloped land around the proposed site. The greater surface roughness due to the forest presumably assists in maintaining greater mixing, even under light wind conditions, than would be the case in the absence of the forest.

TABLE 2

MIXING HEIGHTS FOR COLLIE AREA

		HEIGHT (m)					
		0 to 200	200 to 400	400 to 600	600 to 800	800 to 950	Over 950
	0	78	132	52	14	1	62
	1	81	132	63	8	4	52
	2	81	134	63	18	4	38
	3	88	138	52	16	4	40
	4	86	144	48	13	4	42
	5	89	143	42	19	1	44
	6	90	144	43	13	1	47
T	7	90	132	49	13	0	54
I	8	66	102	64	18	3	86
M	9	34	63	56	41	8	136
E	10	20	27	41	38	7	208
	11	5	19	13	14	1	289
O	12	1	6	8	4	1	323
F	13	1	2	3	2	3	331
	14	0	1	2	0	1	338
D	15	0	1	1	1	1	338
A	16	1	1	0	2	0	338
Y	17	25	1	1	1	0	314
	18	59	7	2	1	0	273
(h)	19	86	64	6	1	0	184
	20	90	85	8	2	0	156
	21	95	100	13	2	1	130
	22	87	107	33	4	4	105
	23	83	116	50	11	1	79
TOTAL		**1,336**	**1,801**	**713**	**256**	**50**	**4,007**

3.0 EMISSIONS

3.1 Proposed Power Station Emissions (Construction and Operation)

During the construction phase of the project there will be some emissions of dust and exhaust fumes from motor vehicles and heavy earthmoving equipment. However, the nearest residences are about 2 km away and no adverse air quality impacts are expected.

During operation, coal combustion products will be discharged through a single stack of suitable height. Typical emission conditions for a 600 MW power station are summarised in Table 3. The figures given apply to operation at full load and an assumed coal sulphur content of 0.7%.

TABLE 3

FULL LOAD EMISSIONS FOR COLLIE POWER STATION

Number of Stacks	1
Stack Height (m)	130
Gas Exit Temperature (^oC)	120
Gas Volume Flow Rate (m^3/s)	590 at STP
Mass Emission Rate NO_2 (g/s)	<422
Mass Emission Rate SO_2 (g/s)	976
Particulate Emission Rate* (g/s)	20

\+ All oxides of nitrogen expressed as NO_2

* Some emissions of particulates from coal handling facilities will also occur.

The operating conditions described in Table 3 have been used in the dispersion modelling calculations, however it is important to note that under normal conditions, emission rates will be lower. Two factors are relevant in this regard. Firstly, the Station will not always operate at full load. The station's capacity factor will be in the order of 70%. Secondly the assumed sulphur concentration (0.7%) is higher than the known average for Collie coal.

Analysis of Collie coal over many years has shown sulphur concentration averages 0.6%. The reason for using these conservative data in the modelling exercise has been to include a safety factor in the calculations.

The stack height of 130 m is a preliminary estimate only. Even though this height is low relative to many modern power stations, it will be shown to be acceptable for atmospheric dispersion purposes, due primarily to the large volume flux of emissions from the two generating units. The final stack height will be determined during detailed design and will most likely be dictated by the results of a wind tunnel study of plume entrainment in building or cooling tower wakes.

3.2 Neighbouring Sources

Some emissions of SO_2, NO_2 and particulates already occur in the area, from the existing Muja A, B, C and D units and from the Alumina Refinery at Worsley. Some additive interaction between the plumes from Muja and those from the proposed power station is to be expected when the wind is from the south-southeast or from the north-northwest. Slight interaction with the Worsley Alumina Refinery plume, might be expected but because the refinery is over 23 km away the interaction should be far less. To account for the possibility of this interaction the sources at Muja and Worsley have been included in the modelling analyses. Table 4 shows the emission parameters assumed.

4.0 AIR QUALITY CRITERIA

No ambient air quality standards have been proclaimed for the Collie area. In the absence of Western Australian standards, the discussions which follow have been based on World Health Organisation (WHO) guidelines, United States Environmental Protection Agency (US EPA) standards, and the Victorian Environment Protection Authority (VEPA) air quality objectives for designated regions of Victoria and the National Health & Medical Research Council's (NHMRC) ambient air quality goals.

TABLE 4

EMISSION PARAMETERS FOR NEIGHBOURING SOURCES

	MUJA A&B	MUJA C	MUJA D	WORSLEY
Number of stacks	2	1	1	1
Stack height (m)	98	151	151	40
Gas exit temperature (^oC)	175	120	120	135
Gas volume flow rate (m^3/s) at STP, Dry	113 per stack	304	304	106
Mass emission rate NO_2* (g/s)	170 per stack	316	316	Not available
Mass emission rate SO_2 (g/s)	233 per stack	650	650	200
Particulate emission rate (g/s)	990 per stack	14	14	Not available

* All oxides of nitrogen expressed as NO_2.

In this report the term air quality criteria will be used when referring to these guidelines, standards or objectives. Table 5 provides a summary of the relevant data.

TABLE 5

SUMMARY OF RELEVANT AIR QUALITY CRITERIA

1. UNITED STATES (US EPA, 1977)

Primary Standard (to protect public health)

Annual average SO_2:	80 $\mu g/m^3$	
Annual average NO_2:	100 $\mu g/m^3$	(NO_x expressed as NO_2)
Annual average particulates:	75 $\mu g/m^3$	(Geometric mean - under review)
24-hour SO_2:	365 $\mu g/m^3$	(Exceeded not more than once per year)
24-hour particulates:	260 $\mu g/m^3$	

Secondary Standards (to protect public welfare)

Annual average NO_2:	100 $\mu g/m^3$	(NO_x expressed as NO_2)
Annual average particulates:	60 $\mu g/m^3$	(Geometric mean - under review)
24-hour particulates:	150 $\mu g/m^3$	
3-hour SO_2:	1300 $\mu g/m^3$	(Exceeded not more than once per year)

2. WORLD HEALTH ORGANIZATION (WHO, 1987)

Public Health Guidelines

Annual average SO_2:	50 $\mu g/m^3$

Annual average particulates	40 $\mu g/m^3$ (1979 guideline)
24-hour average SO_2:	125 $\mu g/m^3$

Ecological Safeguards (Europe)

	SO_2	NO_2*
Annual average ($\mu g/m^3$)	30	30
24-hour average ($\mu g/m^3$)	100	-
4-hour average ($\mu g/m^3$)	-	95

* In the presence of SO_2 and O_3 no higher than 30 $\mu g/m^3$ and 60 $\mu g/m^3$ respectively.

3. VICTORIA (Victoria Government Gazette 63, 1981)

	Acceptable Level	
24-hour average SO_2:	171 $\mu g/m^3$	(Exceeded for no more than 3 days per year)
24-hour average NO_2:	123 $\mu g/m^3$	(Exceeded for no more than 3 days per year)
1-hour average SO_2:	486 $\mu g/m^3$	(Exceeded on no more than 3 days per year)
1-hour average NO_2:	308 $\mu g/m^3$	(Exceeded on no more than 3 days per year)

1-hour particulates	Visibility 20 km (equivalent to about 100 $\mu g/m^3$) Applies for relative humidities of less than 70 percent

Detrimental Level

24-hour average SO_2:	314 $\mu g/m^3$	(Not to be exceeded)
24-hour average NO_2:	308 $\mu g/m^3$	(Not to be exceeded
1-hour average SO_2:	972 $\mu g/m^3$	(Not to be exceeded)
1-hour average NO_2:	513 $\mu g/m^3$	(Not to be exceeded)

4. NHMRC (Ambient Air Quality Goals)

24-hour average SO_2:	60 $\mu g/m^3$
1-hour average NO_2:	320 $\mu g/m^3$
Annual average particulates	90 $\mu g/m^3$

N.B. Missing entries occur for some averaging times because of different criteria adopted by different regulatory bodies.

5.0 METHODS FOR IMPACT PREDICTION

5.1 Overview

The air quality impact of the proposed power station has been assessed using an air dispersion model to predict the resulting ground level concentrations of SO_2, NO_x and particulates for appropriate averaging periods. Results for SO_2 are presented in the form of diagrams which show the annual average, maximum 24-hour and maximum 1-hour concentrations over a 15 x 20 km area, approximately centred on the power station site. Concentrations of NO_2 and particulates have been conservatively estimated by reference to the SO_2 predictions.

In each case the model estimates have been made for the proposed power station in isolation and for the proposed power station considered together with other significant sources.

The model used in these studies is a Gaussian dispersion model which is described in Section 5.3.

All modelling scenarios are conservative in that they assume Collie Power Stations will be operating at full load conditions, and will burn coal with a 0.7% sulphur content. In practice the Station will operate at less than 100% capacity factor and will utilize coal with lower sulphur content than indicated above.

5.2 Processing of Meteorological Data

The model (in the form used in this study) requires meteorological input data as follows:

- half hourly average wind speed,
- half hourly average wind direction,
- half hourly estimates of mixing depth,
- half hourly temperature,
- stability class for each half hour, and
- the estimated temperature increase in the inversion layer at the top of the mixed layer.

The wind speed and wind direction data (including data on the standard deviation of wind direction fluctuations) were obtained from recording instruments at the 37 m level on the Base Station tower. The data available for the study were collected during the period 6 August 1983 to 24 July 1984 (approximately 1 year). The data recovery rate was 98%. Thus approximately 8,304 hours of data were available for the study.

Temperature data were obtained from a sensor at the 37 m level. Mixing depth data were obtained from analysis of acoustic sounder records (see Figure 1 for location of the instrument). Mixing depth during the night was generally taken to be the top of the rising echoing layer. This layer usually became too faint to be recorded when the height was above approximately 500 m. When this was the case the record was extrapolated linearly up to a height of 1,000 m, after which the mixing height was conservatively held constant. Table 2 (refer back to Section 2.3) shows the frequency of occurrence of the mixing depths assigned for each hour of the day in a range of height intervals up to 1,000 m for the year of data used in the present analysis. As would be expected many mixing depths were above 1,000 m. The exact height is not known and is therefore assigned to the interval "greater than 950 m".

During daytime hours (defined as one hour after sunrise to one hour before sunset) the standard deviation of wind direction data was analysed and used with the United States Nuclear Regulatory Commission (US NRC) criteria to assign a stability category.

The increased roughness of the Collie site (estimated from analysis of wind profiles under neutral conditions to be 1 m) and the non-standard height of the wind direction sensor (37 m compared with a standard height of 10 m) necessitated some adjustments to the US NRC sigma - theta categories. These adjustments followed a simple power law correction for roughness with an exponent of 0.2 which has the net effect of increasing the sigma-theta range limits by a factor of 2.02. Adjustment for the non-standard measurement height followed recommendations by Pendergast (1977). This led to a decrease which was equivalent to multiplying the sigma-theta limits by a factor of 0.9. Table 6 shows stability classes and corresponding limits on sigma-theta which were finally used.

TABLE 6

ADJUSTED SIGMA-THETA AND z/L RANGES CORRESPONDING TO STABILITY CATEGORIES

Adjusted Sigma-Theta Range (degrees)	z/L (dimensionless)	Stability Category
greater than 40.9	not used	A
30.1 to 40.9	not used	B
20.6 to 30.1	not used	C
11.2 to 20.6	-0.1 to 0.20	D
4.8 to 11.2	0.20 to 0.65	E
less than 4.8	greater than 0.65	F

During the night-time hours (defined as one hour before sunset to one hour after sunrise) stability was estimated by first calculating the Monin-Obukhov length (L), given by,

$$L = \frac{-P_a \, C_p \, \mu_*^3 \, T_a}{kg \, H} \qquad \dots (1)$$

where,

P_a	=	ambient air density;
C_p	=	specific heat of air at constant pressure;
T_a	=	ambient air temperature;
μ_*	=	friction velocity;
k	=	0.4 (von Karman's constant), and;
H	=	heat flux

The function z/L (where z is the measurement height) was then used as a stability parameter to assign stability categories. The ranges of z/L which define a given stability category are shown in Table 6. These were determined by plotting z/L against corresponding measurements of sigma-theta over extended periods and determining which values correspond to the sigma-theta ranges specified in Table 6.

The advantages of using this method at night, rather than directly using sigma-theta measurements, is that wind meander under stable conditions at night can lead to large values of sigma-theta being measured. These values, if used directly, can lead to large underpredictions of stability at night.

5.3 Dispersion Models

Two computer based dispersion models were applied to assess different air quality aspects of the proposed power station.

The model (DISPMOD) was used to estimate ground level concentrations of gaseous emissions; namely SO_2, NO_x, and particulates for the proposed power station in isolation and for the proposed power station and existing air pollution sources (Muja A,B,C, and D and the Worsley Refinery).

A second model (known as ISCV) is a modified version of the US EPA model ISCST (Industrial Complex Model Short-Term) was used for comparison. Both models produced similar results on 30 days of test data and because of the shorter running time for DISPMOD it was used as the principal model for air quality assessment in this study.

The essential features of these models are described in detail in the literature or in the model user manuals (see KAMS, 1982 and VEPA, 1984). The following sections provide a brief overview of the models, providing sufficient detail to define the calculations that were undertaken and allow an understanding of the strengths and weaknesses of the approach. Readers requiring detailed technical information will need to consult the appropriate literature.

5.4 Dispersion Model (DISPMOD)

5.4.1 Introduction

DISPMOD as used in this study is an adaptation of the Gaussian dispersion model (Model 1) described in KAMS (1982). The basic equation used to calculate pollutant concentration is the widely used Gaussion equation as follows:

$$X(x,y,z,h) = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp\left[\frac{-y^2}{2\sigma_y}\right]\left[\exp\left[\frac{-(z-h)}{2\sigma_z}\right] + \exp\left[\frac{-(z+h)^2}{2\sigma_z^2}\right]\right] \quad .... (3)$$

where,

x	=	concentration
Q	=	source emission rate;
h	=	effective plume centreline height, and
x,y,z	=	downwind, crosswind and vertical coordinates respectively.

5.4.2 Plume Rise

The effective plume height in Equation 2 is calculated by adding the plume rise Δh to the stack height. The plume rise is estimated using the Briggs (1975) equations, as presented in KAMS (1982).

5.4.3 Plume Penetration of Inversion

Many Gaussian models assume that, provided the predicted effective plume height is greater than the mixed layer depth, then the plume is effectively prevented from contributing to ground level concentrations. In practice, although plumes can interact with inversions in this way, it is more common for only a portion of the plume to penetrate the inversion and be removed from contributing to ground level concentrations, leaving the remainder trapped within the mixed layer.

DISPMOD estimates the fraction of the plume remaining in the mixed layer using an approach developed by Mannins (1979). The estimated fraction of the plume (f) which remains within the mixed layer is given by,

$$f = \frac{0.08}{P} - (p - 0.08)$$

where,

$$p = \frac{FT}{\mu g \, \Delta\theta \, \Delta h^2} \quad ....(4)$$

where,

T	=	ambient temperature (^{o}K)
F	=	buoyancy flux of the plume
u	=	wind speed
g	=	acceleration due to gravity
Δh	=	distance from stack tip to the inversion, and
$\Delta\theta$	=	the size of the temperature rise across the inversion

The only parameter in Equation (4) which is not directly available from measured data is $\Delta\theta$. Estimates of $\Delta\theta$ might be inferred from radiosonde profiles if these were available, but only for the time of radiosonde release, rather than on a continuous basis as required. An alternative mathematical scheme has been developed for the present study, as described below.

The Kwinana air Modelling Study Report (KAMS, 1982) describes a well mixed layer model used to predict the erosion of radiation inversions following sunrise due to the action of solar heating and wind induced mixing. The model formula for the erosion rate (neglecting wind shear across the inversion) is,

$$\frac{dh}{dt} = C_K q^3 \left[C_T q_*^2 + \frac{gh\Delta\theta}{T_a} \right]^{-1} \qquad ...(5)$$

where $q_*^3 = w_*^3 + c_N^3 u_*^3$ and where $w_* = (ghH_v/\rho_a C_p T)^{1/3}$ is the buoyancy velocity scale, u_* is the friction velocity, $\Delta\theta$ is the idealised inversion strength, and C_K, C_T and C_N are experimentally determined constants with values of 0.18, 0.8 and 1.33 respectively. Values of q_*^3 may be calculated from heat and momentum flux values which in turn are calculated from the Base Station profiles of wind speed and temperature. The erosion rate $^{dh}/_{dt}$ can be estimated from the acoustic sounder record during periods where erosion is proceeding at a measurable rate (ie. during the morning). Hence, the only unknown, $\Delta\theta$, may be determined by solving equation (5).

The value of $\Delta\theta$ obtained from the above method is believed to provide a reasonably objective estimate of the inversion strength relevant to plume penetration prediction. There may be very stable layers of air immediately adjacent to the top of the mixed layer, but such layers would tend to trap a penetrating plume rather than present a lid to it.

In practice, the $\Delta\theta$ prediction scheme was used only for periods following sunrise when appreciable mechanical and thermal mixing was occurring ($q_*^3 > 0.2$). Prior to this time, it was assumed that no lid would be sustained and so the plume was allowed to disperse in an unbounded manner in the stable atmosphere. Note that this is a conservative approach as it neglects the possibility of the plume escaping from the nocturnal boundary layer and not reaching ground level due to the lack of mixing in the very stable air adjacent to the ground. Another simplifying assumption (again conservative) was to limit all plume dispersion to 1,000 m, which was the highest measurable mixing depth from the acoustic sounder.

Transient fumigation, which occurs when the mixing layer deepens to include the level of the plume, can result in high short term ground level concentrations. However, due to the rapid growth of the well mixed layer at Collie, combined with the high final plume height, fumigation is not likely to significantly increase concentrations averaged over periods of one hour or greater. A model study by Rye (1984) has confirmed this and consequently fumigation is not treated in any more detail in this report.

5.4.4 Horizontal Plume Spread Parameters

In the version of DISPMOD used in the present study, the Briggs open country sigma-y curves (see Gifford, 1975) were used. These curves have been synthesized by Briggs and it has recently been shown (Weill and Brower, 1984) that when these curves are applied with an allowance for buoyancy induced dispersion, they result in statistically more accurate prediction of ground level concentrations for elevated sources than if the Pasquill-Gifford curves are used.

In the application of DISPMOD, it has been assumed that the Briggs horizontal plume spread parameters correspond to a three minute averaging time and surface roughness of 0.1m. The Briggs curves have then been adjusted following the recommendations of Hanna et. al., (1977), so that they apply to 1 m surface roughness and 1/2 hour averaging time. To do this, the unadjusted sigma-y curve is multiplied by 1.58 for the time correction and 1.58 for the roughness correction.

These adjustment factors must be considered approximate as the reference conditions (that is averaging time and roughness conditions) for the Briggs curves are not clearly defined in the literature.

Many workers would have applied the Briggs curves without adjustments. The justification for doing so in this study is that the model runs using measured sigma-theta data and Pasquill's (1976) approach to calculate the horizontal plume spread parameter, gave good agreement with model runs using the adjusted plume spread parameters. This agreement similarly provides confidence in the stability categorization scheme described in Section 5.2.

The adjustment for buoyancy enhanced dispersion followed the recommendation of Pasquill (1976) as follows,

$$\sigma'_y = \sqrt{\sigma'_y{}^2 + \frac{\Delta h^2}{3.5}} \qquad \text{...(6)}$$

where σ_y = the adjusted horizontal plume spread parameter

5.4.5 Vertical Plume Spread Parameters

The Briggs open country curves were used to provide estimates of the vertical plume spread parameters. As before, adjustment were made to these curves for roughness and buoyancy enhanced dispersion. The roughness correction was derived from work by Smith (1972) and resulted in a distance dependent correction factor (CF) given by:

$$CF = 1.38\, x^{-0.0777} \qquad \text{...(7)}$$

where x is the downwind distance in kilometres. The adjustments for buoyancy enhanced dispersion, were calculated as in Section 5.4.4, with sigma-z replacing sigma-y. Finally, in neutral and unstable conditions plume spreading was limited by the ground or the top of the mixed layer by assuming material that reached these surfaces was reflected (except in the case of plume penetration discussed in Section 5.4.3). The calculation algorithm allowed for three reflection terms, after which uniform vertical mixing was assumed. In stable conditions the plume was not bounded except by the surface, as discussed in Section 5.4.3.

5.5 Dispersion Model (ISCV)

5.5.1 Introduction

The dispersion model used for comparison with DISPMOD was the modified version of the Industrial Source Complex Short-Term Model used by the Victorian Environmental Protection Authority (VEPA). The model is referred to in this report as ISCV and is well documented in the VEPA User's Manual for the VEPA plume calculation procedure. The description presented here is restricted to specifying the options that were used in the model runs and in providing an overview of the approach.

5.5.2 Plume Rise

The plume rise equations used in ISCV are the generalised Briggs (1971 and 1975) equations which estimate the effects of buoyancy and momentum. Default parameters of 0.020K/m and 0.035K/m were used for E and F stability respectively and the final plume rise option was selected.

5.5.3 Plume Penetration Inversions

ISCV permits estimates to be made of the fraction of the plume which penetrates into stable air above the mixed layer. The estimates use the approach described by Weill and Brower (1984). It should be noted that their approach is different from the approach by Mannins (1979), which is discussed in Section 5.4.3 of this report. Tests using the ISCV plume penetration algorithm in DISPMOD, resulted in significantly higher ground level concentrations. For example, the maximum annual concentration increased by 55%, the maximum 24-hour concentration increased by 63% and the maximum hourly concentration increased by 197%. However, the Mannins (1979) approach appears to have a far stronger physical and experimental basis than that described by Weill and Brower (1984). The latter approach assumes, when estimating the amount of plume that penetrates the inversion, the plume rise, prior to reaching the inversion, occurs within a stable layer. While no field studies are available at present to provide support for one approach over the other, it is significant to note that both approaches are more conservative than the usual US EPA regulatory procedure, which assumes that the plume cannot contribute to ground level concentrations if the estimated plume height is above the mixed layer.

5.5.4 Horizontal Plume Spread Parameters

The Briggs dispersion curves were used to estimate the horizontal plume spread parameters. Adjustments to these curves were made to account for different averaging periods, surface roughness and buoyancy enhanced dispersion.

5.5.5 Vertical Plume Spread Parameters

As with the horizontal plume spread parameters the Briggs curves were used for vertical dispersion. These were adjusted to account for surface roughness and buoyancy enhanced dispersion. In addition, under neutral and unstable conditions the plume growth in the vertical was assumed to be limited by reflections from the surface and the top of the mixed layer, as described in VEPA (1984).

6.0 IMPACT ASSESSMENT

6.1 Criteria for Impact Assessment

As previously described, the WHO, US EPA and VEPA air quality criteria are used as the basis for impact assessment.

The cumulative effects of all major sources are considered in detail for the major emission, which is SO_2. However, for emissions which only occur in minor quantities and where the ground level concentrations from the proposed power station are predicted to be well below the relevant air quality criteria, the treatment is less detailed. The approach taken in assessing the impact due to SO_2 emissions form the Collie Power Station has been to use the model DISPMOD described in Section 5.4, in conjunction with the Base Station meteorological data, to produce estimates of ground level concentrations of SO_2 for 1-hour, 24-hour and "annual" periods; with the annual period being equivalent to 346 days rather than a full year, because of gaps in the meteorological data. This has been done for two different scenarios as listed below.

- Assuming the only emissions in the area are those from the proposed power station (operating at full load).

- Assuming that the proposed power station is operating at full load at the same time as the power stations at Muja and the Worsley Refinery (all sources emitting at maximum rates).

6.2 Predicted Impact for Collie Power Station Alone

6.2.1 Sulphur Dioxide

The results for this scenario are presented in Figures 3, 4 and 5. Ground level sulphur dioxide concentrations have been predicted on a 1 km square grid over an area 15 by 20 km. Figure 3 shows contours of the annual average concentrations. Clearly most areas are predicted to experience less than 1.5 $\mu g/m^3$ and the highest predicted annual average concentration within the 1.5 $\mu g/m^3$ isopleth is 2.0 $\mu g/m^3$. This is well below the 80 $\mu g/m^3$ primary US EPA standard and the 50 $\mu g/m^3$ and 30 $\mu g/m^3$ (ecological safeguard) WHO guidelines which apply for annual average concentrations.

The 24-hour concentration data is presented in a slightly different way in Figure 4. This shows isopleths for the highest predicted concentrations at each receptor for any day throughout the year. Again it is clear that the expected maximum concentrations (the highest predicted concentration is 30 $\mu g/m^3$) are well below the US EPA, VEPA or WHO air quality criteria for this averaging period and no adverse impacts are expected to systems sensitive to relatively long exposures.

Figure 5 presents equivalent data for the predicted 1-hour averages. The highest predicted concentration over the grid is 382 $\mu g/m^3$. This is below the VEPA acceptable ground level concentration of 486 $\mu g/m^3$ and also below the US EPA 3-hour secondary standard of 1,300 $\mu g/m^3$.

In summary, there appears to be no difficulty for the proposed power station when considered in isolation to meet any of the annual, 24-hour or short-term SO_2 air quality criteria listed in Table 5.

6.2.2 Nitrogen Dioxide

Oxides of nitrogen are emitted from coal fired boilers primarily in the form of nitric oxide (NO) with a small amount, (about 5%) of nitrogen dioxide

(NO_2). As the plume is advected downwind, the NO gradually oxidises to NO_2.

The observations of Smith (1980) showing the percentage oxidation of NO as a function of downwind distance are reproduced in Figure 6. It would be more useful to relate the percentage oxidation to travel time, but nevertheless the information as provided represents useful experimental data.

Whilst the ambient concentration of NO_2 is addressed in air quality standards such as those in Table 5, there are no corresponding standards for NO since it does not represent a health hazard even at the highest concentrations that normally occur in the ambient air.

Other studies of power stations have shown that compliance with SO_2 ambient standards generally ensures compliance with NO_2 standards, by virtue of the normally occuring ratios of SO_2 and NO_x in power station plumes (ETSA, 1977).

A simple means of verifying compliance is to assume that all NO_x leaves the stack as NO_2, in which case the concentration patterns for NO_2 are given by those for SO_2 multiplied by the ratio of emission rates. Reference to Figure 6 indicates that this procedure is extremely conservative, over-estimating NO_2 concentrations out to tens of kilometres from the stack.

The emission rate of NO_x (expressed as NO_2) from the Collie stack is 60% of the rate of SO_2 and applying the argument presented above, it can be seen that conservative estimates of NO_2 concentrations can be found by multiplying the isopleths in Figures 3 to 5 by 0.6. The maximum predicted 1-hour, 24-hour and annual average NO_2 concentrations following this approach will be 229, 18 and 1.2 $\mu g/m^3$ respectively. These are well below any of the criteria presented in Table 5.

6.2.3 Particulates

Particulate concentrations can be estimated by multiplying the predictions for sulphur dioxide by the ratio of the emission rates. This is a valid approach because nearly all the particulate emissions will be in the form of particles less than 10 μm aerodynamic diameter. The appropriate factor is 0.025, thus the maximum 1-hour, 24-hour and annual average concentrations will be 9.5, 0.75 and 0.05 $\mu g/m^3$ respectively. These are negligible concentrations when compared with the relevant air quality criteria in Table 5. For example, the US EPA 24-hour primary standard (to protect public health) is 260 $\mu g/m^3$ and the 24-hour secondary standard (to protect public welfare) is 150 $\mu g/m^3$. The WHO (1979) guideline annual average concentration is 40 $\mu g/m^3$ and the VEPA 1-hour concentration is equivalent to approximately 100 $\mu g/m^3$.

6.2.4 Future Expansion

Although additional generating units are unlikely to be constructed prior to the year 2000, it is of interest to calculate the ultimate impact.

If the station is ultimately expanded to 1200 MW, with two stacks of 130 and 150m height respectively, the predicted peak hourly SO_2 value at any location throughout the year would exceed 486 $\mu g/m^3$ for 1 hour only, which is well within the VEPA definition of acceptability.

6.2.5 Sensitivity of Results to Inversion Strength Calculation

The method of computing inversion strengths, as described in Section 5.4.3, is the only novel aspect of the modelling exercise which has not appeared in the scientific literature.

A simple sensitivity test was performed by specifying a range of conservatively high values of $\Delta\theta$ to be held constant during a model run, namely:

$$= \quad 2^{\circ}C \text{ for } 500 < h < 950m$$
$$= \quad 3^{\circ}C \text{ for } 200 < h < 500m$$
$$= \quad 4^{\circ}C \text{ for } 0 < h < 200m$$

Additionally, when the mixing depth was greater than 950 m the plume was assumed to be completely trapped.

The results of this test indicated that the hourly SO_2 concentration, predicted at any location throughout the year, exceeded 486 $\mu g/m^3$ for only 2 hours, which is within the VEPA acceptable level. Consequently, although the $\Delta 0$ prediction scheme is believed to be scientifically sound and appropriate, its inclusion is not a critical factor in determining the project's acceptability.

6.3 Predicted Impact Including Neighbouring Sources

6.3.1 Sulphur Dioxide

Model predictions of the annual, 24-hour and 1-hour SO_2 dispersion patterns taking into account emissions from other major sources in the area are shown in Figures 7, 8 and 9 respectively. The highest predicted annual average concentration is 7 $\mu g/m^3$ and highest 24-hour concentration is 75 $\mu g/m^3$. As before there is no threat to the annual or 24-hour standards, however the 1-hour VEPA acceptable level of 486 $\mu g/m^3$ is approached with the maximum predicted concentration being 408 $\mu g/m^3$.

Since the VEPA acceptable level is permitted to be exceeded on up to three days per year, it can be considered that the impact will be within the VEPA criterion. The levels are well within the US EPA 3-hour standard of 1300 $\mu g/m^3$. Two further considerations, discussed below, show that there is no cause for concern.

Firstly, Table 7 shows the frequency of occurrence of ground level concentrations in various concentration ranges for the receptor with the highest predicted hourly concentration. This demonstrates that high concentrations are rare events.

Secondly, as may be seen from Figure 9, the location of the peak SO_2 prediction is immediately north of Muja Power Station and can be demonstrated to result mainly from the operation of Muja units C and D. The predicted capacity factor of these machines is only 70% (not 100% as modelled). A model run including these capacity factors and realistic weekly load cycles for each month, resulted in a reduction at the same location to 317 $\mu g/m^3$ (i.e. approximately 20% lower).

TABLE 7

FREQUENCY OF OCCURRENCE OF 1-HOUR CONCENTRATION ESTIMATES

Concentration $\mu g/m^3$	No. of Occurrences Per Year
450-500	1
400-450	1
350-400	2
300-350	3
250-300	10
200-250	24
150-200	64
0-150	8,304

6.3.2 Nitrogen Dioxide

Very conservative estimates for NO_2 concentrations can be obtained by multiplying the highest predicted annual, 24-hour and 1-hour SO_2 concentrations by 0.73, which is the ratio of NO_2:SO_2 emissions for Muja A and B. The ratio is higher than that which applies to more modern units (Muja C & D) due to a number of factors, the most important of which is boiler design.

When this is done the annual average concentration at the worst affected receptor is 4.6 $\mu g/m^3$ which is well within the 100 $\mu g/m^3$ primary and secondary US EPA standards.

The highest 24-hour concentration is 50 $\mu g/m^3$ which is well below the 123 $\mu g/m^3$ VEPA acceptable concentration.

The highest 1-hour concentration is 266 $\mu g/m^3$ which may be considered to be well below the 308 $\mu g/m^3$ VEPA acceptable level when the conservative nature of the estimate is taken into account, as discussed above and in Section 6.2.2.

Thus no adverse impacts are expected due to NO_X emissions in the area.

6.3.3 Particulates

Predicted particulate ground level concentrations due to the proposed power station are extremely small, as would be the associated deposition rates. Although high concentrations and deposition rates in the close vicinity of the Muja Power Station will continue, the additional impact due to the proposed power station will be negligible. Monitoring studies to assess the significance of Muja Power Station as a point source of particulate emissions were conducted by SECWA within the area between the power station and the closest inhabited areas at the Collie townsite. Monitoring utilized a series of Directional Dust Gauges. Monitoring throughout a full year's cycle of weather conditions showed no significant contribution from the system over the natural background dust levels in the area (SECWA, 1989).

7.0 ACID DEPOSITION

The oxides of sulphur and nitrogen discharged from the stack are eventually further oxidised, either in dry air or water droplets, to sulphates and nitrates. These are then brought to the surface by a process of dry deposition, whereby gravitational settling and diffusion brings particles into contact with vegetation and soil; or by a process of wet deposition where the acid particles and/or gases are incorporated into raindrops during their formation phase, or are washed out of the atmosphere as the rain drops fall through the air below the cloud.

In the last two decades considerable concern has been expressed over the effects of acid deposition in Eastern North America and Western Europe.

The principal effects appear to be adverse ecological changes which take place in lakes and rivers, particularly in areas where the neutralizing capacity of the soil is low. These effects, and other effects on terrestrial eco-systems (mainly forests and crops) are the subject of intensive research in North America and Europe.

The effects are complex and are not fully understood. They range, in extreme cases from alterations in the pH of water bodies, so that fish are prevented from breeding, to the mobilization of metals in soils (and related effects on the nutrient status of the soil) and to direct effects on plant foliage. While many of the changes are harmful others may be beneficial.

At present it is estimated that approximately 40% of the global budget of sulphur is derived from anthropogenic sources (Harrison, 1982); combustion of coal and smelting of ores being the primary anthropogenic sources. However in those areas where acid deposition problems have been identified and documented (eastern North America and Europe) it is notable that the emissions are geographically concentrated. For example in the eastern US, natural sources are estimated to be about 1% of the total budget (Harrison, 1982 and Friedman, 1982). Thus it would appear that environmental problems due to the deposition of sulphates are likely to be due to anthropogenic activities. However, the exact mechanisms involved, along with the relative importance of distant sources compared with nearby sources and identification of appropriate control measures, are the subject of intensive investigation. The inherent uncertainties mean that no established methods for assessing the likely impact of acid deposition have been developed.

The most common control measure proposed is the reduction of SO_2 emission, either by using low sulphur coal or by removing sulphur from the flue gases. Sulphur removal is expensive, adding as much as 25 percent to the capital and running costs of a power station (EPRI, 1982). It is practised in the US, particularly in stations which utilize very high sulphur coals. (Collie coal has a low sulphur content, generally less than 0.8 per cent).

In order to assess whether flue gas desulphurization may be applicable for the proposed Collie Power Station, it is useful to compare the sulphur dioxide emissions in the southwest of Western Australia with those in other areas of the world. In this context it is interesting to note that the major industrial sources of sulphur dioxide in the southwest of Western Australia (taken as sources at Kwinana, Bunbury and Collie - including the present proposal) produce approximately 0.15 Mt/y of SO_2. In the northeast US the state of Ohio (which produces the greatest amount of SO_2 of all the states in the US - see Zimmer et al., 1983) had a 1980 annual emission rate of 2.4 Mt/y. This is 16 times the local SO_2 emission. On a larger scale the north eastern portion of the US (see Zimmer et al.(1983) for more detail) had an annual total emission rate of approximately 15 Mt/y in 1980, which is approximately 100 times the local figure. States such as California which have approximately triple the local emission (0.45 Mt/y) do not appear to experience problems due to acid deposition, although studies (Morgan and Liljestrant, 1980) do show that the effects of industrial emissions on the pH and acidity of rainfall is readily detected.

Measurements of the pH of rain in Sydney, Melbourne and the Latrobe Valley have also shown pH values of rain water below the nominal equilibrium value of 5.6, although no adverse effects are known to occur.

Two other factors which would minimize the risk of acid rain in W.A. are the separation of the major sources and the good ventilation provided by synoptic and local winds.

Thus on the basis of this brief review it is likely that measurable changes in the pH of rainfall will occur, however measurable adverse (or beneficial) effects are unlikely. SECWA will maintain contact with research workers in Australia and overseas and follow developments closely for findings which may be relevant to Western Australia.

8.0 ACCURACY OF MODELS

Air dispersion models have a component of error associated with their predictions. These occur as a result of errors in the input data describing emissions, and within the meteorological baseline data. In addition, limits to accuracy occur because the model does not necessarily take proper account of the physical and chemical processes which may be important in a particular dispersion problem.

The best assessment of a model's performance is achieved by comparing model predictions with monitoring data. SECWA proposes to conduct a short term monitoring survey to validate model predictions following commissioning of the station. A further indication of model accuracy is that provided by reference to literature evaluations of typical performance of Gaussian models of which DISPMOD (as used in this study) is a typical example. Generally models of this type are found to perform relatively poorly when hour-by-hour comparisons are made of predicted and monitored data at a given receptor (see for example Weill and Brower, 1984 and Liu and Moore, 1984). However it should be noted that Gaussian models appear to perform reasonably well in the important problem of predicting the highest concentrations that will occur. In view of the conservative nature of assumptions used for input parameters (for example, the assumption of full power output and higher than average sulphur content in the coal) it may be concluded that the model predictions discussed in Section 6 are a good indication that the concentrations of SO_2, NO_2 and particulates will be within acceptable concentrations.

Nevertheless, SECWA undertakes to examine the ground level concentrations of pollutants with other models and consideration of more detailed design parameters which will affect dispersion characteristics in the Collie area. These parameters will be optimised to meet ground level criteria as discussed above.

9.0 REFERENCES

Briggs, G.A (1971). Some Recent Analyses of Plume Rise Observations. In "Proceedings of the Second International Clean Air Congress", Academic Press, New York.

Briggs, G.A. (1975). Plume rise predictions. In "Lectures on Air Pollution and Environmental Impact Analyses", Ed. Duane A. Haugen, Sponsored by the American Meteorological Society, Boston, Massachussetts, 59-105.

Bureau of Meteorology. (1965). "Climatic Survey Region 16 - Southwest Western Australia", Director of Meteorology, Melbourne.

EPRI (1982). "Scrubbers the Technology Nobody Wanted" October, 1982.

ETSA (1977). "Northern Power Station - Environmental Impact Statement", Parts 1 & 2.

Friedman, R.M. (1982). "Transported Air Pollutants: Risks of Damage and Risks of Control: In Proceedings Atmospheric Deposition Speciality Conference, East Coast Section of the Air Pollution Control Association.

Gifford, F.A. (1975). Atmospheric Dispersion Models for Environmental Pollution Applications: In "Lectures on Air Pollution and Environmental Impact Analyses", Ed. Duane A. Haugen, American Meteorological Society, Boston, Massachussetts. 35-54.

Hanna, S.R., Briggs, G.A., Deardorff, J., Egan, B.A., Gifford, F.A., and Pasquill, F. (1977). "Summary of Recommendations made by the AMS Workshop on Stability Classification Schemes and Sigma Curves", Bull. Am. Meteorol. Soc., 58: pp 1305-1309.

Harrison, P.R. (1982). "Summary and Critique" In Proceedings Atmospheric Deposition Speciality Conference, East Coast Section of the Air Pollution Control Association. p464.

KAMS (1982). "The Kwinana Air Modelling Study": Report No. 10 Department of Conservation and Environment, Perth, W.A.

Liu, M.K. and Moore, G.E. (1984). "On the Evaluation of Predictions from a Gaussian Plume Model": Journal of the Air Pollution Control Association, 34, No 10, pp 1044-1050.

Mannins, P.C. (1979). "Partial Penetration of an Elevated Inversion Layer by Chimney Plumes", Atmospheric Environment 13, pp 733-741.

Morgan J.J. and Liljestrant, H.M. (1980). "Measurement and Interpretation of Acid Rainfall in the Los Angeles Basin", Final Report Keck Laboratories of Environmental Engineering Science, Division of Engineering and Applied Science, California Institute of Technology, Pasadena, CA 91125.

Pasquill, F. (1976). "Atmospheric Dispersion Parameters in Gaussian plume modelling. Part 2. Possible requirements for changes in the Turner Workbook values": Office of Air Programmes, Environmental Protection Agency, Research Triangle Park, North Carolina.

Pendergast, (1977). "Estimating Diffusion Coefficients from Meteorological Data", Savanah River Laboratory, E.I. De Pont de Nemours and Company.

Rye P.J. (1984). "Estimation of Air Quality Impacts of Existing and Proposed Power Stations at Collie, Western Australia", WAIT-AID Ltd, Reference No. 84 7462 R & D: ED.

Smith, I (1980). "Nitrogen Oxides from Coal Combustion - Environmental Effects": Report No. ICTIS/TR10 IAE Coal Research, London.

US EPA (1977). "Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. 11 - Ambient Air Specific Methods." Environmental Protection Agency, Research Triangle; Ark, North Carolina.

VEPA (1984). "User Manuals for use with the Plume Calculation Procedure", Victorian Environment Protection Authority, 240 Victoria Road, East Melbourne.

Victorian Government Gazette (1981). "State Environmental Protection Authority -
The Air Environment. No. 63." Australian Government Publishing Service, Melbourne.

Weill, J.A. and Brower R.P. (1984). "An Updated Gaussian Plume Model for Tall Stacks", Journal of the Air Pollution Control Association, 34, No. 8, pp 818-827.

WHO (1979). "Sulphur Oxides and Suspended Matter - Environmental Health Criteria 8": WHO Geneva.

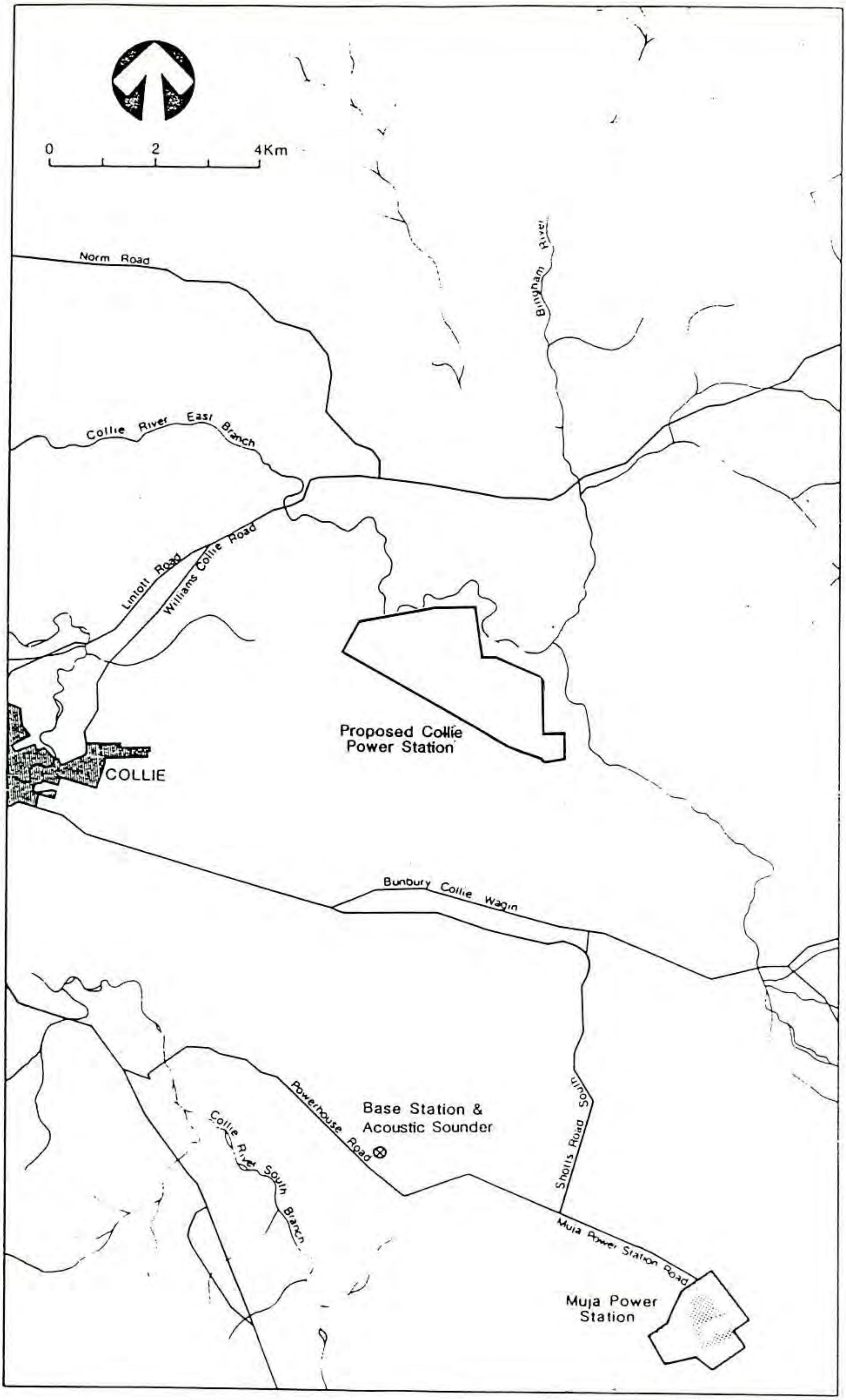
WHO (1982). Air Quality Guidelines for Europe. Regional Office for Europe, Denmark.

WHO (1987). "Air Quality Guidelines for Europe - Regional Publications, European Series No. 23": WHO Copenhagen.

Worsley Alumina. (1983). "Dispersion Meteorology of the Worsley Area", Worsley Alumina Pty Ltd, 140, St Georges Terrace, Perth.

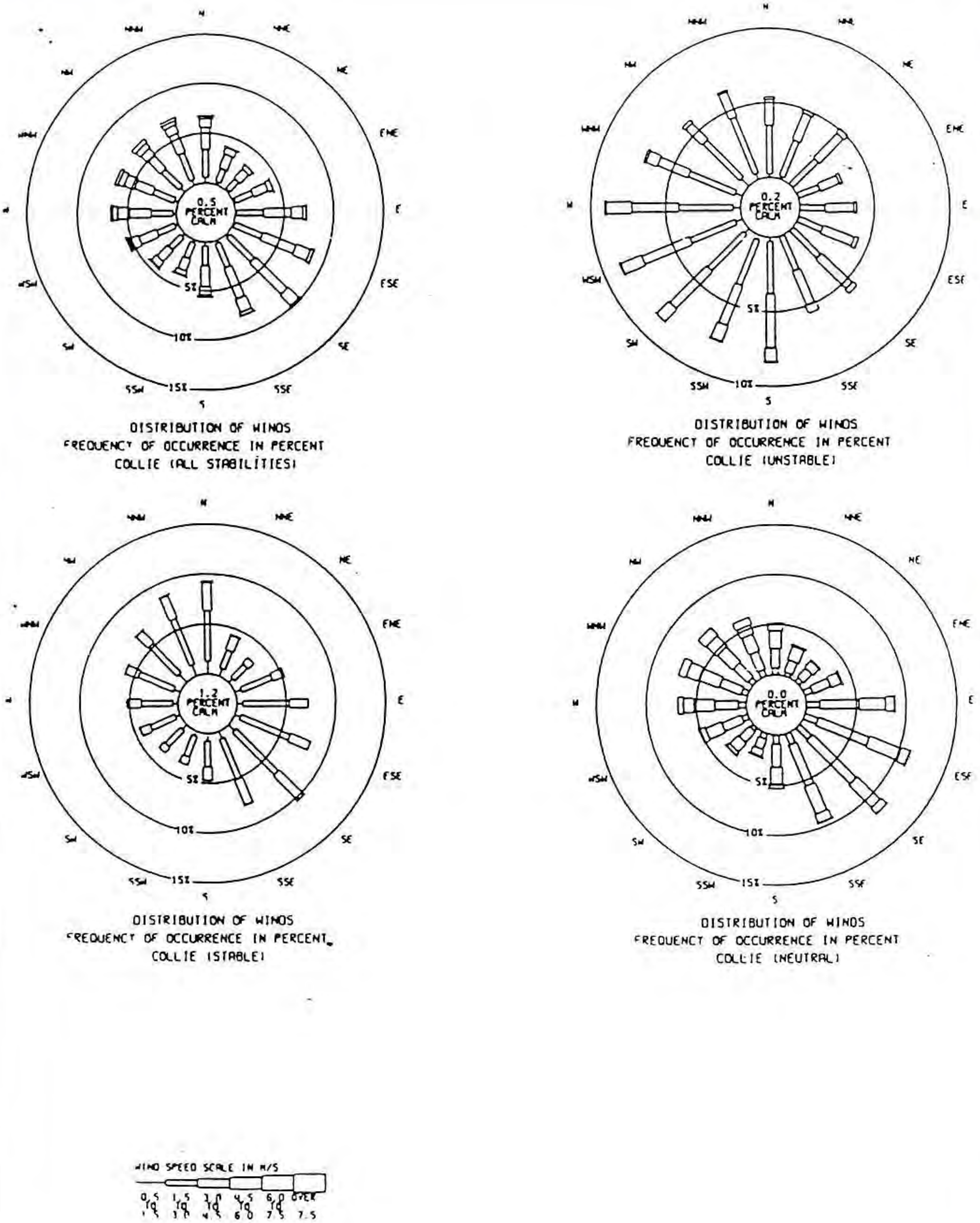
Zimmer, M.J. and Thompson, J.A. (1983). "Acid Rain Planning for The 80's", Government Institutes Inc., Rockville MD, 966 Hungerford Drive #24 Rockville, Maryland 20859, USA.

FIGURES



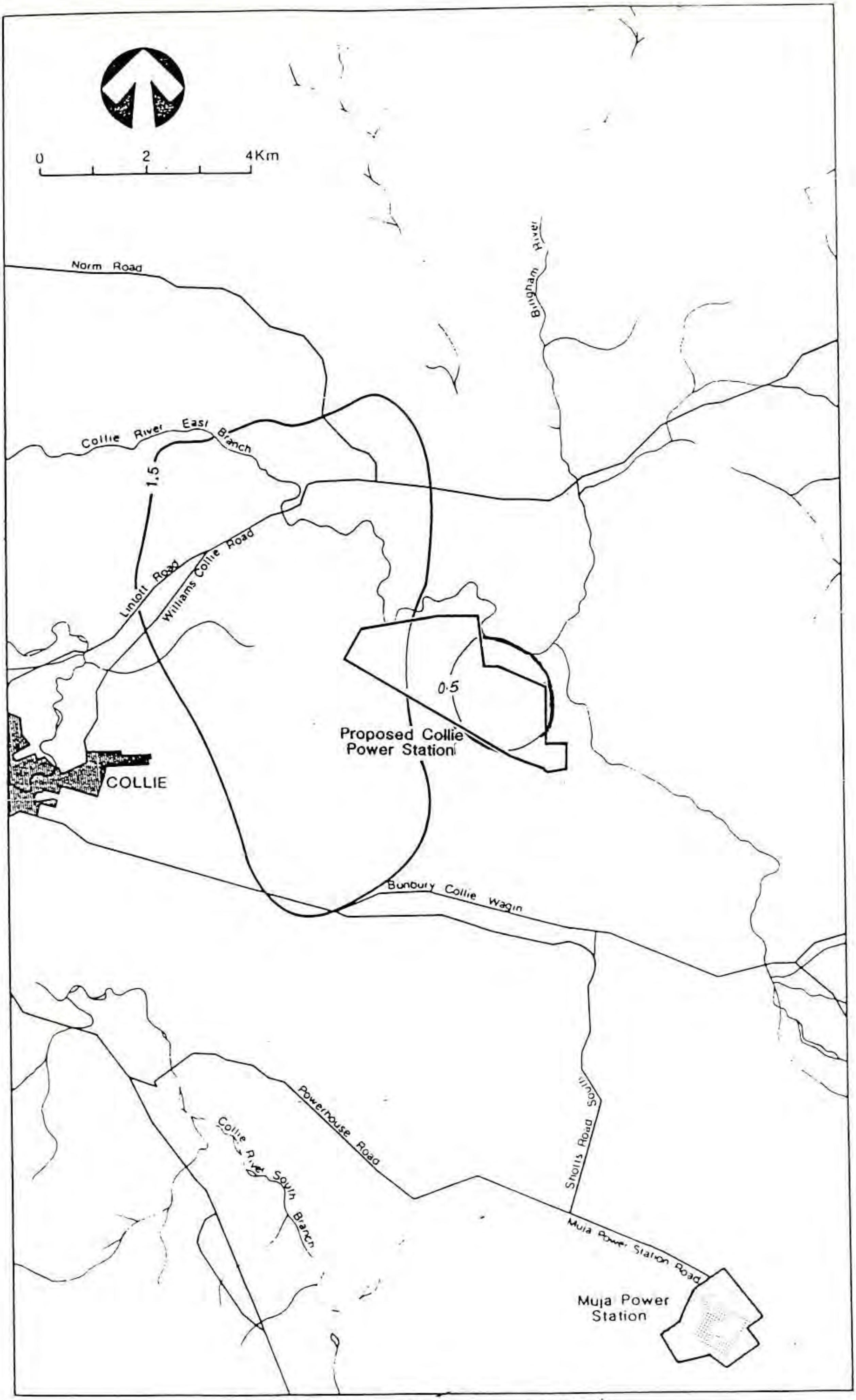
Locality Map

Figure 1



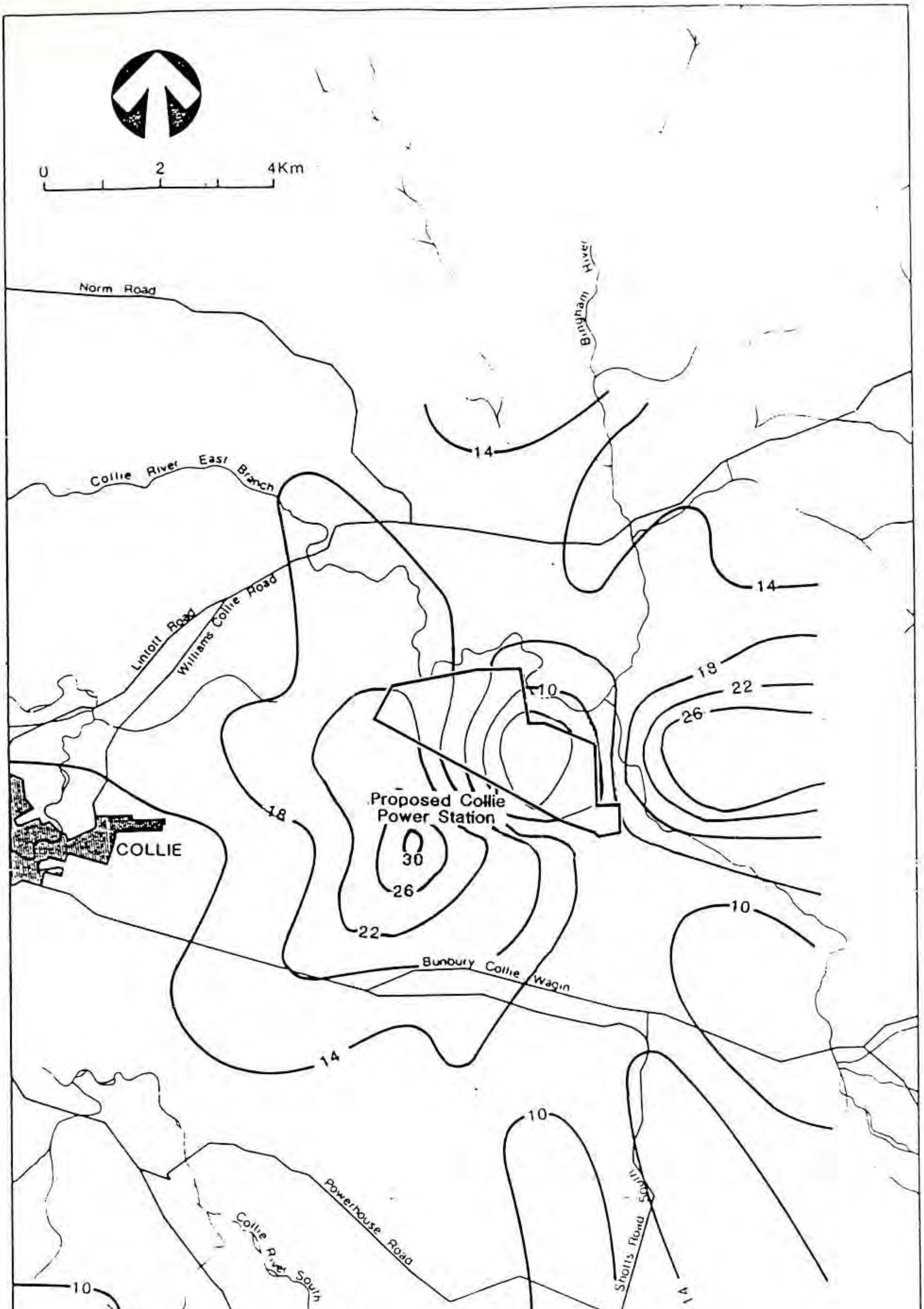
Wind Roses for Base Station (see figure 1)

Figure 2



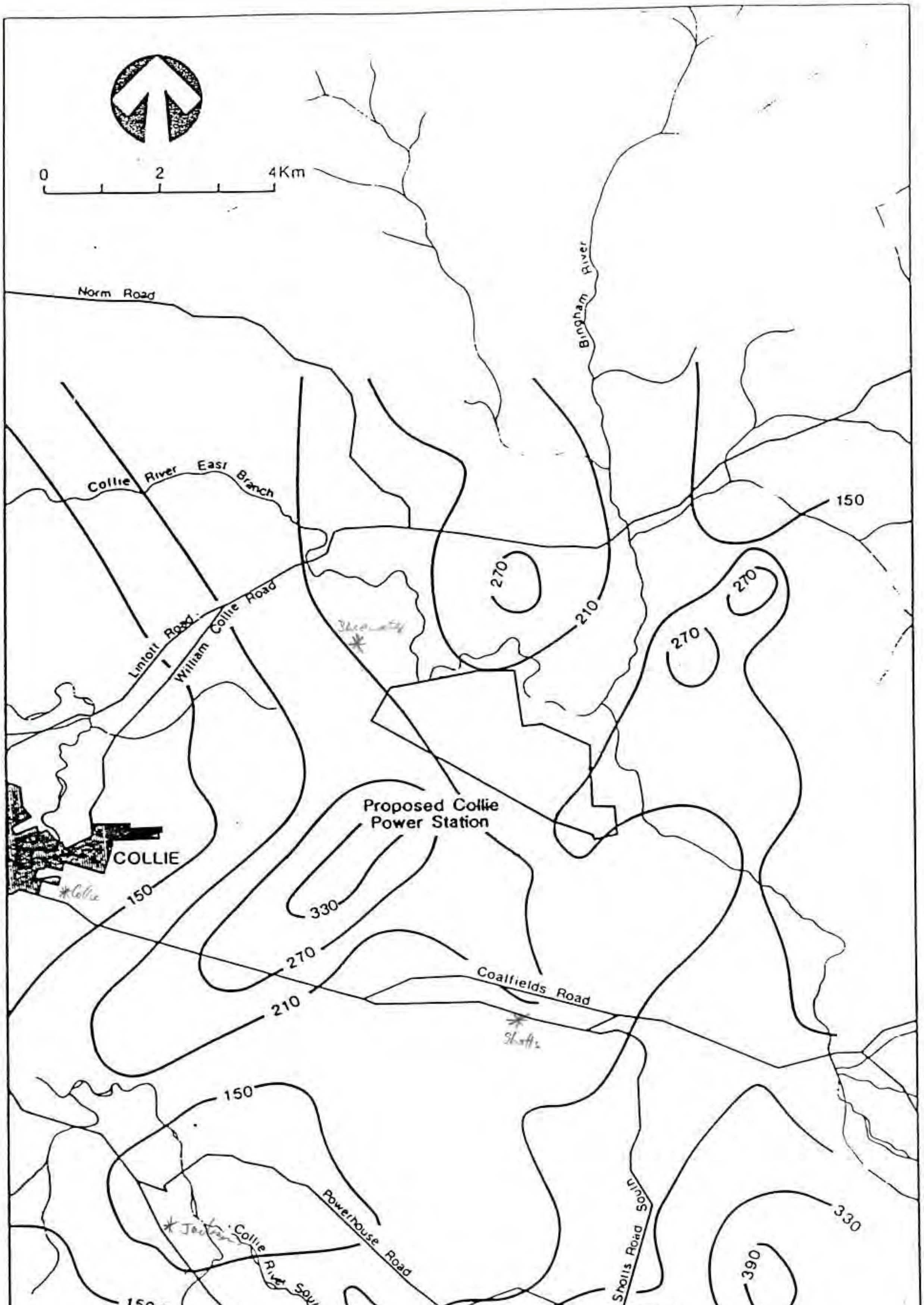
Annual Average SO_2 Concentrations
$\mu g/m^3$ Collie Power Station

Figure 3



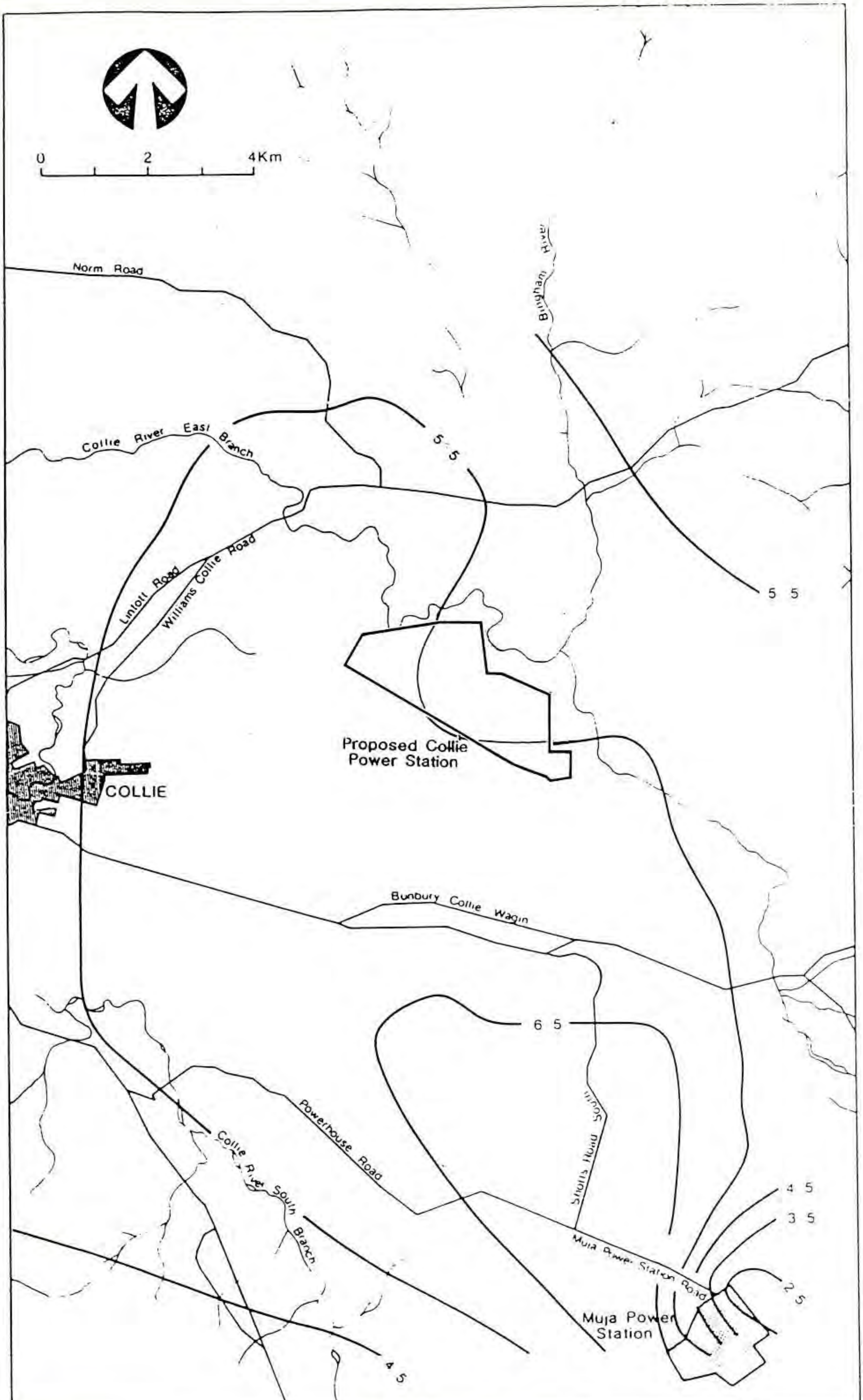
Maximum 24 hour SO_2 Concentrations
$\mu g/m^3$ Collie Power Station **Figure 4**

APPENDIX B



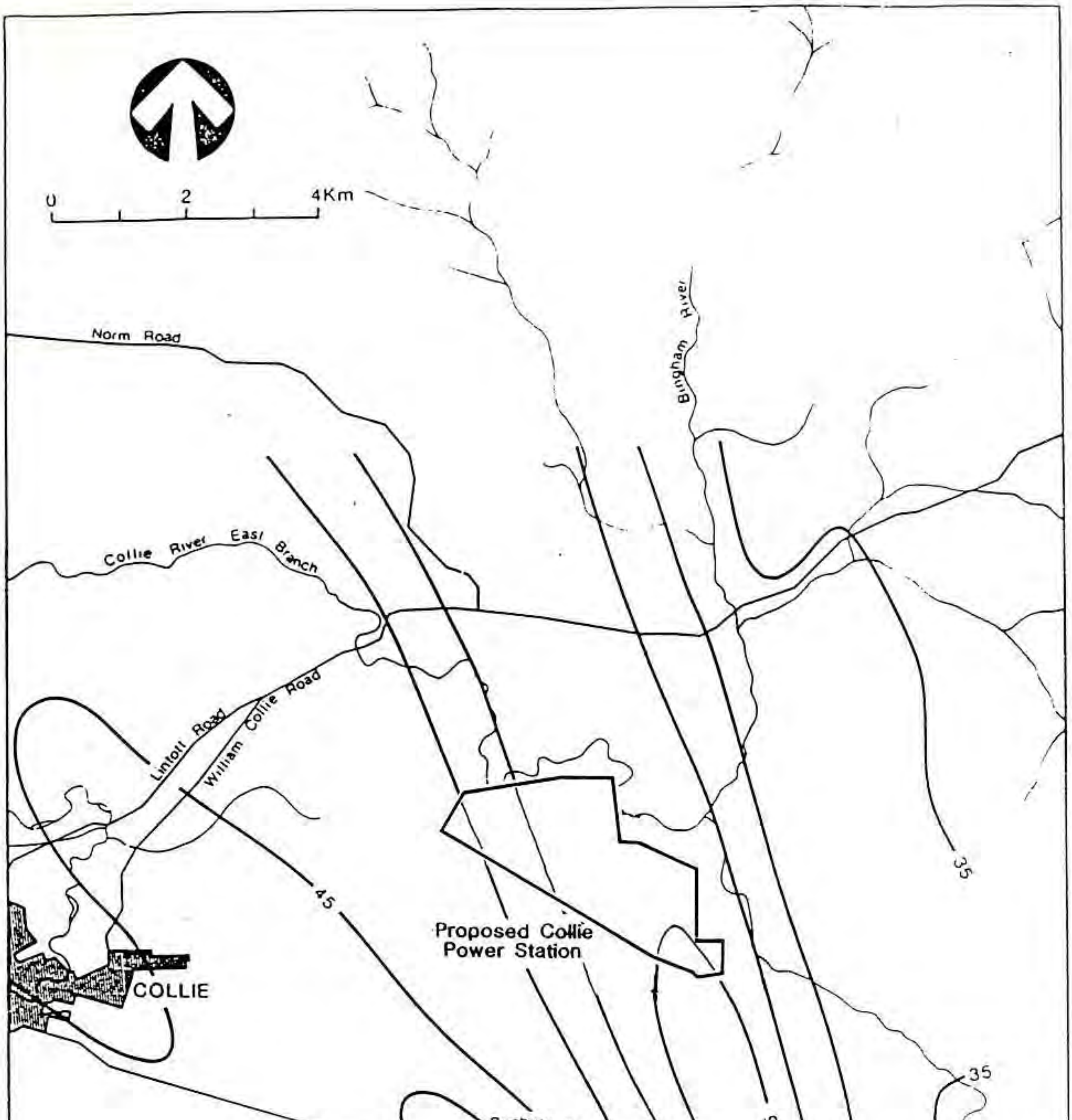
COLLIE POWER STATION ERMP

MAXIMUM 1-HOUR SO_2 CONCENTRATIONS ug/m^3 COLLIE POWER STATION, MUJA POWER STATIONS AND WORSLEY REFINERY



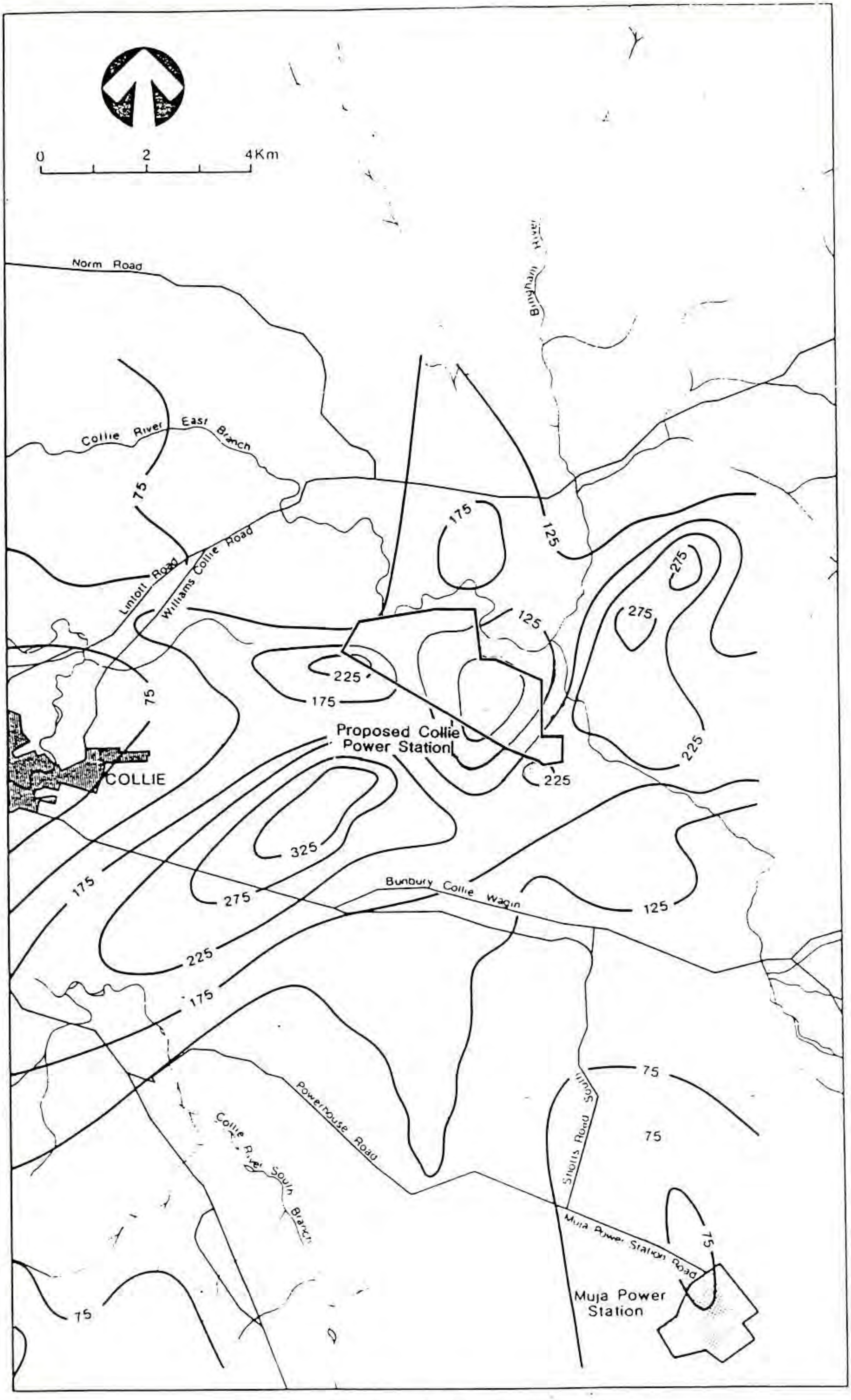
Annual Average SO_2 Concentrations
$\mu g/m^3$ Collie Power Station, Muja Power Stations
& Worsley Refinery

Figure 7



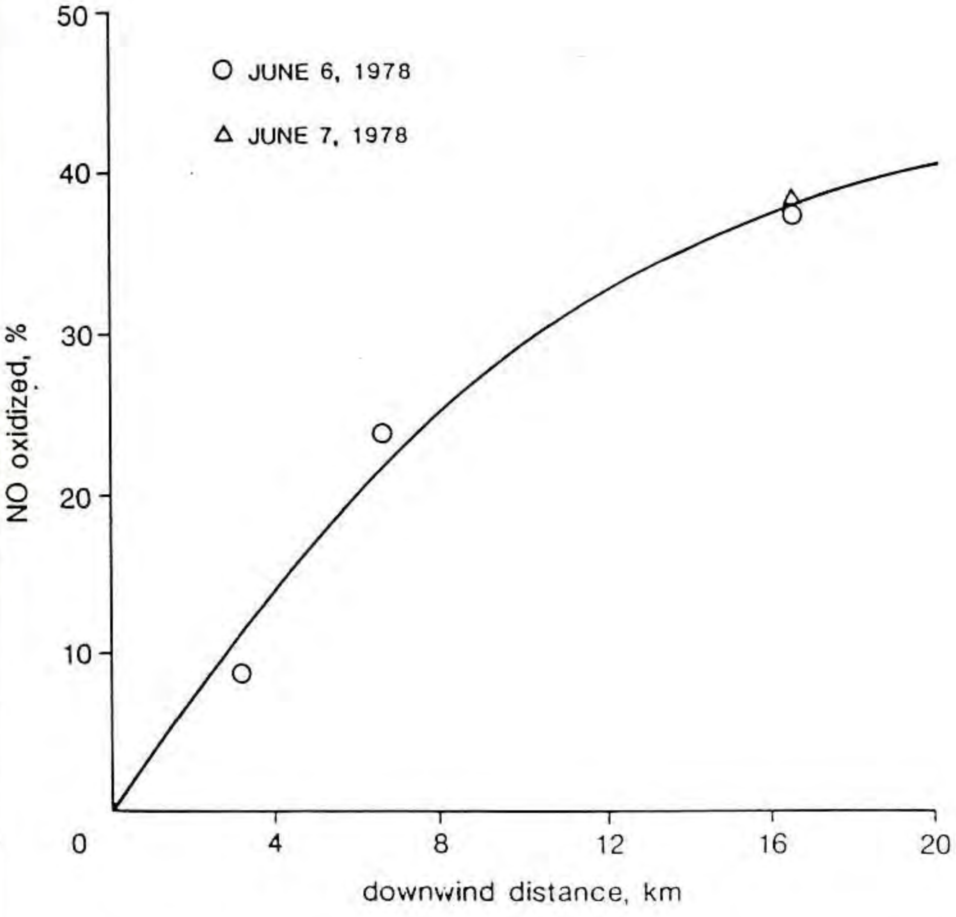
Maximum 24-hour SO_2 Concentrations
$\mu g/m^3$ Collie Power Station, Muja Power Stations
& Worsley Refinery

Figure 8



Maximum 1-Hour SO_2 Concentrations
$\mu g/m^3$ Collie Power Station

Figure 5



Variation of degree of NO oxidation with distance - after Smith (1980)

Figure 6

PROPOSED SECWA POWER STATION - COLLIE

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME GUIDELINES

OVERVIEW

INTRODUCTION

The following sections contain information on the purpose of an Environmental Review and Management Programme and guidelines for studies on the power station. The primary function of an Environmental Review and Management Programme is to provide the basis for EPA advice to Government on protecting the environment. An additional function is to communicate clearly with the public so that EPA can obtain informed public comment. As such, Environmental Impact Assessment is a public process. The Environmental Review and Management Programme should set out the series of decisions taken and why.

OBJECTIVES

The Environmental Review and Management Programme has the following objectives:

- to explain the issues and decisions which led to the choice of this project at this place and at this time;

- to set out the environmental impacts that the project may have, and,

- for each impact, to describe any environmental management steps the proponent believes would avoid, mitigate or ameliorate that impact.

The ERMP should focus on the major issues for the area andanticipate the questions that members of the public will raise.

STRUCTURE

It is not intended that the ERMP should address issues of Government policy in detail or duplicate other published reports. It should however refer to other published sources and especially any dealing with energy policy, the greenhouse effect and social impacts as appropriate to this proposal.

1. SUMMARY

The summary should clearly outline the important features of the proposal, site location alternatives, alternatives to coal, the existing environment and the safeguards and management proposed. It should itemise the key issues for this proposal and clearly indicate how they will be dealt with.

2. OUTLINE

This section should include:

- the background and objectives of the proposal;
- the scope and timing of the proposal;
- the details of the proponents;
- the aims of the document; and,
- reference to relevant legislative requirements and,
- approval processes (State and Commonwealth if applicable)

3. THE PROPOSED PROJECT AND THE NEED FOR IT

Describe the proposal. The need for the proposed project should be clearly demonstrated in relation to the State's energy demand growth rate. The relationship of the project to other relevant published documentation, particularly on the Greenhouse effect, is also required. The ERMP should discuss specifically the contribution that this proposal will make to the production of 'greenhouse gases' and outline any potential of means to mitigate these effects.

The ERMP should also foreshadow any known power station development.

4. KEY ISSUES

The key issues for this project should be identified and the contents of succeeding sections determined by their relevance to these issues.

In this case the key issues should include:

- the reason for selecting the preferred site and the alternatives;
- native fauna and flora;
- landscape and recreational values;
- dieback hazard and control;
- groundwater supply, competition and protection from pollution;
- predicted groundwater drawdowns, zones of influence and impacts on other users;

- dewatering and discharges;
- siltation control;
- fly ash disposal, especially leachates to groundwater;
- effects of emissions on crops, native biota, stock,humans, soil and water;
- transport of materials;
- feral fauna, weeds, access and fire control, including co-operation with the local fire brigade;
- impact on resources necessary for farming, tourism, beekeeping and other livelihoods; and
- broad implications of project workforce and attendant population.

5. DESCRIPTION OF THE PROJECT

This section should outline the proposed power station and include details for the preferred site, of:

- coal supply, storage and handling;
- cooling water supply and disposal;
- waste water management;
- ash disposal system;
- atmospheric emission control;
- indicative details of power line transmission corridors;
- construction and operational work force; and, de-commissioning.

Any detailed technical discussion should be included in the Appendices.

6. EVALUATION OF ALTERNATIVES

The proponent should give details of the project in the context of WA's energy resources and projected energy demand and generating capacity. It should indicate what alternative options exist to meet energy demands in Western Australia including demand management. Where relevant, the ERMP should refer to other published reports, in sufficient detail to set the proposal in context.

7. SITE SELECTION ALTERNATIVES

The proponent should examine the range of alternative sites available.

An evaluation of the range of sites available should be provided together with an explanation of the selection criteria used. Detailed analysis should be provided for the preferred site. For each of these cases, environmental costs and benefits should be comprehensively discussed.

This section should provide the reader with an understanding of why the proponent chose the preferred site.

The sections following provide guidance on the topics to becovered.

8. DESCRIPTION OF SITE

A general description of the alternative sites for the powerstation should be provided. This should include, for each site, a description of the existing environment sufficient to explain the evaluation and selection of the preferred site. Topics for consideration at the alternative sites should include:

- topography, geology and soils;
- watercourses and groundwater aquifers;
- landscape;
- generalised air quality
- acoustic environment;
- flora and fauna;
- local ecology including modifying factors such as dieback, clearing, fire etc;
- landuse and zoning of the site and surroundings; and
- human environment and regional economy, including population, work force economy, existing community facilities, transport networks and aboriginal sites. Reference should be made to other relevant reports where applicable.

9. THE EXISTING ENVIRONMENT

This section should provide an overall description of the environment and an appraisal of the physical, ecological systems likely to be affected by all aspects of theproposal. It should concentrate on the significant aspects of the environment subject to potential impacts from the development. Only the habitats, resources, and communities which could be influenced by the project should be described. Excessive descriptions which are irrelevant to the impacts of the project detract from the document. A clear synthesis which shows the proponent's understanding of the key environmental processes should be linked to later discussions of proposed control measures and rehabilitation.

A discussion of the regional situation within which the project is situated should be provided before discussing the project site. Conceptual models or diagrams should be provided wherever possible to illustrate and synthesize the interactions between the physical and biological aspects of the habitats and resources discussed. Diagrams and photographs should be included wherever possible.

In particular, the aspects of the environment relevant to, or impacted by transport links, materials handling, ash disposal and project work force should be discussed. A good understanding of the local meteorology, soils and geology, land-use, groundwater and biota and their interactions with existing water resources, level of dust and other possible pollutants should be demonstrated for the workforce accommodation and new transport corridors.

Discuss the physical and biological processes which maintain the various habitats and resources. Assess the resilience of these habitats and resources in the face of natural and development pressures. Cover such phenomena as bush fires, drought, weed and feral animal invasion and regeneration biology. A community profile in terms of population, land/use and services should be given.

The discussion of the human environment should include sites of cultural and scientific interest including any historical, archeological or ethnographic sites should be considered. Reference should be made to other studies in sufficient detail to set the proposal in context.

10. ENVIRONMENTAL IMPACTS

The impacts from the power station should be discussed under, but not necessarily limited to, the following headings:

- construction phase impacts;
- air emissions, including impacts on vegetation;
- production of greenhouse gases;
- waste disposal, including leachates from ash disposal;
- water resources;
- acoustic environment;
- ecology of the surrounding area;
- electromagnetic radiation from the station;
- visual impacts;
- land use and resource planning;
- transport and traffic; and
- indicated power transmission corridors.

11. ENVIRONMENTAL MANAGEMENT

An environmental management programme should be based on and referenced to the synthesis of environmental impacts previously outlined. The objectives, scope and details of the programme should be described. Assignment of responsibility for environmental management should also be clearly stated and commitments for such management given.

Sufficient detail should be provided to allow the EPA to assess whether the environmental management programme for the power station is likely to be successful. As well as undertaking to meet all relevant standards, provide explanations of how these requirements will be met.

Monitoring programmes should be detailed with attention to how the environmental management programme will be adapted in response to results from the monitoring programme.

The procedures for reporting results of monitoring and environmental management to the appropriate authorities should be provided. Also summarise and, where necessary, detail management commitments described in this and earlier sections.

For each site the potential impacts on the environment identified in the preceding section should be discussed and a description given of the management proposed to ameliorate these impacts. This section should include management of:

- water supply;
- waste water disposal;
- air emission fallout and air pollution control technology;
- any proposals for mitigating effects of greenhouse gas production;
- solid residue disposal;
- use and management of any buffer zones;
- landscaping;
- final site use, decommissioning and rehabilitation; and
- monitoring, reporting and accountability.

12. CONCLUSIONS

Conclusions on the overall impact of the proposal (including the role of ameliorative measures) should be stated together with an assessment of the environmental acceptability of the project.

13. DETAILED LIST OF ENVIRONMENTAL COMMITMENTS

This section should broadly define the commitments being made by the proponent to protect the environment. They should be numbered and take the form of:

In the event of ...

the proponent will ...

to the satisfaction of ...

APPENDIX C

CAPTIONS FOR THE COLOUR PLATES

a. View of one possible ash disposal area, within the power station site.

b. The existing swampland on the Collie Power Station site. Note the dead Eucalypt trees around the margins.

c. Proposed East Transfer Pumping Station on the borefield, looking southeast towards Bore Site 12. Stockton Pine Plantation on left.

d. View along 330kV transmission line, to the north of Coalfields Road. The proposed pipelines from the borefield follows this easement.

e. Wandoo (*Eucalpytus wandoo*) open forest with an understorey of pasture grasses and other herbaceous plants.

f. The pond near the western boundary of the Collie Power Station site, with shrubs, sedges and bulrushes around it, with wandoo trees on the banks.

a

b

c

d

e

f

COLLIE POWER STATION PROJECT AREA PHOTOGRAPHS

(SEE OVERLEAF FOR DESCRIPTIONS)

15. REFERENCES (BIBLIOGRAPHY/ABBREVIATIONS)

. GLOSSARY

Provide definitions of technical terms used. Also define and explain units of measurement which may not normally beunderstood by members of the public.

. FIGURES

Maps, photographs and diagrams should be used wherever possible to illustrate the proposal. Maps indicating the relationship of the proposed development to surrounding properties, residences and farm buildings should beincluded.

. ERMP GUIDELINES

These guidelines should be reproduced in the document.

. APPENDICES

These may be produced as separate volumes or incorporated at the back of the document.

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