Water Authority
of Western Australia

Margaret River Town Water Supply

Consultative Environmental Review for Proposed Water Supply Reservoir

ISBN 0 7309 1815 7

Dames & Moore
Report No. WP 90
March 1990

Water Authority
of Western Australia

WATER RESOURCES DIRECTORATE
Water Resources Planning Branch
Assessment Planning

Margaret River Town Water Supply

Consultative Environmental Review for Proposed Water Supply Reservoir

Dames & Moore

Published by the

Water Authority of Western Australia
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Leederville WA 6007

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MARGARET RIVER WATER SUPPLY

PROPOSED WATER SUPPLY RESERVOIR

CONSULTATIVE ENVIRONMENTAL REVIEW

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

The proposal deals with the intention by the Water Authority to construct a water supply reservoir on Ten Mile Brook to supply potable water to the town of Margaret River. The site of the proposed reservoir is in the Bramley Forest Block immediately east of the town of Margaret River.

The Consultative Environmental Review (CER) for the proposed project has been prepared in accordance with Western Australian Government procedures. The report will be available for comment for 4 weeks, finishing on Thursday April 26, 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.

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 helpful if you indicate any suggestions you have to improve the proposal.

All submissions received will be acknowledged.

DEVELOPING A SUBMISSION

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

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

When making comments on specific proposals in the CER

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

POINTS TO KEEP IN MIND

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

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

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

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 SUBMISSIONS IS THURSDAY 26 APRIL 1990

SUBMISSIONS SHOULD BE ADDRESSED TO:

The Chairman
Environmental Protection Authority
1 Mount Street
PERTH WA 600

Attention: Mr Colin Murray

(WR-M600)

EXECUTIVE SUMMARY

The existing Margaret River reservoir is no longer large enough to supply the rapidly developing town with potable water. There is also concern for potential contamination problems arising from agricultural activities and a part of the town in the catchment. Ten Mile Brook Dam is favoured as the best option for the future supply of potable water to the town of Margaret River and for possible extension of the scheme to serve other towns in the region.

Ease of pollution control and overall cost are the primary factors in choosing this option. The next most cost-effective options, upgrading the existing pipe head dam or development of a dam in other locations, would be dependent on carefully implemented catchment management policies to prevent pollution of the river flow from agricultural and industrial activities. This would be disadvantageous to rural activities on the catchment area. Even if such constraints were implemented, existing approved catchment activities with potential to pollute the water supply would be a growing source of concern.

The Ten Mile Brook Dam and associated reservoir will cause some local damage to the environment. These impacts are believed to be acceptable in a regional context. No significant local flora, fauna or Aboriginal Sites will be endangered as a result of the project.

Some environmental and social impacts have been identified but the Water Authority believes that all these can be managed and that none will have substantial detrimental effects in either the short or long term.

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1.0 INTRODUCTION

1.1 BACKGROUND

The Water Authority of Western Australia (Water Authority) has commissioned Dames & Moore to prepare a Consultative Environmental Review (CER) document for the development of an improved water supply for Margaret River. The existing water supply scheme, a reservoir on the Margaret River, was commissioned in 1951 to supply 151 services. The scheme is currently supplying 704 services (September 1989) of which approximately 500 are for domestic purposes. The existing supply is drawn from a small concrete pipe head dam on the Margaret River. The safe supply from this source is estimated to be 300,000m^3 per annum. Until 1986 annual consumption was well within this safe supply level. However, increased consumption rates together with drought years in 1986/87 and again in 1987/88 caused a substantial increase in demand, which is now very close to annual supply limits from the existing pipe head dam.

In addition to the quantity limitation, there are also aesthetic water quality problems with the existing supply. With the small on-stream storage, high turbidity river flows are supplied virtually direct to the town during winter. For summer supply, the reservoir stores the more highly coloured late season flows. The colour of the water deteriorates further during summer due to vegetation in the reservoir.

In 1989, a petition containing 527 signatures was presented to Parliament requesting urgent action be taken to resolve the problems associated with the existing water supply of Margaret River.

Detailed discussions have been held between Dames & Moore and the Water Authority and several site visits have been undertaken. This document is the Water Authority's formal submission to the Environmental Protection Authority of its plans for development of a source of supply for Margaret River.

1.2 THE PROPOSAL

The Water Authority intends to construct an off-stream storage dam on Ten Mile Brook, a tributary of the Margaret River (Figure 1). Water will be collected both directly from Ten Mile Brook and by pumping to the reservoir from the Margaret River during periods of highest water quality. This scheme would readily secure the required quantity of water to meet the long term demands at Margaret River. The scheme would also provide a significant improvement in water quality because only the better quality winter flows would be pumped from the Margaret River, particles causing turbidity would settle out in the Ten Mile Brook reservoir and natural reduction of colour would occur in the reservoir. It is expected that these water quality factors will enable any consideration of full treatment to be deferred indefinitely.

Cowaramup, Prevelly and Gracetown may also be supplied from the proposed off-stream storage, should upgrading of other existing supplies prove inadequate or not feasible. This document deals solely with the proposed Ten Mile Brook off-stream storage and does not consider the other town water supplies.

1.3 THE PROPONENT

The proponent for the Ten Mile Brook off-stream storage project is the Water Authority of Western Australia, a State Government authority with responsibility for provision of public water supplies throughout the State.

The Water Authority's head office is located at:

John Tonkin Water Centre
629 Newcastle Street
LEEDERVILLE WA 6007

The regional office for Margaret River is located at:

61 Victoria Street
BUNBURY WA 6230

The Water Authority also has a local depot at:

Wilmott Avenue
MARGARET RIVER WA 6285

1.4 LOCATION AND TENURE

Margaret River town is located 272km due south of Perth. The proposed storage site is on Ten Mile Brook, a small tributary of the Margaret River, approximately 4.5km due east of the town. The Brook is within the Bramley Forest Block, which is a Timber Reserve vested in the Lands and Forest Commission. The Department of Conservation and Land Management (CALM) is the manager of all this block apart from linear easements along the State Energy Commission's power line, and Rosa Brook Road, which is controlled by the Augusta-Margaret River Shire. Figure 1 shows the general location and details of the Bramley Forest Block.

1.5 HISTORY OF THE PROPOSAL

Margaret River has been one of the fastest growing towns in Western Australia during the last decade. Since 1978, the number of water services has grown at an average rate of 5.9% per annum. In the last few years growth has averaged 7.2% per annum. The current water supply dam on the Margaret River was built in 1951 when the number of services was 151. The current number of services is 704 (September 1989).

In the last two years, substantial increases in water consumption have almost reached safe annual supply levels (300,000m^3 per annum). It has thus become necessary to provide increased water supplies through a source of larger capacity.

A further consideration is the expanding market garden and fruit growing industry in the Margaret River catchment, upstream of the present water supply reservoir. These activities have the potential to cause increasing levels of pesticides, fertilisers and sediment to enter the Margaret River and eventually reach the existing reservoir.

A significant feature of the Ten Mile Brook proposal is the provision of pumpback from the Margaret River into the Ten Mile Brook Reservoir. In this way the water pumped can be carefully selected, based upon chemical water quality considerations, thereby avoiding water with unacceptably high concentrations of pollutants. Concentrations of pollutants rise, for example, with the first winter rain runoff, and during the pesticide spraying season. Water at these times will be permitted to pass downstream. When water quality improves the water will be pumped to Ten Mile Brook reservoir.

The Shire of Augusta-Margaret River was notified by the Water Authority in August 1989 of the intention to investigate an alternative water supply on Ten Mile Brook. The Department of CALM, on whose land the proposed site is located, was notified in September 1989 and subsequently assisted by providing information required for preparing this submission.

1.6 EXISTING FACILITIES

The Ten Mile Brook project area has an existing SECWA power line (330kV), and numerous roads and tracks including the Margaret River-Rosa Brook Road. It is intended that some of these facilities will be utilised, especially during the dam construction period. There is also a Telecom line along the route of the SECWA power line, and an area used for passive recreation near the proposed dam site. These facilities are shown on Figure 1.

1.7 LEGISLATIVE CONSIDERATIONS

A broad range of legislation is relevant to the proposed project. These Acts and Regulations are outlined below in Table 1.

This document fulfills the requirements for a formal Consultative Environment Review as required under Part 4 of the Environmental Protection Act 1986 (EPA, 1989).

TABLE 1

LEGISLATION COVERING THE PROPOSED DEVELOPMENT

Environmental Protection Act 1986
Water Authority Act 1984
Conservation and Land Management Act 1984
Soil and Land Conservation Act 1945
Construction Safety Act 1972
Bushfires Act 1954
Rights in Water and Irrigation Act 1914
Country Areas Water Supply Act 1947
Occupational Health, Safety and Welfare Act 1984
Aboriginal Heritage Act 1972
Health Act 1911
Wildlife Conservation Act 1950
Agriculture and Related Resources Protection Act 1976

The Water Authority will comply with requirements under these Acts.

2.0 ALTERNATIVES TO THE PROPOSAL

Several options for alternative water supply proposals were investigated by the Water Authority. In all cases it was assumed that each of the alternative sources of supply would be developed to commence supply to Margaret River in December 1991. Table 2 summarises some of the economic, social and environmental factors considered in evaluating the options.

Selection of the preferred option from the alternatives is based upon economic, technical (particularly water quality), environmental and social considerations. The cost of the scheme is recognised as a prime consideration, particularly because the water supply scheme at Margaret River operates at a financial loss. However, the cost of the scheme must be balanced against water quality, environmental and social factors when they are significant.

TABLE 2

COSTS AND COMPARISON OF ALTERNATIVE WATER SOURCES

SOURCE	ESTIMATED COST FOR MOST LIKELY POPULATION GROWTH	BENEFITS	DISADVANTAGES
Raise Existing Dam	$6,770,000	1. Makes use of existing infrastructure (pipeline, pumps etc.)	1. 25-30ha inundated, including some farmland. 2. Loss of about 10km of riverine vegetation. 3. Class I catchment. Strict controls on activities on alienated land would be required to limit the impact of pollution. 4. Existing townsite is on catchment area, and scheme would inhibit eastwards extension of the town in the future. 5. Full treatment required for colour and turbidity. 6. Acquisition of treatment site would disrupt private landholder. 7. Does not facilitate town reticulation development.
Damsite 16	$7,230,000	1. The existing townsite is not on catchment. 2. Opens up the opportunity, subject to negotiation, for recreational use of the existing water supply reservoir, and use of water for the irrigation of recreation areas.	1. 25-30ha inundated, including some farmland. 2. Loss of about 10km of riverine vegetation. 3. Class I catchment. Strict controls on activities on alienated land would be required to limit the impact of pollution. 4. The scheme would inhibit eastwards extension of the town in the future. 5. Full treatment required for colour and turbidity. 6. Acquisition of treatment site would disrupt private landholder. 7. Does not facilitate town reticulation development.

TABLE 2
(continued)

SOURCE	ESTIMATED COST FOR MOST LIKELY POPULATION GROWTH	BENEFITS	DISADVANTAGES
Groundwater (Perth Basin)	$9,370,000	1. Reduced (or deferred) risk of pollution from agriculture. 2. Opens up the opportunity, subject to negotiation, for recreational use of the existing water supply reservoir, and use of water for the irrigation of recreation areas.	1. About 2-4ha of clearing would be required in State Forest for a pipeline. 2. Full treatment required for iron and possibly manganese. 3. Acquisition of treatment site would disrupt private landholder. 4. Does not facilitate town reticulation development.
Damsite 44	$11,150,000	1. Forested catchment compatible with water supply development. 2. No treatment required (other than chlorination and fluoridation). 3. Opens up the opportunity, subject to negotiation, for recreational use of the existing water supply reservoir, and use of water for the irrigation of recreation areas.	1. 50-60ha of State Forest would be cleared for reservoir, pipeline, powerline etc. 2. Difficult structural conditions in dam foundations. 3. Possibility of dam leaking through foundations, abutments and reservoir basin. 4. Does not facilitate town reticulation.
Local Borefields	Not Costed		1. Only very limited supplies are available. 2. Treatment would be required. 3. Does not facilitate town reticulation development.
Northern Tributary	$5,780,000	1. Significant improvement in water quality over existing supply due to controlled pumpback and improvement in reservoir. 2. Treatment can be deferred indefinitely. 3. Class II catchment. More relaxed catchment management controls.	1. Clearing of about 40ha required for dam, reservoir, pipeline, power etc. 2. Less disturbed environment than Ten Mile Brook. 3. Does not facilitate town reticulation development.

TABLE 2
(continued)

SOURCE	ESTIMATED COST FOR MOST LIKELY POPULATION GROWTH	BENEFITS	DISADVANTAGES
Northern Tributary (continued)		4. Opens up the opportunity, subject to negotiation, for recreational use of the existing water supply reservoir, and use of water for the irrigation of recreation areas.	
Ten Mile Brook Proposal	$4,600,000	1. Significant improvement in water quality over existing supply due to controlled pumpback and improvement in reservoir. 2. Treatment can be deferred indefinitely. 3. Class II catchment. More relaxed catchment controls. 4. Facilitates development of town-site reticulation because of the proximity of the hill to the route of the supply main. 5. Opens up the opportunity, subject to negotiation, for recreational use of the existing water supply reservoir, and use of water for the irrigation of recreation areas.	1. Clearing of 40ha required for dam, reservoir, pipeline, power, Rosa Brook Road relocation etc. 2. Requires relocation of Rosa Brook Road.

o **Raise Existing Pipehead Dam**

It is estimated that to supply the town of Margaret River in the year 2015, a water storage capacity of 860,000m^3 (high growth scenario) or 600,000m^3 (likely growth scenario) would be required. In order to provide this capacity, the existing dam would have to be raised 4m or 3m respectively. About 25-30ha of bushland and farmland would be inundated as a result, as would the loss of about 10km of riverine vegetation.

The storage on the Margaret River would still be small compared to the river flow, therefore full treatment (chemical dosing, sedimentation and filtration) would be required to ensure the supply of good quality water. The cost of treatment is included in the estimate in Table 2.

This option is not favoured by the Water Authority because of the difficulty in managing pollution impacts and water quality in the long term. The catchment area for the existing pipehead dam encompasses some 90km^2 of agricultural land and a significant part of the Margaret River townsite, including the town's light industrial area. Development of this scheme would impose constraints on the development of the existing townsite and would inhibit any eastwards extension of the town in the future.

Under this scheme the Margaret River would be classified as a Class I catchment (Western Australian Water Resources Council Publication No. WRC 1/85). To minimise the risk of pollution it would be necessary to implement and police strict land-use controls, particularly in relation to the storage and use of chemicals in areas used for agriculture (herbicides, pesticides, fertilisers, etc.) and light industry (solvents, fuels, etc.). Such controls would not be well-received by the rural community living and farming in the catchment area. Further, the risk of pollution is likely to increase in the long term.

o **Margaret River Damsite 16**

There is a possible dam site on the Margaret River about 1km upstream from the existing pipehead dam (Figure 1), although site investigations are required to confirm its development potential. Development of this site would avoid the problems of the dam being located in the townsite portion of the catchment area, but the water would still require treatment for colour removal. The

Margaret River would be classified as a Class I catchment, with controls required on the agricultural area to prevent pollution from fertilisers and pesticides.

The areal extent of additional flooding would be the same as for raising the existing dam, but this option would flood a larger area of farmland.

- **Groundwater from the Perth Basin**

  As shown on Figure 1, the Dunsborough Fault which separates the Perth Basin (to the east) from the Leeuwin Block (to the west) is located about 10km east of Margaret River townsite.

  A series of bores to the east of this fault, in the Perth Sedimentary Basin, could readily supply the water demand at Margaret River. Treatment of the water for iron and possibly manganese removal would be required and the cost of installing and operating the bores is twice as expensive as the off-stream storage option (Table 2).

  The major impact of this proposal would be the acquisition of a 4ha site of farmland just east of the Dunsborough Fault for a bore, treatment plant and treated water storage site. The proposal would also involve some clearing of State Forest near Margaret River for construction of a pipeline to the town.

- **Margaret River Damsite 44**

  A new dam site upstream of the existing Margaret River alienated catchment area would eliminate the threat of any water quality problems arising from agricultural activities on the catchment area.

  Preliminary inspections indicate that there are no obviously suitable locations for dam construction in this area, although one or two broad valleys may be suitable. However, geological conditions at these sites would make dam construction difficult and very expensive, because the locations are on sedimentary foundations between the Dunsborough and Darling Faults.

  Water quality data from the Upper Margaret River at Damsite 44 suggest that the water supply would not require treatment for colour or turbidity.

The major impact of this option would be the clearing of 50-60 ha of State Forest for the dam, reservoir, pipeline, power line, etc. Subject to detailed investigation, it could also involve disruption of established recreation areas.

- **Local Borefields**

  Local borefields in the vicinity of Margaret River town might provide some water suitable for potable use but some degree of treatment would probably be required. However, the quantities available would be very limited, requiring numerous production sites and the bores would be of little value in providing water in the long term. This option has therefore not been considered further.

- **Off-stream Storage on Margaret River Tributaries**

  Approximately 3km upstream of the existing pipehead dam there are two tributaries of the Margaret River with fully forested catchments. However, the catchment area of each of these streams is only about 4.5km^2, with each having a mean annual flow of about 300,000m^3. The maximum supply that could be developed from the streams is therefore about 400,000m^3 per annum, insufficient to supply predicted demand, even in the short term.

  Alternatively, a large storage constructed on either of these tributaries could be filled by pumping from the Margaret River. A significant advantage of this proposal is that the risk of pollution from agricultural land on the Margaret River catchment could be minimised by careful timing of the pumpback operation. Also because any significant contamination of the Margaret River flow is expected to be intermittent (i.e. either seasonal or due to an accidental spill), further protection is afforded by the large storage capacity compared to the pumpback rate (i.e. any contaminants would be diluted in the storage).

  Investigations indicate that the southern tributary, Ten Mile Brook, is favoured for the construction of a large storage to supply the town (Figure 1). This is because of the better topography and foundation conditions (which lead to cheaper construction) and because the northern tributary is more isolated and less disturbed, and has higher conservation values than the southern tributary.

The quality of water from this scheme is expected to be good in all respects. As stated above, the impact of agricultural activities would be minimised by the nature of the pumpback and by dilution in the relatively large storage on Ten Mile Brook. The colour of water drawn from the reservoir would be within acceptable limits because of the pumping of low colour winter flows from the Margaret River and because of natural colour reduction in the reservoir.

Turbidity would be reduced in the reservoir by the settling out of the offending particulate matter. As demand increases, the turbidity and natural colour reduction factors may become less effective. If this situation develops, it is expected that some success can be achieved with bulk treatment in the reservoir rather than proceeding with the construction of a treatment plant.

This scheme is not a short term expedient solution to the water supply problems at Margaret River. The proposed reservoir and pumpback would supply the demands for 25 years under the high growth rate scenario, or 40 years under the most likely growth rate scenario. Beyond the design capacity of the scheme, a small raising of the reservoir (3-4 metres), together with increased pumpback rates, would enable a further doubling of demand to be met.

Additional flexibility is also available in the development of this scheme, in relation to the location of the pumpback station. If the flows in the Margaret River become contaminated from agricultural activities, it would be possible to relocate the pumpback station upstream of the agricultural area. This development is a fall back option that could be considered in the long term, if the need arises.

Under this scheme the Margaret River would be classified as a Class II catchment. Catchment management controls would therefore be more relaxed than for raising the existing dam or for a new storage at Damsite 16.

About 28ha of bushland would be inundated as a result of the project, but there would be minimal loss of riverine vegetation as this is very localised in Ten Mile Brook. A total of 40ha of bushland would be cleared as a result of the project, including the realigning of Rosa Brook Road (Section 5.1). However, some of the existing road alignment would be progressively rehabilitated following completion of the construction phase.

The feasibility of developing an off-stream storage on an alienated tributary of the Margaret River has not been investigated in detail. Continuing farming on such a catchment area would be undesirable for water quality reasons, and acquisition of the entire catchment combined with the generally unfavorable topography would make this option prohibitively expensive. Similarly, an off-stream excavated storage outside the State Forest has not been considered because of the high cost due to the very large volumes of earth-moving involved.

3.0 EXISTING ENVIRONMENT

3.1 REGIONAL SETTING

Margaret River, the nearest town to the preferred damsite borders the Bramley Forest Block on the north and is separated by 2km of farm land on the east (Figure 1). Margaret River has a population of 798 (Australian Bureau of Statistics, 1986 Census).

Traditionally, its main industries have been dairy farming, beef cattle farming and timber production. The last decade or so, however, has seen the rapid development of a wine-making industry. Margaret River is also a notable tourist location and holiday and retirement resort. The region has also proved popular to many people seeking an alternative lifestyle.

3.2 CLIMATE

The Bureau of Meteorology recorded climatic data at the Margaret River Post Office, located 4.5km west of the project area, between 1970 and 1975. The project area is characterised by a temperate mediterranean climate, with warm, dry summers and cool, wet winters. The seasonal rainfall results from westerly frontal systems bringing moist air from the ocean.

Lowest temperatures are normally experienced in August, when the mean monthly minimum and maximum temperatures are 8.1°C and 16.3°C respectively. Highest temperatures occur in February, when the average monthly minimum temperature is 15.2°C and the average monthly maximum temperature is 28.1°C.

Rainfall averages 1197mm per annum and falls predominantly during winter (53% falls between June and August while 78% falls between May and September). In contrast, only 3.4% falls during the months of December, January and February.

Relative humidity is also highest during winter months and in the morning. The highest mean level of relative humidity occurs at 0900 hours in June (83%). Its lowest recorded mean level is 49% at 1500 hours in February.

Annual Windroses are reproduced as Figure 2. Based on records from the Margaret River Post Office, the most prevalent winds are south-easterlies and south-westerlies. South-easterlies are most common in summer and autumn, especially at 0900 hours (more than 30% occurrence in summer). South-westerlies occur most often in winter and spring at 1500 hours. North-westerly winds also occur (<20%) at these times.

3.3 GEOLOGY

The Margaret River area is part of the Leeuwin Block, an isolated ridge of high-grade metamorphic rock with a maximum width of 32km and a maximum elevation of about 230m above sea level. The Leeuwin Block is formed by a complex sequence of high-grade metamorphic rocks which have been variously described as granulites and gneisses. The sequence is layered and folded, with the main fold trend north west at the northern end of the block. Cross folding, striking north of east, commonly with reversal of the plunge of folds, results in a pattern of domes and basins.

Two rock types commonly outcrop in the area east of Margaret River: granulite and laterite. The medium-grained granulite is a grey rock, granitic in composition and well foliated and banded. Some bands are richly garnetiferous. It is more than 600m thick and is the highest unit exposed, forming the bulk of Precambrian crystalline rocks in the area.

Laterite and associated quartz sand are also well developed in the Margaret River area. Limonitic laterite covers hills underlain by Mesozoic and Precambrian rocks. The laterite is massive and vesicular, or pisolitic. The sand that once covered the laterite has been washed into the valleys.

3.4 TOPOGRAPHY

A substantial part of the Margaret River area consists of a low, undulating plateau, at one time extensively capped by laterite. The plateau is dissected by the westward-flowing Margaret River. The altitude of most of the plateau is between 100m and 140m, sloping downward from east to west and from north to south. On the plateau the two branches of the Margaret River form floodplains, and some large swamps occur above the headwaters of one of its tributaries, Mowen River.

3.5 SOILS

3.5.1 Regional Soils

Two broad soil types are found in the vicinity of the project area:

- Acid grey earths, sometimes containing ironstone gravels. These podzol soils are often separated by peaty swamps. Flooding is seasonal, although the soils are mainly free-draining. The soils support principal areas of jarrah forest and woodland.

- Yellow and red mottled duplex podzol soils. These are less common than the grey earths and support minor areas of high open Karri forest.

There is a clear correlation between soil type and the distribution of vegetation associations.

3.5.2 Site Specific Soils

At the proposed Ten Mile Brook Dam site the soils are as follows.

- On the hill tops, for example where the storage tank would be located (Figure 1), the soils are white to yellow to yellow-brown sands to sandy loams with varying amounts of laterite pebbles. This soil is locally deep (up to 2m) but in other areas is skeletal. Laterite outcrops variably over the area as pavement or boulders. These soils are stable and erosion-resistant.

- On the upper hill slopes the soils are yellow-brown loams with up to 80% laterite pebbles. These soils are relatively freely draining but are prone to moderate levels of erosion. Slopes vary from 5^{o} to 15^{o}.

- On lower slopes of hills the soils are sandy loams, loams or clay loams, usually red-brown or yellow-brown in colour and with 10-50% of laterite pebbles. They are generally fairly free draining but a lot of surface runoff occurs. Slopes vary from 10^{o} to 25^{o} and soils are highly erodible.

- On the lowest slopes and the levee banks of the Margaret River, and in the bed margins of Ten Mile Brook, the soils are red-brown to grey and variable from clay loams to light clays. Patches of skeletal grits and riverine pebble deposits may be present. A high proportion of peaty debris or organic silts may also occur, as well as pockets of river gravels and laterite pebbles in the creek beds themselves. These soils are free draining in summer, but waterlog readily and are very erosion-prone in winter if the soil is disturbed. When not disturbed the river bank and bed soils are fairly stable.

3.6 HYDROLOGY

The primary surface water drainage system in the region of interest is the Margaret River. At the existing pipehead dam, this river has a total catchment of about $380km^2$ of which about $90km^2$ is alienated and used for agriculture. The mean annual flow at the existing dam is approximately $80,000,000m^3$. Streamflow records for Margaret River at Wilmotts Farm (PWD, 1975; 1984) some 3km downstream from the pipehead dam, show that chloride ion by titration has an estimated weighted value of between 85mg/L and 95mg/L and an estimated total soluble salts value of 200mg/L. It was noted that more than 35% of the catchment above the Willmotts Farm gauging station was cleared by 1982. Ten Mile Brook is much smaller, being only $4.5km^2$ in catchment area, producing some $300,000m^3$ of runoff per year of potable water.

3.7 VEGETATION AND FLORA

The project area in not a pristine environment. Considerable clearing for agricultural purposes was undertaken in the upper reaches of the reservoir basin in the 1930's, and logging operations have been carried out throughout the Bramley Forest Block.

The regional vegetation of the Margaret River area has been mapped at a scale of 1:250,000 as belonging to the Chapman System (Smith, 1973).

Examples of some of Smith's (ibid.) vegetation units are described below, illustrated on Plate 1 and discussed in detail in Appendix A.

Jarrah Open Forest

Jarrah open forest covers most of the region, particularly the lateritic plateaux, and is the most common vegetation type in the area. The dominant species, Jarrah (Eucalyptus marginata), is codominant with Marri (E. calophylla) on slopes and along watercourses. Yarri (E. patens) occurs along the lower reaches of rivers. In deeper gullies and on sandier, shaded or moist slopes Peppermint (Agonis flexuosa) adds a dense upper storey, occasionally extending upwards into the top storey.

Common understorey trees in the project area are Peppermint, Bull Banksia (Banksia grandis) and Fraser's Sheoak (Allocasuarina fraseriana), the latter forming almost pure stands of open forest or low open forest on poor soils over massive laterite sheet. Other understorey trees include Snottygobble (Persoonia longifolia), Hakea lasianthoides, Christmas Tree (Nuytsia floribunda) and, especially along Ten Mile Brook, Native Willow (Oxylobium lanceolatum). Common shrubs include Blackboy (Xanthorrhoea preissii), Zamia Palm (Macrozamia riedlei), Emu Bush (Podocarpus drouynianus), Adenanthos obovata, Hakea lissocarpha, Acacia spp, Bossiaea linophylla, Blue Bird (Hovea elliptica), Heaths (Leucopogon spp.), Trymalium floribundum, Native Buttercup (Hibbertia spp.), Logania vaginalis, Rose Banjine (Pimelea ? rosea), Tremandra stelligera, and, along the realignment site for the highway, Pineapple Bush (Dasypogon hookeri) and Agonis parviceps. Jarrah open forest vines (lianas) and herbaceous plants in the project area comprise Native Wistaria (Hardenbergia comptoniana), Old Man's Beard (Clematis pubescens), Scarlet Climber (Kennedia coccinea), Opercularia volubilis, O. ? vaginata, Bracken Fern (Pteridium esculentum), Yellow Kangaroo Paw (Anigozanthus flavidus) and Swamp Buttercup (Ranunculus sp.). Yarri occurs along the currently proposed route for the pipeline and permanent access track.

Karri High Open Forest

High open forest dominated by Karri (Eucalyptus diversicolor) occurs in the vicinity of Margaret River town and in a band across the proposed route for realignment of the Rosa Brook Road around the reservoir.

It commonly occurs in pure stands but often intermingles with jarrah and marri, generally at the edges of pure stands. Understorey trees include Bull Banksia, Swamp Banksia (B. littoralis), Allocasuarina decussata, Peppermint and Warren River Cedar (A. juniperina). The two Agonis species and B. littoralis occur mainly in the bottom of valleys. Shrubs may form a closed understorey to 5m high. Common shrub species in the vicinity of Margaret River are Acacia subracemosa, Bossiaea linophylla, Oak-leaf Hazel (Chorilaena quercifolia), Hibbertia cuneiformis, Blue Bush Trymalium floribundum, Acacia urophylla and Prickly Moses (A. pulchella). Bracken thrives where the understorey has been reduced by recent or periodic burning.

Closed Sedgeland

Sedgelands occur along broad river valleys such as the upper reaches of the Margaret River and in poorly drained hollows in the jarrah forest such as occur along the eastern half of the proposed highway realignment route. Shrubs most frequently associated with sedgelands are Leptospermum firmum, L. oligandrum, Pericalymma ellipticum, Astartea fascicularis, Agonis linearifolia, Leucopogon gilberti, L. pendulus, Andersonia caerulea and Swamp Bottlebrush (Beaufortia sparsa). On the flats of the Margaret River typical plants are Leptocarpus tenax, Stylidium spp., Restio spp., and Pineapple Bush.

Watercourse Vegetation

Watercourse vegetation is poorly developed in Ten Mile Brook. Two species of small trees, common along Ten Mile Brook at the proposed dam site and elsewhere where the valley is narrow, are Peppermint and Native Willow. The Willow and the shrub Agonis linearifolia form thickets or low forests where the valley and its alluvial flats are broader. One small grove of an eastern Australian tree fern (Sphaeropteris cooperi) survives at the edge of a small clearing covered with an unidentified grass and Hydrocotyle hirta.

The wet alluvial flats and borders of the stream support dense sedges to more than 1m high of Lepidosperma tetraquetrum, L. effusum and Baumea ? acuta. Towards the south east end of the reservoir site, there are climbing mats of a geographically restricted undescribed species of Loxocarya and unidentified sedges.

A few small infestations of Blackberrys (Rubus sp.) were seen in the reservoir site.

No gazetted rare flora or priority species have been recorded in the project area. The species of gazetted rare flora and other rare, geographically restricted and poorly collected species searched for during the September 1989 botanical survey in the project area are listed and discussed in Appendix A. The project is not expected to have any significant impact on any of these species or their habitats.

3.8 FAUNA

No field surveys for fauna were undertaken. This overview of vertebrate fauna within the Margaret River area is based on a paper by How et al. (1987), incorporating data from W.A. Museum records and trapping results from How et al.'s study of the Leeuwin-Naturaliste area. It should be noted that this is not a complete record of fauna assemblages in the area as the paper concentrates on rare, geographically restricted and threatened species.

Mammals

Most mammal species were infrequently recorded in How et al.'s study and, consequently, it is difficult to ascertain complete assemblages at a regional level. This suggests that nearly all known mammal species, including widespread ones, occur in low population densities in the South West region.

The Chuditch (Dasyurus geoffroii), a Gazetted Rare species, appears to have declined considerably within the South West region, with no museum records in the last 20 years. Several sightings have, however, been reported from the Leeuwin-Naturaliste Ridge between 1984 and 1986 (P. Lambert, pers. comm.) and it is possible that this species occurs near the Project Area. However, the Project Area is not near any of the recent sighting locations and the proposal would only affect about 5% of the Bramley Forest Block. The proposal is not expected to have any impacts on the species.

The conservation status of the Mardo (Antechinus flavipes), the Brush-tailed Wambenger (Phascogale tapoatafa) and Coastal Dunnart (Sminthopsis griseoventer) appears to have changed little in recent years, despite extensive regional clearing. The project is unlikely to affect these species, which appear quite tolerant to disturbance.

The Bush Rat (Rattus fuscipes) is the most abundant of all ground mammals in the South West region. It undoubtedly occurs in the Project Area but would not be seriously affected by the proposed activities.

Few of the mammals recorded in the study have changed in conservation status during the last forty years or more. The number of species has declined slowly, however, and contraction of ranges for mammals has occurred commonly. How et al. (1987) attribute the contraction in range to a combination of the accumulated effects of changed fire regimes, land clearance for agriculture, predation, competition and disease. There is no evidence that the proposed dam construction would adversely affect any of the mammal species, although further clearance of land will undoubtedly continue the existing trend of habitat loss which is occurring throughout the south-west of Western Australia.

Herpetofauna

Historically, herpetofauna has been poorly documented due to substantial taxonomic revision, disinterest by early collectors and a poorly known sub-fossil fauna. How et al. (1987) found that the predominantly sandy soils of the south western near-coastal areas, together with the cool, moist environment, result in a considerably reduced assemblage of poikilothermic vertebrates. The prolonged winter, lower temperatures and higher rainfall have been advanced as factors to explain the lower number of reptile species present in southern forests, compared with the rich assemblage of the Northern Swan Coastal Plain.

There is no evidence based on soil types, habitats or other information to suggest there may be rare or restricted reptiles in the project area. To the contrary, the herpetofauna may be both species poor and scarce in numbers.

Birds

Zoogeographically, south-west Western Australia is an area where Eyrean and Bassian faunas mingle (Serventy and Whittell, 1954). The coastal areas contain a number of Bassian endemics or species with disjunct populations in south western and south eastern Australia. In general, these species have extremely limited distributions. All have been markedly affected by European activities in the last 100 years.

The Project Area, however, is not strictly coastal, belonging as it does to the lateritic plateau. Avifauna found in this area are more likely to be widespread and typical of much of the south-west forest.

Scarcer species such as Red-eared Firetail Finch and Emu-Wren, may be present. These species are known to be regionally widespread, although they are limited in numbers at any given location. The proportion of the Bramley Forest Block which will be affected by the project is quite small (5%) and impacts on these species, if they occur, are expected to be minimal.

3.9 ABORIGINAL HERITAGE

A search of the Register of the Department of Aboriginal Sites failed to locate any recorded sites in the vicinity of Ten Mile Brook. Examination of the proposed dam site area by a consultant archaeologist[1] found only two insignificant artefact scatters.

Much of the area around the proposed dam site location was cleared for pastoral purposes, probably in the 1930's. The vegetation has since regrown but undoubtedly the clearing would have destroyed, or greatly reduced, the archaeological values of any artefacts that may once have occurred in the area.

Consultation[1] with local Aborigines indicated that they had no ethnographic concerns.

3.10 EUROPEAN HERITAGE

Margaret River was settled in 1830, at the same time as Augusta. As a result of its long history, many items of historical interest remain in the region, including Wallcliffe House (1864), and Ellenbrook (1851). A number of museums and historical parks are open to the public within Margaret River town. The Project Area contains ruins of an old farmhouse and traces of old fencing and land clearing. This clearing is believed to have occurred in the 1930's. The ruins, while of historical interest, are not of heritage value.

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[1] In accordance with standard practice the archaeological and ethnographic consultant's report has been lodged with the Registrar of Aboriginal Sites of the Western Australian Museum, and is not reproduced in this document.

4.0 PROJECT DESCRIPTION

4.1 INTRODUCTION

The Water Authority's proposal to construct a dam on Ten Mile Brook would include a number of components which would impact, either directly or indirectly, on the natural and social environment of the region. These are:

- the dam wall
- the pumpback, comprising a pumping offtake on the Margaret River, pumping station and pipeline to the Ten Mile Brook reservoir
- the transfer pumping station and pipeline from the dam to the summit tank
- the summit tank and contingency treatment plant site
- the pipeline from the summit tank to Margaret River
- SECWA power supplies
- disturbance downstream from the dam wall construction area
- a construction workshop and maintenance area
- realignment of existing roads
- realignment or raising of existing powerlines
- relocation of Telecom cables

The following sections describe these components of the project in greater detail and Figure 2 indicates their location.

4.2 DAM WALL

The dam wall would be a 17m high homogeneous earth fill embankment, with the upstream slope protected by a rip-rap layer of rock fill material. Foundation stripping would be required over the entire embankment area to remove organic and other unsuitable materials. The main physical statistics of the dam would be as follows:

o Embankment crest level	approx. 89m AHD
o Embankment crest length	approx. 190m
o Embankment crest width	approx. 7m
o Volume of fill in the embankment	approx. 95,000m^3

o	Creek invert at downstream toe	approx. 72m AHD
o	Embankment height	approx. 17m
o	Full supply level (FSL)	approx. 87m AHD
o	Storage volume at FSL	approx. 1.5 x $10^6 m^3$
o	Reservoir surface area at FSL	approx. 28ha

Material for the earth embankment would be obtained from within the reservoir basin as much as possible, but some material may be required from outside sources. Similarly, rock for the upstream face of the dam might be available from the spillway excavation, otherwise it would be necessary to transport rock from a local quarry. The exact requirements for, and sources of, imported materials remain to be determined. The requirements of the Augusta-Margaret River Shire and CALM would be complied with in the use of any local quarries.

The spillway crest structure and chute would be of concrete construction. Concrete would be brought to site using local commercial suppliers.

4.3 PUMPBACK

The pumpback comprises a pumping offtake on the Margaret River, a pumping station and a pipeline to deliver water into the Ten Mile Brook reservoir. Precise details of the pumping offtake and pumping station would not be available until some site investigations and detailed design work have been undertaken. The most likely form of these facilities would be to use submersible pumps and motors, with a rising column installed either in the existing natural pool in the Margaret River, or in a wet well on the bank of the river. Two pump sets of about 60 kilowatts would be installed.

The rising main from the Margaret River to the Ten Mile Brook reservoir would be a 350mm nominal diameter buried pipeline. To ensure reasonable detention time of the water in the reservoir, the pipeline would terminate about 300m upstream of the dam wall on the west bank of the reservoir as shown on Figure 2.

4.4 PIPELINE FROM THE DAM TO THE SUMMIT TANK

It is proposed that a summit tank be located west of the dam on a hilltop (Figure 2). Water would be pumped from the dam to the summit tank, and would then gravity feed from the tank to Margaret River townsite.

The pumping station would consist of two 60 kilowatt pump/motor sets initially, with provision for the installation of a third unit in the future. Chlorination and fluoridation facilities would be included with the pump station. The pumps, controls and water treatment facilities would be housed in a building immediately downstream of the toe of the dam. The type of building and landscaping would be decided in consultation with CALM.

The pump suction main would comprise a floating offtake in the Ten Mile Brook reservoir and a concrete-encased offtake pipe through the dam embankment.

The main access road to the damsite would be constructed adjacent to the pipeline. The difference in elevation between the tank location and the reservoir surface at full supply level would be about 31m. To obtain a suitable grade along the pipeline and access road, a route traversing the contours will be selected as shown on Figure 2. The final route of the pipeline would be determined on site in consultation with CALM. Options for pipe construction in this area are either pipe burial or surface placement on concrete stanchions. Burial would be the preferred option. With either system the required clearing of vegetation could result in soil erosion difficulties, although these can be overcome with appropriate design.

4.5 SUMMIT TANK

A summit tank of 5,000m^3 capacity would be required. The tank would be about 35m in diameter and 6.5m high. Construction of the tank would require clearing of forest over an area about 70m in diameter to allow access and to prevent trees falling onto the tank. The proposed location is shown on Figure 2. This area is old dieback-affected forest and so very little timber would need to be removed. A spur line from the main access road would be required for the pipeline and to allow cranes, concrete trucks, etc., to reach the site.

If treatment of water from the Ten Mile Brook reservoir ever proves necessary, a treatment plant would be required adjacent to the summit tank. A site of up to 4ha could be needed, depending on the treatment process required. An alternative site downstream of the dam could not be considered because of the limited area available and the importance of this area for recreation. There are no other alternative sites available without very extensive pipeline upgrading or site works.

4.6 PIPELINE FROM THE SUMMIT TANK TO MARGARET RIVER

The proposal is to construct the pipeline to Margaret River generally west from the summit tank, to the north-east corner of Location 2665, then west to Jones Road. From here it would approximately follow the existing State Energy Commission power line easement and property boundaries to Margaret River (Figure 2). The pipeline would be 450mm nominal diameter pipe laid below ground.

Apart from the section in State Forest between the tank and Jones Road the land along the pipeline route is cleared for agricultural purposes. In the forested section the pipe would be buried alongside the proposed permanent access road. This access road would be retained for operational purposes and would replace an existing forestry track in the area for forestry management purposes. It would also become the main access to the area for recreational purposes.

4.7 SECWA POWER SUPPLIES

As shown on Figures 1 and 2, a power line passes from Margaret River due south-east to Location 2665, then travels directly east across the upper reaches of Ten Mile Brook. Power to run the pumpback station and reservoir pumps could be obtained by direct linkage to this existing line along the western edge of the reservoir basin. This extension of the existing line would be above-ground construction from the existing State Energy Commission power line to the dam. The further extension of the power line from the dam to the pumpback station would be constructed below ground to minimise the impact in the recreational area downstream of the dam.

The existing State Energy Commission power line presently crosses an area which would be part of the reservoir, and hence under water. Two options are available, the favoured one being a raising of the existing line over the Reservoir. Alternatively, a new alignment would be required to bypass the line around the reservoir. It is currently believed that this would follow the new Rosa Brook Road alignment (Figure 2).

4.8 CONSTRUCTION WORKSHOP AND MAINTENANCE AREA

A workshop and maintenance area, including site office, workshop, equipment storage area, etc., would be required for the project.

The exact location of the construction area is yet to be determined, but temporary construction facilities would be likely to be located upstream of the dam in the area that would be inundated by the reservoir.

4.9 REALIGNMENT OF EXISTING ROADS

Several of the smaller roads would need to be realigned or replaced during or after construction. For example, the proposed permanent access road along the pipeline route will replace an existing forestry track over portion of its route. Also a section of Lorry Road would be inundated and would not be replaced.

The most significant realignment would be the deviation of the Rosa Brook Road to bypass the upper reaches of the Reservoir. Current belief is that the new road alignment would be approximately as shown on Figure 1. Over much of this route the new road would replace Lang Road, an existing forest access track. This alignment has been chosen because:

- it avoids a stand of Karri trees which occurs between Rosa Brook Road and Lang Road,
- it is located very close to the watershed for the reservoir, thereby helping to reduce pollution from the roadway, and
- would pass through cut-over and degraded forest, thereby avoiding good stands of timber.

4.10 TELECOM SERVICES

A number of Telecom cables are laid along the route of the SECWA power line that crosses the proposed reservoir. To provide access to these lines when water is in the reservoir, it would be necessary to construct a deviation around the reservoir (probably following the Rosa Brook Road realignment) or to construct a new cable in a sealed sheath across the Ten Mile Brook. Both of these options are under investigation with Telecom.

4.11 DISTURBANCE DOWNSTREAM FROM THE DAM WALL

Approximately 200m to 300m downstream from the proposed dam wall location is an area of reasonably flat land on the banks of Ten Mile Brook. This is used for camping and picnicking although CALM discourages camping, especially in the summer when there are high fire hazards.

Some of this area may be disturbed by construction activities. If disturbance does occur, it is the Water Authority's intention that either this area would be rehabilitated or redeveloped for recreational purposes as part of the project. Any recreational development of this area will be planned jointly by the Water Authority, CALM and the Shire of Augusta-Margaret River.

4.12 SOCIAL CONSEQUENCES

The main social consequences of the project would be a temporary increase in numbers of people living in Margaret River. The construction workforce is expected to peak at about 20-30 people during the period of October 1990 to June 1991. All the workforce would be located in the town, probably in the hotels, boarding houses or caravan park. Some of the workforce would include people already living in or near Margaret River. As the numbers are unlikely to exceed 30 individuals, this is not expected to adversely affect the town, but will provide some additional income for the region. There would also be some temporary increased demands on local suppliers of food, hardware, concrete, etc., but this is seen by the local government authority as beneficial.

Staff would be recruited from local and surrounding areas where possible. Some employment opportunities would also be available by way of machine and operator hire with plant hire companies. There would be a demand for all forms of skilled and unskilled labour with the various contractors engaged to construct the project. Some day labour construction by the Water Authority may provide some additional short term employment opportunities. These items would assist to provide some employment for a range of local residents.

Traffic

There would be some traffic increase on Rosa Glen Road but this will be limited to the construction phase of the project.

Sewage Disposal

Sewage disposal at the dam site would be by pumping and removal from on-site self-contained units.

5.0 ENVIRONMENTAL IMPACTS AND MANAGEMENT

5.1 LAND CLEARING

Impact

The total area to be cleared for the operation would be about 40ha comprising:

Reservoir		28ha
Dam site, transfer pumping station and construction area	approx	2.5ha
Access tracks, tank, pipelines and pumpback station		2.5ha
Realignment of Rosa Brook Road		6ha
Power supply to pumping stations		1ha

The rehabilitation of the existing alignment of Rosa Brook Road would mean the revegetation of about 3ha of currently cleared land.

If the existing SEC power line has to be realigned (rather than raised as proposed), an additional 7ha would need to be cleared. This would be offset by rehabilitation of 6ha of the existing SECWA easements. A further area of up to 4ha may be required for a treatment plant if treatment of reservoir water proves necessary.

Management

Every effort would be made to minimise the amount of land cleared during the operation. Construction facilities would be largely located upstream of the dam wall within the area below full supply level. Prevention of unnecessary clearing is an integral part of the project as sediment control is vital in protecting water quality, both in the existing reservoir and in the new reservoir after commissioning. Arrangements would be made for CALM to log suitable timber prior to commencement of construction activities.

The main access road to the damsite would be located adjacent to the pipeline. Selection of the precise route of the pipeline and access track from the dam to Jones Road would be carried out in consultation with CALM. Particular consideration would be given to forest management and long term forest hygiene requirements. Factors to be taken into account in the route selection include drainage patterns, soil types, tree species and locations, the presence of areas of dieback infection and road design requirements.

5.2 WATER QUALITY

Impact

Owing to the location of the project within the Margaret River catchment and upstream of the existing Margaret River reservoir, there are concerns regarding temporary impacts on water quality during the construction period.

Sediment deposition into the existing reservoir would adversely affect water quality during the construction period, as would incidents such as accidental fuel spillages or any chemical or substance used in construction entering the water. Possible contaminants are cement, rust-proofing agents, solvents and paints.

Management

As it is essential that water quality in the existing reservoir is maintained until the new reservoir comes on line, the Water Authority would make special provisions to ensure that contaminants do not pass downstream. Vegetation clearing would be minimised, sediment traps will be constructed where necessary, fuel and oil storages would be bunded and all chemicals would be carefully managed.

5.3 FLORA AND FAUNA

Impact

The impact on flora and fauna would primarily come from land clearing and disturbance. Reduced streamflow below the pumpback in the Margaret River would be very minor because only 2% of the Margaret River flow would be diverted, and then only during winter.

Management

As mentioned in Section 5.1, land clearing would be kept to an absolute minimum to prevent sediment entering the Margaret River. This approach would minimise the impact on both the flora and fauna of the project area.

Some non-mobile species of fauna would be lost during the operation, but it is expected that the bolder species such as kangaroos, magpies and ravens would continue to use the area. When construction of the dam is complete the reservoir would probably attract waterfowl.

To determine the impact of the project on fauna, the Water Authority will carry out studies as the project proceeds both before and after construction, with a view to taking early action to protect or relocate any seriously affected species. The implementation of these studies will be carried out in consultation with CALM. No other direct management of flora and fauna is possible, apart from deliberately minimising impacts and rehabilitating cleared areas (see Section 5.11). Firearms, domestic pets, etc., would not be permitted on site.

5.4 JARRAH DIEBACK DISEASE

Impact

Dieback disease impact could be severe, unless carefully controlled, as there are known infections in the area. Most of the vegetation types are susceptible.

Management

There are four primary sources of dieback introduction or spread: dam construction activities, summit tank/pipeline construction, realignment of Rosa Brook Road and rehabilitation. Dam construction is less of a risk because the majority of activities would be in the valley and hence low in the landscape. Further, the vegetation within the reservoir area is to be removed and hence the introduction of dieback is of minor significance. Dieback which passes downstream and enters the Margaret River would have limited impact as the riverine vegetation types are less susceptible to the disease than are the hill-slope vegetation types. The riverine vegetation would also have been coping with the disease since its introduction, perhaps as long ago as the 1940's.

The summit tank site is a potential significant source of dieback as it is known to be infected. CALM, in conjunction with the Water Authority, would develop a disease management plan to ensure that the disease is not permitted to spread from this site. Possible management approaches include doing the work in summer under dry soil conditions, careful placement of access roads, vehicle and machinery washdowns and other standard CALM procedures.

Similar disease management would be required in the Rosa Brook Road realignment programme. This section of the forest also contains dieback and standard CALM requirements for road construction would be applied. Similarly, CALM procedures would be applied at the pumpback station, for all pipe installations, etc.

Effective rehabilitation of the existing alignment of Rosa Brook Road will require the importation of topsoil to the area. The disease management plan referred to above will include conditions to ensure that this rehabilitation topsoil is free of Phytophthora cinnamomi

5.5 EFFLUENT AND TOXIC CHEMICALS

Impact

There would be no effluent produced on site by project operations. Some chemicals and other materials such as cement would be stored on site during construction. These must be prevented from entering the present or future water supply.

Two chemicals used in the water treatment process are potentially hazardous in their bulk, concentrated form. They are chlorine and fluoride.

Management

Fuels and oils would be stored in bunded pits in a locked compound. All other chemicals such as solvents, glues, paints, rust-proofing substances, etc., would be only kept in small quantities. Their use would be carefully controlled by the Water Authority.

Sewage would be controlled by self-contained units during the construction phase. A carefully designed septic tank system would handle the small post-construction toilet usage.

The water treatment facilities for the storage, handling and dosing of chlorine and fluoride will be carefully designed to comply with EPA risk assessment guidelines.

5.6 DUST

Impact

Dust would arise from all operations which cause soil disturbance. As the dam is in a valley surrounded by forest and the nearest residence is at least 1.5km away (this is the distance within the forest block), and Margaret River townsite is 3.5km away, the impacts of dust are expected to be localised. The pipeline would be closer to populated areas en route into the town. However, pipeline construction involves a much lower level of earth moving and only relatively small areas of the route would be under construction at any one time.

Management

If excessive dust occurs as a consequence of operations the source would be controlled by damping down with water from the river.

5.7 NOISE

Impact

A detailed noise evaluation has not been undertaken, but some preliminary estimates are available. The only equipment likely to be in use on site and which would generate loud noise would be earthmoving equipment, cranes and other heavy machinery. It is assumed that generated noise levels from machinery of this type are likely to be in the vicinity of 110dB(A) (Standards Association of Australia, 1981). Assuming that two machines would be operating at the same time the cumulative noise output is expected to be about 113dB(A).

From this noise level, if one assumes that there would be soft-ground attenuation of about 4dB(A), and because the operation would be in a deep, heavily forested valley there would be a further reduction of about 10dB(A), the final output from the operation will probably be in the vicinity of 100dB(A).

If one further assumes that, because of the rural environment, that average background noise levels are about 25dB(A) then background noise levels are reached about 4 to 5km from the construction site.

Blasting will be required to clear rock from the spillway of the dam. The main possible sources of disturbance to local residents would be air-blast overpressure and ground vibration.

Management

The potential high noise radius includes part of Margaret River townsite and some local residences. For this reason the Water Authority would restrict site operations to the period between 0600hrs and 1900hrs Monday to Saturday. Any site action which can be taken to reduce noise levels, e.g. noise suppression of machines, would be undertaken.

It should also be noted that the above assumptions are worse case scenarios. Field observations from other projects suggest that noise attenuation by the forest would be greater than predicted by the Standards Association of Australia (1981) data.

With regards blasting, the physical distance from the reservoir site, and the forest, will greatly reduce noise and vibration. Nonetheless, residents will be informed, probably through the local press, of the proposed schedules of blasting operations.

5.8 EROSION CONTROL

Impact

As stated in previous sections, erosion control is required as an essential and integral part of the operation, to prevent unnecessary turbidity in the existing Margaret River water supply reservoir.

Management

Vegetation clearing would be minimised, all erodible surfaces would be drainage controlled and sediment traps would be constructed in areas where they are deemed to be required. Rehabilitation would commence as soon as operations are complete in any area (refer Section 5.10).

5.9 SOCIAL IMPACTS

Impacts

Social impacts would comprise:

- o noise and dust impacts,
- o temporary loss of recreation potential of the area downstream of the dam,
- o permanent loss of the dam and reservoir area for other uses,
- o temporary increased population impacts on the resources of Margaret River,
- o temporary disruption of the use of Rosa Brook Road,
- o loss of the Rosa Brook airport site as an option for future development due to the realignment of Rosa Brook Road,
- o temporary disruption of SECWA power supplies,
- o temporary disruption of Telecom services.

Management

Noise and dust are discussed in Sections 5.6 and 5.7.

The loss of recreation potential is recognised by the Water Authority and cannot be managed during the construction phase. However, there is potential for developing some recreational facilities in the area downstream of the dam and adjacent to the Margaret River. This would be part of the site management program and would be examined in greater detail by the Water Authority in conjunction with CALM.

The existing Margaret River Reservoir is to be retained after construction of the Ten Mile Brook dam, and would be available to be used as a recreation resource subject to satisfactory arrangements being made with the Water Authority. The water available from this source can also be used to supplement the Local Authority's parkland watering supply, after satisfactory negotiations with the Water Authority.

The Ten Mile Brook reservoir would not be available for any recreational pursuits, but associated facilities such as picnic grounds, walk trails, etc., are compatible uses of the area downstream of the dam.

The increase in population of Margaret River as a result of the project would be minimal, as only a workforce of about 30 people, and their families (say a total of 75), is involved during the construction phase. The local demand on resources for food, fuel, etc., are expected to be a temporary boost to the town's economy. After construction there will be no long-term increase in population as a consequence of the project.

The use of Rosa Brook Road would be temporarily disrupted when the road is realigned. The new road would, however, be constructed before the existing road is closed. The impact is thus expected to be minimal.

If the SECWA power line has to be rerouted rather than raised, the new power line will be constructed before the old line is dismantled. Disruption to services would last only a few hours.

Similarly if the Telecom cable has to be rerouted or relaid in a sheath below the reservoir, only a minor disruption to services would occur when the existing line is connected to the new cable.

5.10 DECOMMISSIONING OF CONSTRUCTION WORKS

Impact

When construction is complete, the main impacts would have been land clearing in the construction area site, the now disused section of Rosa Brook Road and sections of roads or upgraded roads which are no longer needed.

Management

Cleared areas no longer required would be rehabilitated. The edges of widened roads would be drawn back in to encourage natural revegetation. The disused section of Rosa Brook Road would be ripped and the bitumen removed to an appropriate disposal site before being covered with topsoil and replanted with local native vegetation.

All unnecessary equipment would be removed from site and the area would be tidied up.

5.11 REHABILITATION

Impact

Construction activities would result in the clearing of about 40ha of land (Section 5.1). The dam site and reservoir comprise approximately 30ha of the land to be cleared.

Management

As stated in section 5.10, any cleared area which is not required would be rehabilitated with local, native vegetation.

The areas to be rehabilitated would be ripped and topsoil stockpiled prior to construction would be placed onto the site. The area would then be artificially seeded with local native plant species or replanted to trees. The methods of doing this, the species used and site details would be determined by the Water Authority and CALM, and the work probably undertaken by CALM.

Topsoil resources from cleared areas will be carefully managed during construction to provide sufficient good quality material to meet rehabilitation needs. As stated in Section 5.4, care will be taken that imported topsoil does not cause any spread of jarrah dieback.

5.12 CATCHMENT MANAGEMENT

Impact

In the operational phase of the project, the Margaret River above the pumpback and the Ten Mile Brook catchment areas would become Class II catchments. Activities on these catchments, particularly on alienated farmland has the potential to cause water quality problems to develop.

Management

The Water Authority would prepare a catchment management plan for the Margaret River and Ten Mile Brook catchment areas with a view to the protection of the water quality. Issues that would be covered by the plan would include compatibility with the Shire's proposed rural strategy, the impact of farming operations (including clearing) on turbidity, the use of chemicals for agriculture (pesticides, fertilisers, etc) and the optimisation of land management practices.

6.0 SUMMARY OF COMMITMENTS BY THE WATER AUTHORITY

Section 4.2 : The Water Authority will comply with the requirements of CALM and the Augusta-Margaret River Shire in relation to the use of any local quarries for dam construction materials.

Section 4.4 : The Water Authority will consult with CALM on details fo the type of construction and landscaping requirements for the pumping station at the proposed dam.

Section 4.4 and 5.1 : The Water Authority will liaise with CALM to fix the route of the proposed access road and pipeline.

Sections 4.10 and 5.9 : The Water Authority will liaise with CALM and the Augusta-Margaret River Shire in preparing a site management plan for the rehabilitation and recreational development proposals in disturbed areas downstream of the dam.

Section 5.1 : Arrangements will be made with CALM to log suitable timber prior to the commencement of construction activities.

Section 5.3 : The Water Authority will carry out fauna studies as the project proceeds, with a view to formulating a plan of action if any species is seriously affected.

Section 5.4 : In conjunction with CALM develop a jarrah dieback disease management plan for the construction and rehabilitation phases of the project.

Section 5.11 : In conjunction with CALM develop a rehabilitation and revegetation program for any areas affected by the project.

Section 5.12 : The Water Authority will prepare a catchment management plan for the Margaret River and Ten Mile Brook catchments.

7.0 CONCLUSIONS

Current consumptions and growth rates show conclusively that there is a need for a new water resource to be developed at Margaret River. Examination of alternative water sources suggests that the Ten Mile Brook option is the best and most economic approach to meeting that demand.

The probable impacts of the project are fairly clearly defined at both an environmental and social level. Most of these impacts are minimal, but those which would be significant, e.g. noise, vegetation clearing, etc., could be managed by appropriate project design.

The Water Authority is well aware of the environmental and social consequences of the project and is experienced in the management of such issues. It is believed the project is viable and that adverse impacts can be minimised.

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Figures

BASE MAP REPRODUCED BY PERMISSION OF CALM

POSSIBLE SITES FOR BORES IN THE PERTH BASIN

DAMSITE 44

WATERSHED BOUNDARY

MARGARET RIVER

EXISTING DAM

DAMSITE 16

Margaret River

PROPOSED TEN MILE BROOK DAMSITE

FOR PROJECT DETAIL SEE FIGURE 2

Northern Tributary

Dunsborough Fault

Busselton Fault

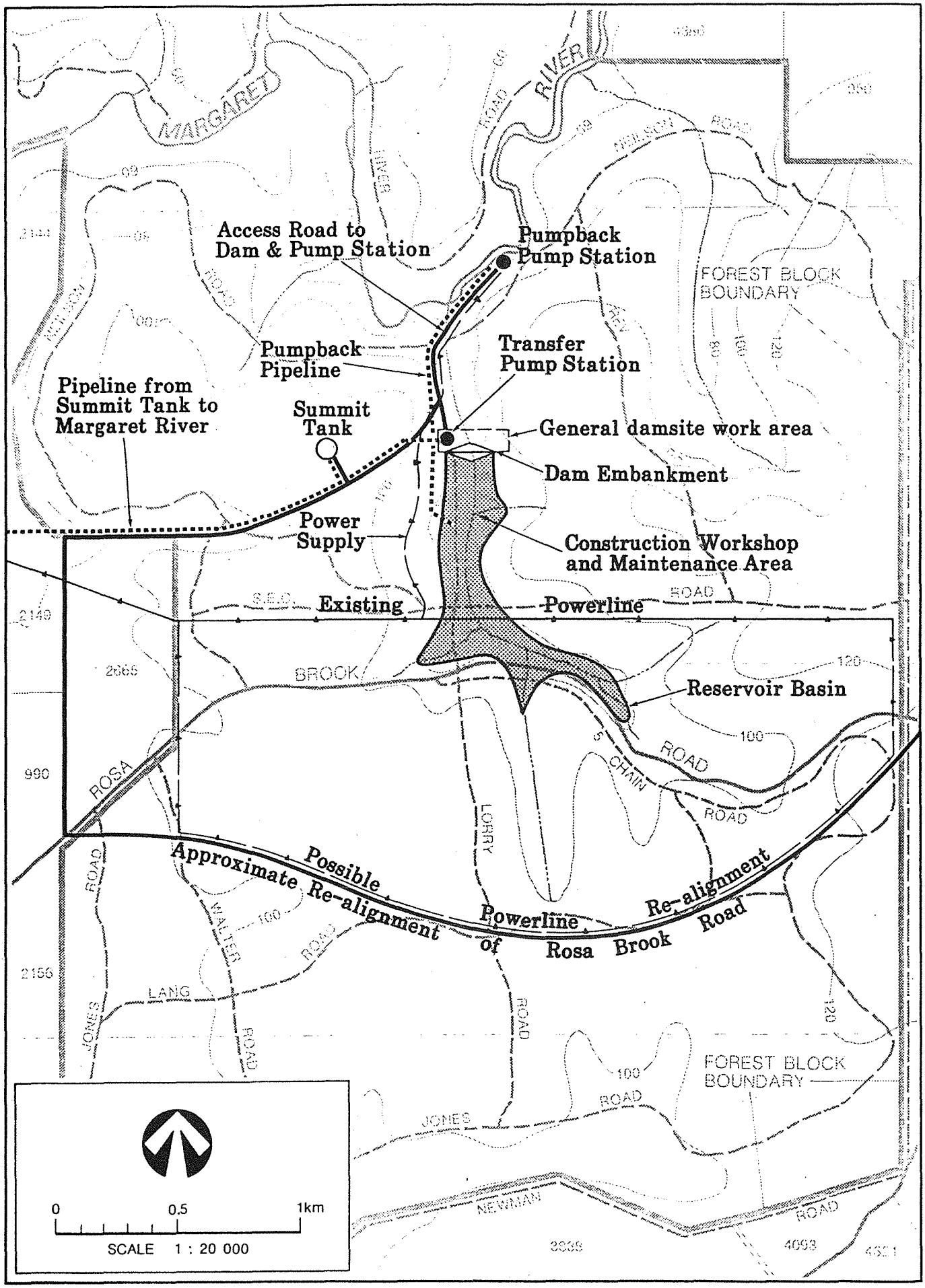
0 1 2km

SCALE 1:50000

LOCATION PLAN

DAMES & MOORE

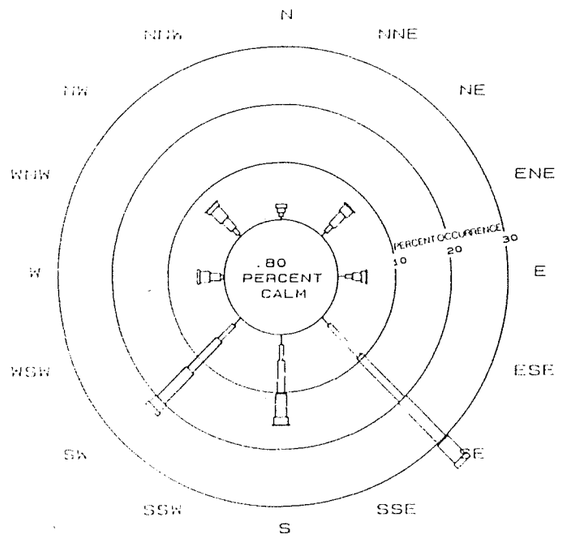
FIGURE 1



PROJECT DETAIL

DAMES & MOORE

FIGURE 2



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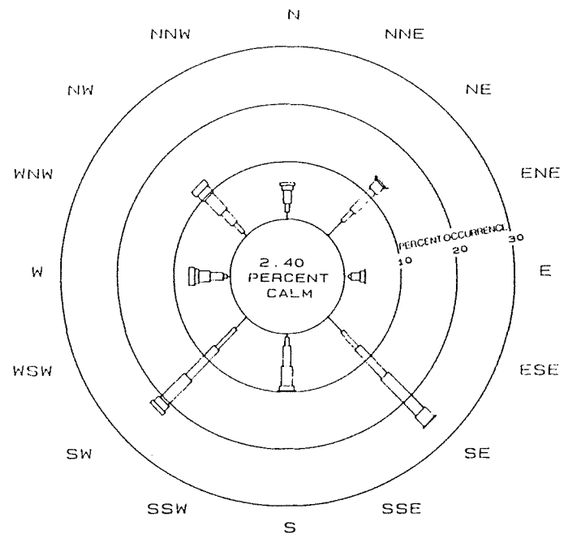

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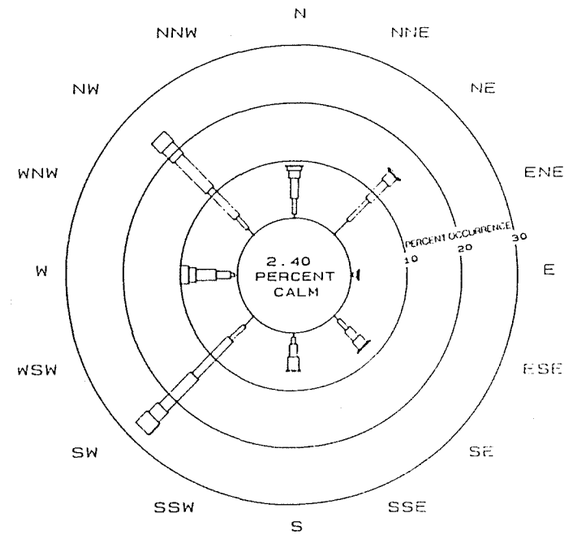

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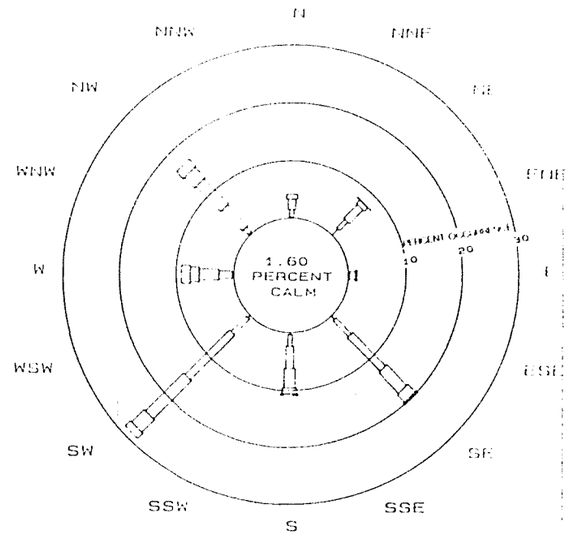

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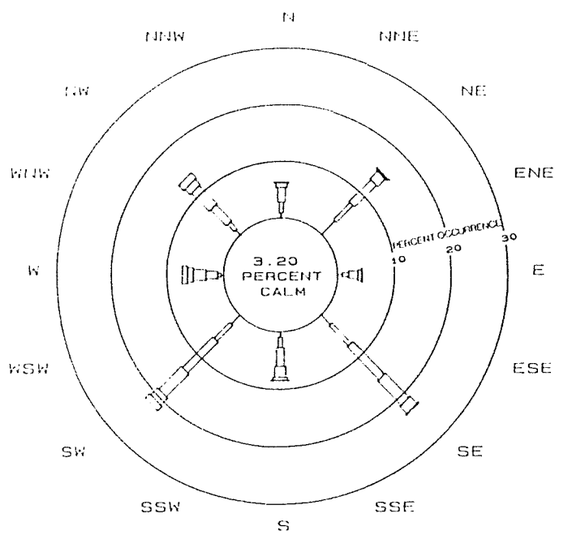

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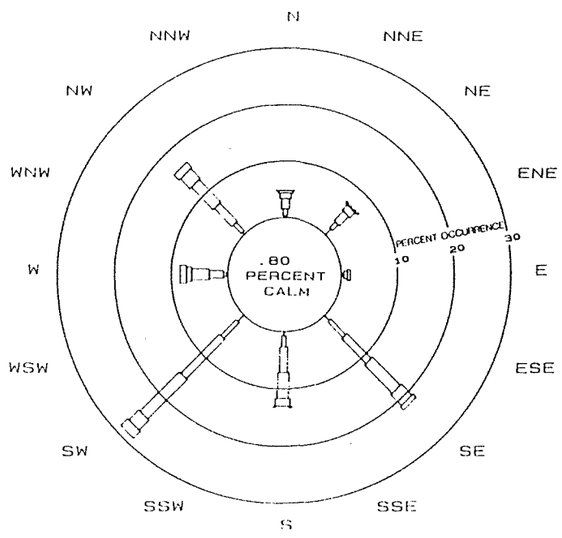

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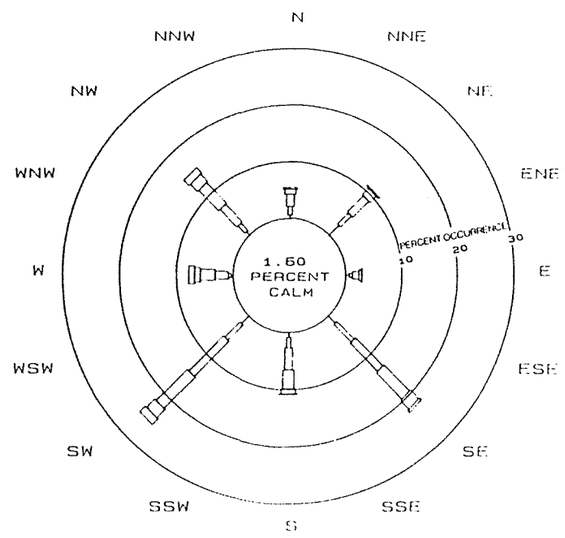

ANNUAL DAILY

WIND SPEED
RANGE (km/hr)

- 1 - 5
- 6 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- OVER 40

WINDROSES
MARGARET RIVER POST OFFICE
(FROM 6 YEARS OF DATA)

Appendix A

APPENDIX A

BOTANICAL REPORT

ASSESSMENT OF VEGETATION AND SIGNIFICANT SPECIES OF FLORA TEN MILE BROOK RESERVOIR SITE

for

Water Authority of Western Australia

by

Arthur S. Weston, Ph.D.
Senior Botanist

Dames & Moore Job No. 08076-068-071
February 1990

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SUMMARY

Vegetation and habitats in the proposed Ten Mile Brook Reservoir Project Area were surveyed for native vegetation, for rare, restricted and poorly collected species of flora, and for habitats for these species on 29 and 30 September 1989.

Jarrah and Marri forest cover most of the Project Area's slopes, often with a tall, dense understorey of Karri Hazel trees, especially on the lower western slopes of Ten Mile Creek valley. Sedges, Native Willow and Peppermint trees and Agonis linearifolia shrubs characterise the Ten Mile Brook valley floor vegetation.

Plateau Jarrah open forest, Agonis parviceps semi-swamp vegetation and a belt of Karri high open forest on redder soils occur along the proposed route for relocation of the part of Rosa Brook Road that would be affected by the reservoir. The relocation route passes through little, if any, Karri forest.

Important habitats, particularly for significant flora (i.e. rare, geographically restricted or poorly collected species listed in Tables 1 or 2), and found during the survey are upland vegetation bordering Agonis parviceps semi-swamps and Ten Mile Brook valley vegetation. Populations of Hydrocotyle hirta and Loxocarya sp. nov., two of the three significant vascular plant species found during the survey, were found along Ten Mile Brook. Dasypogon hookeri, the third, occurs in the Rosa Brook Road realignment corridor in Jarrah open forest containing Agonis parviceps semi-swamp vegetation.

Loxocarya sp. nov. and Dasypogon hookeri are geographically restricted but common within their ranges and are protected, possibly adequately, in national parks and nature reserves. Hydrocotyle hirta has a wide-ranging distribution but is poorly collected and possibly rare. Though recorded from one national park (Porongurup National Park), the species may not be adequately protected in conservation reserves.

ASSESSMENT OF VEGETATION AND SIGNIFICANT SPECIES OF FLORA TEN MILE BROOK RESERVOIR SITE

1.0 INTRODUCTION

Improvement and long-term augmentation of the Margaret River water supply scheme are urgently required because the existing sources of water for the scheme are close to their limits. The Water Authority of Western Australia proposes to improve and augment the current water supply at Margaret River from a 17m high dam to be constructed across Ten Mile Brook, about 4.5km east of the townsite.

Construction of the dam, inundation of the Ten Mile Brook valley above the dam site and realignment of a portion of Rosa Brook Road are features of the project that will have permanent impacts on native forest vegetation in the southern third of Bramley State forest block. Laying a pipeline will also have an impact on State forest between the dam site and farmland to the west. Other project components which will have direct and indirect environmental impacts are outlined and discussed in the Consultative Environmental Review for the project (Dames & Moore 1990).

The southern third of Bramley State forest block in general and, in particular, the proposed dam site, reservoir site, pipeline route and Rosa Brook Road realignment corridor on 29 and 30 September 1989 were traversed on foot and by vehicle. During this survey and along the transects, vegetation types were recorded and rare, restricted and poorly collected species of flora and habitats in which these species might occur were looked for.

Distribution of vegetation types and, to some extent, forest condition were assessed from colour aerial photography flown in October 1988.

2.0 PHYSICAL ENVIRONMENT

The locations, topography and density of vegetation for Margaret River, Rosa Brook Road and Ten Mile Brook are shown on the Department of Conservation and Land Management 1:50,000 scale Margaret map and the Department of Land Administration 1:25,000 scale Cowaramup SW-Mentelle SE and Cowaramup SE topographic survey maps. The reservoir site is 4.5km east of the centre of Margaret River in Bramley State forest block between Margaret River and Rosa Brook Road. The dam site is on Ten Mile Brook between 400m and 500m upstream from Margaret River.

The reservoir site is gently to steeply sloping, with watercourses coming into its upper end from the south-west, south and south-east.

The typical soil in the Project Area is grey and sandy, with outcropping granulite especially at the dam site and on the eastern slopes of the lower part of the reservoir site. Dames & Moore (1990) provides more details of the regional geology and soils.

The Project Area is probably somewhat wetter than Busselton, the climate of which is shown in diagrams on the 1:25,000 topographic survey Cowaramup and Mentelle maps. Average annual rainfall is between 1000mm and 1400mm with average monthly highs of more than 150mm, in June and July, and lows of less than 25mm, in December, January and February. Average temperatures range from monthly highs of close to 30^{o}, in January and February, to a monthly low of close to 10^{o}, in July and August.

3.0 VEGETATION AND FLORA

Smith (1973) mapped the vegetation of the Project Area, at a scale of 1:250,000, as Jarrah-Marri Open Forest.

Forest types on slopes and plateaux identified during the botanical survey of the Project Area are Marri Open Forest, Jarrah-Marri Open Forest, Marri-Yarri Open Forest, Karri-Marri High Open Forest and Marri-Karri High Open Forest. There is essentially a continuum of forest running from pure Karri forest to pure Marri forest without clear-cut divisions between the types.

The vegetation of Ten Mile Brook, its alluvial flats and its tributaries comprises low closed forests of Peppermint (Agonis flexuosa), especially between the dam site and Margaret River, and Native Willow (Oxylobium lanceolatum), tall shrublands of Agonis linearifolia, tussock sedge wetland of Carex ? appressa and dense sedgeland of Lepidosperma tetraquetrum, L. effusum and Baumea ? acuta with patches of Gonocarpus hexandrus. There is a small grove of eastern Australian tree ferns (Sphaeropteris cooperi) next to a small remnant clearing. Acacia divergens, climbing mats of Loxocarya sp. ('grossa') and a few Blackberry (Rubus sp.) canes occur locally.

Small low open mats of Hydrocotyle hirta occur in some parts of the reservoir site which do not appear to have been burnt for many years. The species is a locally common, medium dense ground cover on the floor of the valley.

Some of the Jarrah, Marri, Yarri and Karri trees seen were large, although virtually all of the Project Area appears to have been logged, at least selectively. The regrowth forest in the Ten Mile Brook valley and on its western slopes is reasonably dense. Upland forest that has been heavily logged, particularly on the east side of the area shown on Figure 1, is still open forest to woodland.

PC dieback disease (Phytophthora cinnamomi) is having an impact on forests and other vegetation in the Project Area. The most severely affected forest noted during the survey is Jarrah forest south of Rosa Brook Road that has Agonis parviceps in the understorey. Plants in the Agonis parviceps semi-swamp vegetation have also been affected: many have already died, some recently. Vegetation in the reservoir site appears also to have been attacked by the fungus, but the effects are more isolated and less apparent.

Photographs and descriptions of representative forest types and other vegetation and plants seen during the survey are presented in Plate 1. The locations of the photographed vegetation sites are shown on Figure 1.

4.0 SIGNIFICANT SPECIES AND THEIR HABITATS

The term 'significant species' as used in this report refers to species that are:

- o rare, geographically restricted or apparently rare or restricted because they are poorly collected or recorded,
- o at the limits of their ranges or in areas outside their normal ranges or habitats,
- o particularly susceptible or vulnerable to environmental changes, especially ones caused by humans, either directly or indirectly,
- o diminishing significantly in abundance or geographical range due to clearing and other environmental changes associated with agriculture, mining, recreation, urbanisation and provision of services, or
- o poorly represented in secure conservation reserves.

The term 'significant' is used in this report instead of 'vulnerable', 'threatened', 'depleted' or 'endangered' because these terms either are too limited in their scope or implications or, as Leigh, Boden and Briggs (1984) put it, "have become highly emotive through popular usage, making it difficult to develop objective criteria for use in ascribing species to various categories". Leigh, Boden and Briggs discuss appropriate terminology in more detail.

The accuracy of most lists of significant Western Australian species is limited by the fact that these are incomplete in that varieties, subspecies or undescribed species, some of which are also rare, are not contained, and in that the intensity, uniformity and seasonal coverage of collecting and systematic surveying have been insufficient to distinguish between genuinely rare (and restricted) species and species which only appear to be rare (or restricted) because they have been poorly collected. Systematic surveying and collecting by Department of CALM Wildlife Research Centre (WRC) botanists, and others, are slowly correcting this deficiency.

In some cases, significant species are found in areas where they were not previously known to occur. For instance, Villarsia submersa, a small water-lily type plant, was believed to be restricted to a few small seasonal ponds between Bunbury and Busselton until recent years, when it was found near Denmark, west of Manjimup and, in 1989, in a few ponds in the Metropolitan Region. Synaphea pinnata is a plant species previously gazetted as rare (Government Gazette, WA, of 14 November 1980) which has since been found to be more common or widespread than previously believed and is no longer gazetted.

In other cases, species are no longer found in areas where they have been previously recorded, often due to habitat destruction or alteration. However, there are many species which emerge and flower for only one or a few years after fire, then disappear until after the next burn. The gazetted rare orchid Diuris purdiei, recorded in the Metropolitan area, is one such species.

Other sources of incompleteness and ambiguity in distribution and abundance information are:

- o insufficient locality information given on the labels which accompany herbarium specimens,
- o inaccurate identification of specimens, and
- o treatment of groups of species as single species.

So little is known about the abundance, distribution and taxonomy of nonvascular plants that few, if any, such species are gazetted as rare flora or are included in lists of rare species, although many of them may also be rare or geographically restricted.

The gazetted list of flora does not include all, or probably even a majority of, rare species. The current list (14 July 1989) concentrates on the south-western part of Western Australia and particular groups of species which have, in general, been studied in greater detail than others. For example, members of the families Proteaceae, Myrtaceae, Leguminosae and Orchidaceae account for more than 150, well over half, of the gazetted species on the July 1989 list. And it is likely that in the south-west alone there are many more ungazetted rare and restricted species than gazetted ones.

Since the early 1980s WRC botanists have been compiling lists, descriptions, illustrations and records of significant species on a regional basis throughout Western Australia. The lists were originally compiled from herbarium records of the species listed in Rye (1982) and Marchant and Keighery (1979) and from taxonomic literature. These lists and records, along with relevant taxonomic studies, provide the basis for the lists of species proposed for gazettal and being considered for gazettal.

The WRC now has continuing programmes of research and, in addition to the list of gazetted species, has five unofficial priority lists of rare and restricted species for each of the eleven CALM management regions into which the state is divided:

- o Priority One Species - species known from only a few localities, which are on lands under immediate threat, and are in urgent need of further survey work,
- o Priority Two Species - species known from only a few localities, which are on lands not under immediate threat, and are in urgent need of further survey work,
- o Priority Three Species - species known from several localities, some of which are on lands not under immediate threat, and are in need of further survey work,
- o Priority Four Species - species presumed to be extinct, and
- o Priority Five Species - species considered to have been adequately surveyed and are not endangered or in need of special protection but could be if circumstances change.

These lists are modified and updated as relevant information and results of survey work become available. Priority One, Two and Three species are under consideration for declaration as rare flora, pending the outcome of further survey work.

4.1 SIGNIFICANT FLORA OF THE REGION

Two lists of significant flora were used as the basis for the rare, geographically restricted and poorly collected plant survey of the Project Area. The lists are presented here as Table 1 and Table 2.

The list of 18 significant vascular plant species presented in Table 1 is based upon six lists which indicate rarity, geographic range or how well a species has been collected, and upon personal communications with botanists at the WRC. For each species, the table indicates family, conservation status, distribution, preferred habitat, flowering time and frequency of collection. Although the table was produced in mid-1986 (for Dames & Moore reports) for an area of main Karri forest east of the Project Area it has many species within the range of which the Ten Mile Brook Project Area falls.

The first of the six lists, by Marchant and Keighery (1979), is based upon the numbers of specimens of each species lodged in the Western Australian Herbarium and the geographical range of the collections for each species. The second of the lists, by Leigh et al. (1981), is country-wide and based upon publications or other information provided by botanists in the various states. It covers presumably rare or threatened plants but does not deal with the adequacy of collection of any species. The third list is of gazetted rare Western Australian flora (Rye and Hopper 1981), and the fourth is a supplement to this publication (Patrick and Hopper 1982). Lists of gazetted rare species are updated from time to time; the most recent list was published in the Government Gazette of 14 July 1989. The fifth of the six lists, in Rye (1982), contains 527 species of flowering plants that are geographically restricted and includes most, if not all, of the species gazetted at that time as rare. The Rye list is based upon a detailed herbarium survey supervised by WRC botanists of species which might be rare or geographically restricted.

The Table 1 list of significant species recorded in the main belt of the Karri forest was developed from these six lists, principally the last one, from the advice of various botanists who are experts on various facets of the local flora, and from the botanical experience of Dames & Moore staff in the Karri forest.

There are 20 species listed by Marchant and Keighery (1979) which have been recorded in the main Karri belt and definitely or probably in Karri forest. Ten of them are listed by the authors because they have restricted distributions, not necessarily because they are believed to be rare. One of the most common Karri forest species in the Warren River catchment, Netic (Bossiaea laidlawiana), is in this category. The other ten species are assigned to the status of "poorly known" because each of them was represented in the Western Australian Herbarium by fewer than five specimens at the time the herbarium collections were surveyed by Marchant and Keighery. Assignment to the category of "poorly known" does not indicate rarity, although some poorly known specimens are undoubtedly rare.

Ten of Marchant and Keighery's 20 relevant species are listed by Leigh et al. (1981) as rare or threatened. Seven of these ten are poorly known species that are suspected of being - but not definitely known to be - rare, vulnerable, endangered or extinct (K species). The other three are considered to be rare (R species) but not currently endangered or vulnerable. "Such [R] species may be represented by a

relatively large population in a very restricted area [e.g. Bossiaea laidlawiana] or by smaller populations spread over a wider range [e.g. Pentapeltis silvatica] or some intermediate combination of distribution pattern [e.g. Gonocarpus hexandrus]" (ibid., p.11).

Fourteen main Karri belt forest species listed by Marchant and Keighery (1979) as being rare, geographically restricted or poorly collected do not appear in the most recent lists. These species include Prasophyllum brownii, Acaena novae-zelandiae (A. anserinifolia of Marchant and Keighery), Bossiaea laidlawiana, Gonocarpus hexandrus, Pentapeltis silvatica, Platysace pendula, Platysace tenuissima, Xanthosia hederifolia, Villarsia latifolia, Hemigenia microphylla, Opercularia volubilis, Goodenia eatoniana and Senecio minimus. Some of these species are no longer believed to occur in the area, and some others have been found to be more common or widespread than previously thought.

The lists compiled by Leigh, Briggs and Hartley (1981) and others, and the list of gazetted rare species, are being continuously updated, and as the flora of the southwest becomes better known, species are being added to (as well as deleted from) the lists. Consequently, any survey for rare species should not be restricted to ones that are currently gazetted.

Table 2 list gives priority species recorded in the Margaret River region from the Dames & Moore computer rare and restricted species database. Additional habitat and distribution data are given where known. The database has been compiled from Marchant & Keighery (1979) and other, more recent lists, including the current list of gazetted species and WRC's unpublished September 1989 lists of Priority Species The sources of listings and information about the species is indicated by letter symbols, which are defined at the end of Table 2.

4.2 SIGNIFICANT SPECIES RECORDED IN THE PROJECT AREA

Three of the significant species listed in Tables 1 and 2 were found during the September botanical survey of the Project Area. These species, Hydrocotyle hirta, Loxocarya sp. ('grossa') and Dasypogon hookeri, are discussed below. The first two are illustrated in Plate 1. None of them is on the current lists of declared (gazetted) rare flora or priority species.

Some significant species, particularly ones that do not flower at the time the survey was done, could have been overlooked during the survey.

Hydrocotyle hirta (Plate 1F) is a prostrate herbaceous plant which, in terms of number of collections in the Western Australian Herbarium, is probably still one of the rarest species listed in Table 1. The one H. hirta collection in the Western Australian Herbarium is from Porongurup National Park Karri forest, east of the main belt Karri forest. Until the species was found in a few Karri and Marri forest stands in the Pemberton area in the mid-1980s, H. hirta was not known to occur in the main Karri belt or elsewhere in the Warren Botanical District. It is now known to occur along Big Brook, in Karri forest south of Scabby Gully, and along Brunswick River, in the northern Jarrah forest. Because H. hirta has very inconspicuous flowers and small leaves that resemble those of other species, it is likely that it is poorly collected rather than rare.

Loxocarya sp. nov. (Plate 1G) is a 'sedge' belonging to the plant family Restionaceae. It is a thin-stemmed, partially climbing herbaceous plant that forms mats or mounds to 2m deep in dense shrub vegetation along streams and in swampy flats and valleys. It is a poorly collected and poorly known species with inconspicuous flowers and probably has a broader range than the recorded one: between Margaret River and Walpole. Well-developed populations of the species occur in the Nuyts Block of Walpole-Nornalup National Park.

Dasypogon hookeri (Pineapple Plant; Plate 1C) is a relative of Xanthorrhoea and Kingia which also produces stems, to 3m high, but has broader leaves. The species grows on sandy clay and gravelly clay soils in Jarrah forest between Donnybrook and Augusta (George 1986).

4.3 SIGNIFICANT SPECIES HABITATS

Most of the species listed in Tables 1 and 2 occur in a limited range of habitats which have a restricted occurrence. These habitats are:

- o streams, pools and other wetlands that are seasonal or permanent and often have fringing Peppermint forest or have dense sedge or shrub vegetation in them or lining them, and
- o rock outcrops or stony areas.

Some habitats in the first category occur in the Project Area and are illustrated in Plate 1.

5.0 CONCLUSIONS

No gazetted rare or vulnerable species were found during the botanical survey, but three significant plant species (i.e. rare, geographically restricted or poorly collected species listed in Tables 1 or 2) were found in the Project Area.

Populations of Hydrocotyle hirta and Loxocarya sp. were found in the reservoir site along Ten Mile Brook. All of the populations are below the projected full supply level of the proposed reservoir.

Dasypogon hookeri, the third significant species, occurs in the Rosa Brook Road realignment corridor, in Jarrah open forest containing Agonis parviceps semi-swamp vegetation. Some, but not all, of the populations of the Dasypogon would probably be affected by realigning Rosa Brook Road.

Jarrah forest and Agonis parviceps semi-swamp vegetation south of Rosa Brook Road have been adversely affected by PC dieback disease. There are signs that the disease extends into the reservoir site but without such devastating effects.

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TABLE
RARE, GEOGRAPHICALLY RESTRICTED AND POORLY COLLECTED SPECIES OF PLANTS THAT MIGHT OCCUR IN OR NEAR THE SURVEY AREA

SCIENTIFIC NAME [1]	FAMILY[1]	STATUS[2]	DISTRIBUTION & HABITAT[3]	ABUNDANCE[3]	FLOWER[4]	SOURCE[2]
Acacia scalpelliformis Meissn.	MIMOS	D[5]	Pemberton area - Donnelly River; karri forest, especially banks of permanent streams	3	9-10	MR
Aotus passerinoides Meissn.	PAPIL	F	Northcliffe-Denmark; swampy areas, sometimes in karri forest	11	8-1	MRW
Bossiaea webbii F. Muell.	PAPIL	D/B	Walpole to Shannon area; heath and jarrah forests	3	9-11	MW
Choretrum laterifolium R. Br.	SANTA	F	Pemberton area - Wheatley-Torbay; karri and jarrah forest	16	5, 10-1	MW
Dasypogon hookeri J. Drumm.	PASYP	F	Donnybrook-Margaret River-Beedelup; jarrah forest, swamps	19	9-1	MW
Deyeuxia inaequalis Vickery	POACE	D/B	Warren River -	2	12	M
Eremosyne pectinata Endl.	SAXIF	F	Manjimup-Augusta-Walpole; small herbaceous plants; recently burnt jarrah forest, swamps and clearings	10	10-12	MW
Grevillea drummondii Meissn.	PROTE	D	Shannon Rock-Bolgart; northern jarrah-marri open forest and granite granite rock verges	13	6-11	HW
Hemigenia podalyrina F. Muell.	LAMIA	D/B[5]	Shannon Rock; damp marri woodland near base at granite rock	2	9-10	MRW
Hibbertia gilgiana Diels	DILLE	[5]	Pemberton area -	-	8-9	MW
Hydrocotyle hirta R.Br. ex A.	APIAC	D/B	Porongorup and Pemberton area; damp, shaded, loamy soil near streams	1	2-3	M
Lomandra ordii (F. Muell.) Schltr.	DASYP	E	Northcliffe-Bull Pool-Inlet River-Gardner River; river banks	8	11-3	RW
Loxocarya sp. nov.	RESTI	E/D	Pemberton area-Walpole; flowing swamps and banks of permanent streams	?	?	-
Pentapeltis silvatica (Diels) Domin	APIAC-	D	Mt. Lindsay-Pemberton-Collie; jarrah forest	4	1-6	MW
Prasophyllum triangulare Fitzg.	ORCHI	D/B	Margaret River-Stirling Range; swamp and granite rock verges and gravel/sandy jarrah forest soils	4	8-11	BW
Pultenaea drummondii Meissn.	APIAC		Collie-Walpole; jarrah forest gravelly soils		2-6	HM
Platysace pendula (Benth.) Norman	APIAC	D	Pemberton-Albany; jarrah and karri forest, heath, granite	6	12-3	MR
Villarsia violifolia F. Muell., southern form	MENYA	D/B	Pemberton (Big Brook)-Lake Maringup; permanent streams	4(9)[6]	11-3	-

1. The SCIENTIFIC NAMES of species and of FAMILIES are those used in Green (1985). Only the first five letters of the family name are used in this table.
2. The STATUS symbols refer to rarity and geographical restriction and are defined and discussed in Marchant and Keighery (1979). Essentially, they are; B-Rare; D-Poorly collected: E-Range < 100km; F-Range < 160km. The SOURCES of the status-related information are: L-Leigh et al. (1984); M-Marchant and Keighery (1979); P-Patrick and Hopper (1982); H-Rye and Hopper (1981); R-Rye (1982); W-W.A.W.R.C. unpublished information and Western Australian Herbarium collections.
3. The DISTRIBUTION & HABITAT information and ABUNDANCE figures are compiled from Western Australian Herbarium specimen labels, personal communications and field notes. The ABUNDANCE figures are the number of collections of each species in the Western Australian Herbarium as of July 1986. In several cases, as with Grevillea drummondii, two or more collections are from the same site.
4. Times of FLOWERing are taken from the same sources as above information. The numbers 1 through to 12 refer to the months January (1) through December (12).
5. Species now believed by some to be more common and/or widely distributed than previously thought. Few specimens of these species, or none, were on file or in the collection cases in the Western Australian Herbarium in July 1986.
6. There are four collections of the southern form of Villarsia violifolia in the Western Australian Herbarium and five of the northern form, a total of nine.

Margaret River Area

Acacia inops - P3
MIMOS
10-11
Region 3, Warren District. Osmington, Rosa Brook, Cowaramup, Yallingup, Margaret River
On creek beds and moist clay
Range <100km/rare. B (7 specimens). 45km - -. Priority Three Species
LBH MK R CALM

Acacia tayloriana - P2
MIMOS
12
Region 3, Warren District. Nilup, Augusta, Blackwood River, Karridale, Sue's Road, east Margaret River
Gravel or deep sandy grey soil in Eucalyptus marginata forest
Range <45km/endangered/poorly collected. D (5 specimens). c10km - -. Priority Two Species
CALM LBH MK R LBB

Aotus carinata - P1
FABAC
9-11
Region 3; Warren District. Augusta-Scott River.
Sandy peat swamps
Range <100km/endangered. D (2 specimens). 5km - - Priority One Species
LBH MK R LBB CALM

Aotus cordifolia - P3
FABAC
8-1
Region 2, Darling District. Gidgegannup, Dwellingup, Perth, Red Hill; Byford, Busselton
Occurring in swamps of Darling Range and Coastal Plain, endemic to Perth region
Range <100km/rare. E (12 specimens). 105km - - Priority Three Species
LBH MK R CALM

Aponogeton hexatepalus - DRF
APONO
8-9
Region 2; Darling District. Kenwick-Harvey; Boyanup, Busselton
Occupies small clay based permanent swamps and temporary ponds 30-50cm deep containing water 3-4 months of year. Tubers are rooted in loamy soil
Range <100km/vulnerable. D (2). Gazetted 14 July 1989
LBH RH MK

Caladenia bryceana - DRF
ORCHI
10
Region 5; Stirling District. Kalbarri to Albany area; Busselton; Northampton-Stirling Ranges.
Open eucalypt forest where it grows on flat sandy ground
Range <100km/endangered. D (3 specimens). Gazetted 14 July 1989
A LBH MK LBB

Margaret River Area

Caladenia sp. (S.D. Hopper 3400) - DRF
ORCHI

Coastal plain

Gazetted 14 July 1989

Caladenia sp. (S.D. Hopper 3553) - DRF
ORCHI

Southern forest

Gazetted 14 July 1989

Cartonema philydroides - P3
COMME
7 10-11
Region 1; Irwin District. Region 2; Darling District. Guildford-Capel, Kemerton, Ludlow, Perth, Kalbarri, Forestdale Lake, Busselton, Midland, Bullsbrook.
Low-lying sandy soils in banksia and jarrah-marri woodlands, brown sand over laterite
Range >100km/vulnerable. F (7 specimens). Priority Three
MK L8H WA Herb. CALM

Chamelaucium sp. (G.J. Keighery 3655) - DRF
MYRTA

Busselton

Gazetted 14 July 1989

Drakaea jeanensis - DRF
ORCHI
10-11
Region 1, Irwin District. Darling District. Perth-Busselton; Kalbarri; Capel
Banksia-Casuarina woodlands in wetter sites and other coastal plain sandy areas. Kunzea ericifolia heath. Landform unit: Parallel ridges, Pr
Range >100km/vulnerable. Gazetted 14 July 1989
MK L8H L88

Drakaea sp. (S.D. Hopper 3566) - DRF
ORCHI

South west

Gazetted 14 July 1989

Margaret River Area

Drosera omissa - P3
DROSE
9
Busselton; Augusta

Priority Three Species
CALM

Helipterum pyrethrum - P2
ASTER
10-11
Region 2, Darling District. Upper Swan, Bullsbrook; near Busselton; Boyanup; Eaton
Endemic to Perth region, occurs in clay or wet mud
Range <100km/rare. Priority Two Species
LBH CALM

Hybanthus volubilis - P1
VIOLA
10, 12
Region 3; Warren District. Margaret River

Range <100km/vulnerable. B (5 specimens). x - - Priority One Species
LBH MK R CALM

Jacksonia mollissima - P1
FABAC

Region 3; Warren District. Harvey-Bunbury, Myalup; Margaret River

Range >100km/poorly known. D (2 specimens). 40km - -. Priority One Species
LBH MK R CALM

Jansonia formosa - P2
FABAC

Region 3; Warren District. Margaret River; Scott River

Range >100km/rare Priority Two Species
LBH CALM

Kennedia macrophylla - DRF
FABAC

Region 3; Warren District. Augusta-Cape Leeuwin.
Lee of sand dunes with wind and salt; black, humus rich, windblown sands. Associated with Agonis flexuosa
Range <100km/endangered. B (5 specimens). 5km VR GP. Gazetted 14 July 1989
LBH MK R LBB

DAMES & MOORE RARE FLORA DATABASE

Margaret River Area

Lambertia orbifolia - DRF
PROTE
1-2 5-7
Region 3; Warren District. Narrikup; near Busselton; King River; Scott River.
Dense scrub on gravelly sands over laterite; on sandy soil generally with laterite; on ridges
Range >100km/endangered. Gazetted 14 July 1989
CALM LBH RH LBB

Prasophyllum triangulare - DRF
ORCHI

Region 3; Warren District. Perth, Margaret River-Albany, Stirling Range, Nannup
In marginal jarrah-marri woodland, in sand and sandy loam soils, laterites.
Range >100km/rare. D (2 specimens). Gazetted 14 July 1989
CALM LBH MK

Pultenaea radiata - P1
PAPIL
9
Region 2; Darling District. Busselton

Range <100km/poorly known. D (1 specimen). x - - Priority One Species
LBH MK R CALM

Restio gracilior - P1
RESTIO
9-10
Region 2; Darling District. Busselton.
Sandy soil damp throughout the year
Range >100km/rare. D (1 specimen). c10km - -. Priority One Species
LBH MK R CALM

Restio ustulatus - P3
RESTIO
9-10
Region 3; Warren District. Busselton-Scott River, Ambergate,Capel, Augusta and near Denmark
In sandy swamps
Range <60km/vulnerable. E (8 specimens). 60km - - Priority Three Species
MK R CALM

Stylidium barleei - P2
STYLI
10
Region 3; Warren District. Busselton

Range >100km/rare. D (2 specimens); 10km - - Priority Two Species
LBH MK R CALM

Margaret River Area

Thysanotus glaucus - P1
LILIA
10-3
Region 2; Darling District. Jurien Bay-Busselton; Regans Ford; Perth; Forrestdale
Coastal plains with vegetations of heath scrub on white sands or eucalypt woodland
Range <100km/endangered. D (2 specimens). Priority One Species
L8H MK L88 CALM

Tripterococcus sp. (A.S. George 14234) - P2
STACK

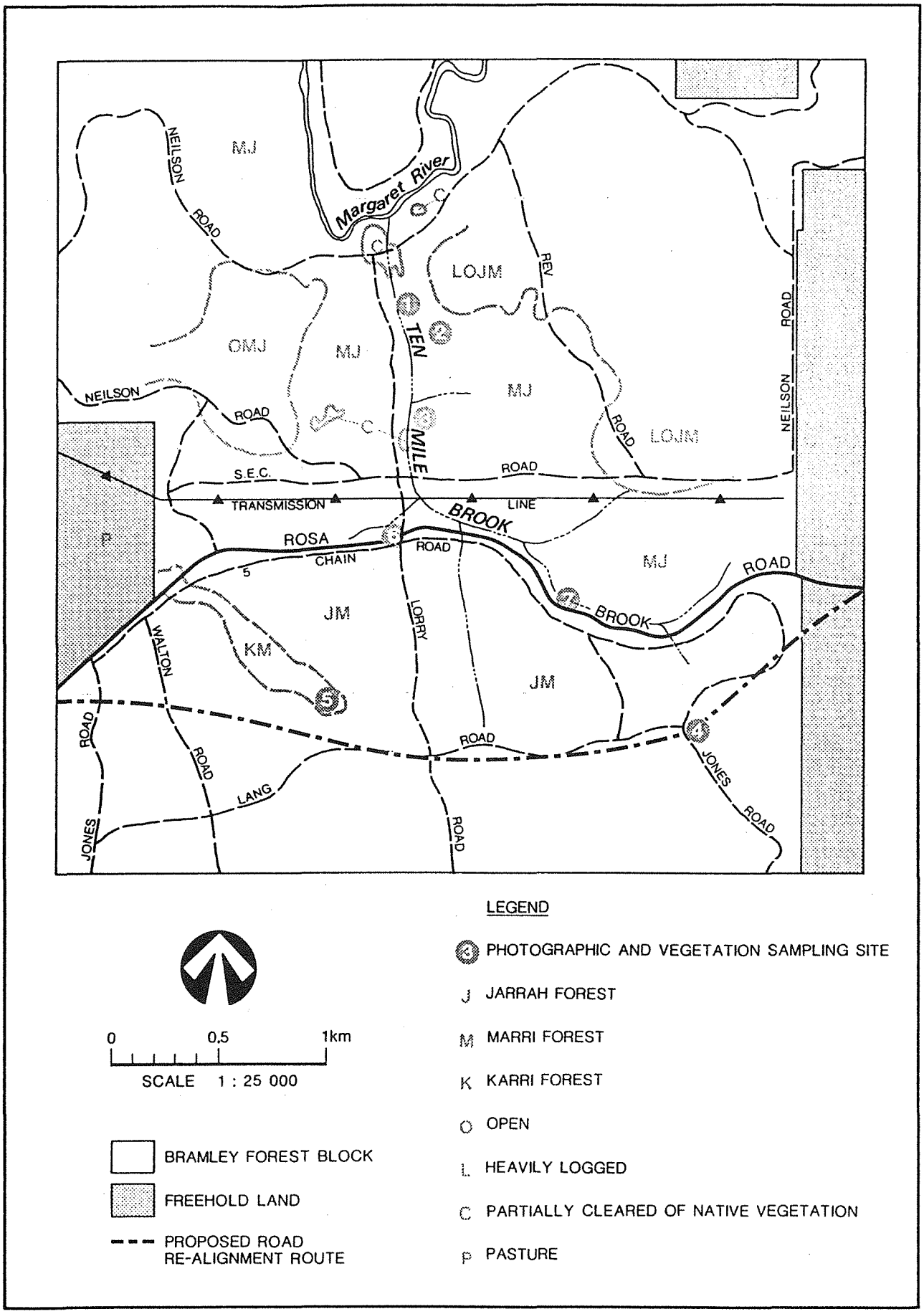
Margaret River, Scott River

Priority Two Species
CALM

Villarsia lasiosperma - P3
MENYA
10-12
Region 3; Warren District. Busselton-Northcliffe; Scott River; Blackwood River; Chokarup; Esperance
Edges of swampy areas in forest or health communities, often on white-grey sands and frequently in association with species of Restionaceae
Range >100km/endangered. D (4 specimens). 135km - -. Priority Three Species
L8H MK R L88 CALM

Villarsia submersa - P3
MENYA
8-9
Region 3, Warren District. Boyanup, Busselton, Yoongarillup.
Rooted in mud under 10-60cm of freshwater in pools and entirely submerged except for floating leaves and flowers
Range <100km/endangered. D (3 specimens). Priority Three Species
L8H MK L88 CALM

Figure



PHOTOGRAPHIC AND VEGETATION SAMPLING SITES TEN MILE BROOK DAM PROJECT AREA

DAMES & MOORE

FIGURE 1

Plate

CAPTIONS – PLATE 1

Vegetation and Plants
of the
Ten Mile Brook Reservoir Project Area

A Upland Karri–Marri High Open Forest near Lang Road. Overstorey of tall Karri (Eucalyptus diversicolor) and Marri (E. calophylla) trees and shrubs of Acacia divergens and A. pulchella dominating the 1.5m to 3m tall dense understorey. Opercularia volubilis and Bracken (Pteridium esculentum) are common. Site 5 (ASW89.9.III–18)

B Marri Open Forest on shallow, rocky soil on slope on east side of reservoir site. Acacia ? browniana prominent in the understorey, with Hakea lasianthoides trees and Logania vaginalis, Hibbertia hypericoides, Hovea elliptica, Hakea lissocarpha and H. amplexicaulis shrubs. Patersonia xanthina conspicuous in the ground layer. Site 2 (ASW89.9.III–15)

C Logged Jarrah–Marri Woodland near the junction of Lang Road and Jones Road. Agonis parviceps, Acacia ? browniana and Hibbertia hypericoides typify the three levels of shrubby understorey. Kingia australis and Dasypogon hookeri stand as emergents over 6.5m and 2.0m tall, respectively. Other species at the site include Peppermint (Agonis flexuosa), Hakea lasianthoides, Xanthorrhoea preissii, Mirbelia dilatata, Acacia myrtifolia, A. divergens, Hakea lissocarpha, Adenanthos barbigera, Podocarpus drouyniana, Hovea elliptica, Persoonia longifolia and species of Andersonia, Conostylis, and Johnsonia. Site 4 (ASW89.9.III–17)

D Ten Mile Brook and bordering vegetation near dam site. Mainly Peppermint (Agonis flexuosa) trees and tall Karri Hazel (Trymalium floribundum) shrubs in flower on the banks and a tall carpet of Lepidosperma tetraquetrum in the streambed. Also, but not apparent in photograph, Lepidosperma effusum, Baumea ? acuta and Gonocarpus hexandrus. Site 1 (ASW89.9.III–14)

E Marri–Yarri (E. patens) regrowth forest in south–west corner of reservoir site. Peppermint trees prominent. Hibbertia cuneiformis, Clematis pubescens, Hardenbergia comptoniana, Hovea elliptica and Bracken also in photograph. Site 6 (ASW89.9.III–19)

F Hydrocotyle hirta, a poorly collected and possibly rare species which, however, is locally common on the floor and lower slopes of the reservoir site. With other small herbaceous plants in the shade of Acacia divergens and Mirbelia dilatata. Site 3 (ASW89.9.III-16)

G Matted Loxocarya sp. nov. ('grossa') climbing on or leaning against and around Agonis linearifolia shrubs along Ten Mile Brook in the south-east corner of the reservoir site. With Astartea fascicularis, Lepidosperma tetraquetrum, Chorisandra sp. and an unidentified, 2m tall, branching, weak-stemmed sedge or grass. Site 7 (ASW89.9.III-20)

A

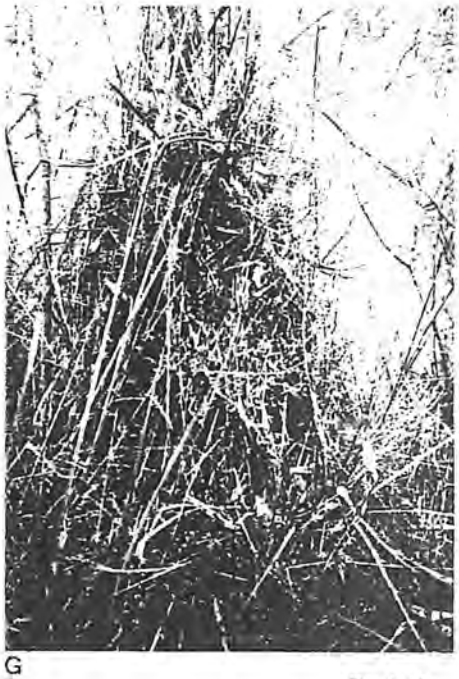
B

C

D

E

F



G

Plate 1
Dames & Moore