Water Authority
of Western Australia

Gracetown Water Supply
Supply from Ellen Brook
Public Environmental Report

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WATER RESOURCES DIRECTORATE
Water Resources Planning Branch

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SUMMARY

Gracetown is a small holiday/retirement town on the West Coast of Western Australia. There are 154 dwellings in the town, most of whose only source of water is from rainwater tanks. Several houses have their own very low yielding bores. Early investigations for a source of potable water for a public, reticulated water supply, had shown that Ellen Brook, located 5 kilometres south of the town was the optimum location. Two methods of developing the Brook as a source of supply were considered. These are, to pump water from an existing masonry pipehead dam immediately upstream of the Ellensbrook Homestead, or to construct a new pipehead dam downstream of the Homestead.

Acknowledging public opposition to the use of the existing masonry pipehead dam, the lower site has been selected as the preferred source for Gracetown, despite the greater cost evolved.

Sensitive environmental issues raised by the proposal to use Ellen Brook as a source of water for the Gracetown Water Supply are addressed in this Report. It is concluded that, with sound management, the preferred proposal can be constructed and operated with a minimal and acceptable impact on the environment.

GRACETOWN WATER SUPPLY

SUPPLY FOR ELLEN BROOK

1. BACKGROUND

Gracetown is a small holiday/retirement town on Cowaramup Bay approximately 40 kilometres south of Cape Naturaliste. The town was opened up in the 1960s.

There are 154 dwelling units in Gracetown at present, making it one of the largest country towns in Western Australia not served by a reticulated water supply. Although it was originally developed as a holiday resort, the number of permanent residents has increased significantly in recent years. There are now about 60 permanently occupied houses in the town, with a resident population of approximately 160. Some further increase in the proportion of permanent residents is expected in the future. The provision of a reticulated water supply at Gracetown will give the residents of the town a standard of living which in the Metropolitan Area has become accepted as the right of every individual.

A reticulated water supply will also lessen the severe summer fire hazard as residents are reluctant to clear the natural scrub if they cannot maintain replacement vegetation because of a lack of water.

Investigations for a reticulated water supply commenced in 1971 following representations from the Gracetown Progress Association. Following an unsuccessful search for groundwater, investigations were extended to include all surface water resources in the area. Ellen Brook was identified as the optimum source of water for the town.

The project involves the construction of a small pipehead dam on Ellen Brook from which water will be pumped to a 1 000 m^3 capacity service tank to be located east of the town. Water will gravitate from the service tank to consumer services in the town.

Ellen Brook is located within the Leeuwin-Naturaliste National Park, and the pipeline route traverses the Park.

2. LEGISLATIVE REQUIREMENTS AND APPROVAL PROCESSES

The proposed project is subject to environmental review under provisions of the Environmental Protection Act 1986 (Western Australia). Under this Act the Environmental Protection Authority (EPA) is charged with the duties of enhancing the quality of the environment and controlling and wherever practical, preventing acts or omissions capable of causing pollution.

In 1985 the Water Authority submitted a Notice of Intent to the EPA which described the proposal, the impact of the proposal on the environment, alternative sources of supply and comparative costs of those alternatives. The EPA has directed the Authority to prepare a Public Environmental Report (PER) for public comment.

As the proposed project site is within an A Class Reserve for National Park, the proposal will need to be endorsed by the National Parks and Nature Conservation Authority, or in the event that such approval is not forthcoming, by a majority in both Houses of Parliament. Approval from the NPNCA for the project to proceed will necessitate inclusion of the scheme in a Management Plan for the Leewin-Naturaliste National Park under the provisions of the Conservation and Land Management Act.

3. WATER DEMAND

There are 152 building lots in the present development of Gracetown of which 149 have been built on. There are 154 dwelling units in the town. Allowing for services to public facilities (tennis courts, beach front ablutions etc) and assuming some minor further development, a total of 160 services can be expected by the time a reticulated water supply is commissioned.

The Department of Lands and Surveys advised that subdivision of an additional 60 blocks could be provided within the townsite, but any further development would be hindered by topographic constraints. There is no pressure at present for the release of additional urban blocks at Gracetown. The implications of future regional development are examined in section 5.5.4 of this Report.

For planning purposes it is assumed that ultimately there could be 220 potential services at Gracetown.

As shown in Appendix 1, the average day of peak week demand of towns similar to Gracetown and which have established water supplies, approximate 2.5 cubic metres per service. This figure has been rising over the past 15 to 20 years as the general standard of living and consumer expectations have risen. A continuing increase to 3.0 cubic metres per service must be anticipated. In the case of new schemes, experience has shown that normal water demands usually take some years to become established. The initial demand at Gracetown is estimated to be 2.0 cubic metres per service.

Thus the average day of peak week water demand at Gracetown is estimated to be 320 cubic metres when the reticulated water supply is commissioned, and rising to a maximum of 660 cubic metres per day, in about 20 years.

4. ALTERNATIVE SUPPLY PROPOSALS

4.1 Cowaramup Brook

The first resource considered as a source for Gracetown water supply was Cowaramup Brook, which enters the ocean at Cowaramup Bay immediately north of Gracetown as shown on Figure 1. Consideration of this resource was discontinued as the stream is ephemeral, and the water is of marginal quality.

4.2 Underground Water

Between 1974 and 1978, 14 exploratory bores were drilled at Gracetown in an attempt to locate a source of underground water to supply the town. These bores were drilled at sites selected by qualified hydrogeologists of the Mines Department and also on the basis of drilling experience by Water Authority officers in other similar localities.

All bores were unsuccessful, except for Bore 1/74 located within the townsite. Pump testing of this bore showed that it was capable of producing 400 cubic metres of water per day, but the annual supply from this source is only quite small due to the limited areal extent of the aquifer. This bore cannot be used as the main source for Gracetown water supply, but it can be used to supplement another source to supply peak demands during summer.

The bore was equipped as a standpipe carting supply in 1978. The available production records are:

Year	Annual Pumping	Peak Week
1982/83	1 099 m^3	84 m^3
1983/84	1 634 m^3	100 m^3
1984/85	1 171 m^3	166 m^3
1985/86	2 107 m^3	206 m^3

It is anticipated that the bore will supply up to 10 000 cubic metres over summer if it is operated as a supplementary source.

4.3 Ellen Brook Springs

Two separate springs on locations 673 (private property) and 202 (now incorporated into the Leeuwin-Naturaliste National Park) were first gauged in 1974/75 and again since 1978/79. Neither spring has sufficient flow to supply the existing development at Gracetown. Utilisation of the spring on location 202 would be unacceptable because of the undesirable impact of the proposal on Meekadaribee waterfall and cave.

4.4 Wilyabrup Brook

Wilyabrup Brook, located about 10 kilometres north of the town, was considered as a source for Gracetown water supply. It would avoid encroachment on the National Park. Wilyabrup Brook stops flowing during summer and a storage of approximately 60 000 m^3 would be required to supply the demand during this period.

Without any of the necessary site investigations, a preliminary estimate of the cost of this proposal is of the order of $1 600 000 to $1 700 000 (at December 1986 price levels) depending on the location of the diversion structure on Wilyabrup Brook.

4.5 Excavated Dam and Bitumen Catchment

Supply from an excavated dam and bitumen paved catchment area has been suggested as a means of avoiding encroachment on the National Park. If a suitable site could be located within 3 kilometres of Gracetown, this option would cost in the order of $1 800 000 (at December 1986 price levels).

4.6 Margaret River

A pipeline extension to supply Gracetown from the existing water supply headworks at Margaret River would minimise encroachment on the National Park (only about one kilometre of pipeline would be within the National Park). As set out in Appendix 3, the estimated cost of supplying Gracetown from Margaret River is $1 210 000 (at December 1986 price levels).

In addition to this direct initial cost, utilisation of the Margaret River water supply headworks would bring forward the requirement for upgrading the supply to Margaret River. Upgrading of the Margaret River water supply headworks at an estimated cost of $250 000 would be required almost immediately after the supply of Gracetown is commissioned in say 1988/89, in lieu of 1992/93. In present worth terms, this is equivalent to an additional present day cost of about $80 000. The total comparative cost of this proposal to supply Gracetown is therefore $1 290 000 (at December 1986 price levels).

4.7 Ellen Brook

Ellen Brook is located some 5 kilometres south of Gracetown. In its lower reaches the brook is perennial. Utilisation of this source would be essentially by a run of the river development in which the demand is supplied from stream flow. A small pipehead dam would be required to facilitate the operation and control of the transfer pumps.

A summary of stream flow observations for Ellen Brook is shown in Appendix 2. Summer flow in the lower reaches of the brook is maintained by discharge from the springs on location 202 and other smaller springs along the stream. Examination of the minimum summer flows appears to indicate that there has been a diminution in the flow in recent years. There has not been any change in the groundwater flow regime at the springs; this apparent reduction in minimum flows observed is due to the more frequent observations in recent years and to the sequence of years of below average rainfall since 1978/79, as shown in the following table.

Year	Date	Minimum Summer Flow (cubic metres per day)	Preceeding Year Rainfall at Margaret River (Average 1168 mm)
1978/79	9/1/79	1 040	1 126
1979/80	-	No observations	1 004
1980/81	16/3/81	950	1 100
1981/82	18/1/82	950	992
1982/83	3/2/83	690	915
1983/84	8/2/84	520	1 002
1984/85	13/2/85	430	960
1985/86	28/1/86	460	870
1986/87	2/2/87	350	1 189

It is concluded that there is adequate flow in Ellen Brook to supply to the existing development at Gracetown. In the longer term as the water demand at Gracetown increases there will be some short fall in stream flow following dry years, if periods of minimum stream flow coincide with periods of peak water demands. Depletion of water storage in the pipehead dam and the service tank, and the conjunctive use of Bore 1/74 will be used to secure the supply during these periods. Periods of peak demand rarely exceed one week, with demand immediately before and after the peak week approximating 70% to 80% of the peak. The existing bore at Gracetown can readily supply up to 400 cubic metres per day over these short periods of peak demand.

Investigations for utilising Ellen Brook as a source for Gracetown water supply have considered two methods of development. The original conceptual design assumed that water would be pumped from the existing masonry pipehead dam located about 60 metres upstream of the Ellensbrook Homestead. Alternatively, a new pipehead dam could be constructed some 250 metres downstream of the Homestead.

As set out in Appendix 4, the cost of a scheme pumping from the existing pipehead dam is estimated to be $770 000. This estimate assumes that only a limited amount of underground power main is provided in the Homestead area. If all power main construction within the National Park (i.e. from the north west corner of location 673 to the pipehead dam) is underground, the cost of the scheme would increase to $840 000.

Alternatively, if a new pipehead dam is constructed downstream of the Homestead, the cost of the scheme is estimated to be $860 000 as detailed in Appendix 5. This estimate assumes that there are no environmentally sensitive areas requiring underground power main construction. If all power main construction within the National Park is underground, the cost of the scheme would increase to $940 000.

5. EVALUATION OF ALTERNATIVE PROPOSALS

5.1 General

Using Cowaramup Brook, groundwater, or the Ellen Brook Springs as sources for Gracetown water supply are not feasible because of water quality, adequacy of supply or environmental factors. These options are not considered any further.

5.2 Wilyabrup Brook

The Wilyabrup Brook scheme would involve construction of a dam of 60 000 m^3 storage on Wilyabrup Brook. If a suitable site is not available on Wilyabrup Brook an excavated offstream storage would be required to maintain supply to Gracetown during summer when streamflow ceases. In addition to a diversion structure and pumping station on Wilyabrup Brook, some 14 to 16 kilometres (depending on the location of the diversion structure) of buried pipeline would be required. This pipeline would follow Caves Road and the bitumised access road into Gracetown.

No field investigation of this proposal has been carried out. The scheme could have some impact on the environment downstream of the diversion structure and on the catchment area, where some controls on rural land use may be necessary. No attempt has been made to identify the environmental impacts of this proposal because of the relatively high cost of the scheme.

5.3 Excavated Dam and Bitumen Catchment

This proposal would require the construction of an 80 000 m^3 excavated dam and about 12 hectares of bitumen paved catchment area. No prospective site has been identified but it is anticipated that this scheme would involve the complete clearing of some 15 hectares of natural vegetation. In addition, the development of a gravel borrow area would be required if in situ soils on the catchment area are not suitable as a base course for bitumen paving. No attempt has been made to undertake a detailed evaluation of the environmental impacts of this proposal because of the relatively high cost of the scheme.

5.4 Margaret River

To supply Gracetown from the Margaret River water supply headworks would require the construction of a new pumping station adjacent to the existing dam at Margaret River and about 16 kilometres of pipeline. The pipeline would generally follow Carter and Caves Roads and existing tracks from Caves Road to the proposed service tank site at Gracetown. About one kilometre of pipeline would traverse State Forest along Carter Road, and one kilometre would be through National Park. Construction of the pipeline would result in only minor disruption of the environment. There are no restrictions on access in this portion of State Forest.

Implementation of this proposal would advance the need to augment the Margaret River water supply. Based on the historical growth in the number of services at Margaret River, this augmentation is estimated to be required in 1988/89 rather than in 1992/93, if Gracetown is supplied from Margaret River.

Raising the existing dam on the Margaret River is the most probable method of augmenting Margaret River water supply. A raise of the order of 1.5 metres would be required to secure the supply to Margaret River and to provide for the supply to Gracetown. Identification of environmental impacts would be required to proceed in conjunction with engineering investigations for the raising of the dam. If there are any significant environmental constraints, the cost of augmenting Margaret River water supply could be significantly higher than the present estimate of $250 000.

No unacceptable environmental impacts have been identified in respect of the pipeline, pumping station and service tank to supply Gracetown under this proposal. The pipeline would be buried (except for the Margaret River crossing) and would follow existing roads and tracks. The pumping station would be located at the existing dam at Margaret River and the service tank would not be visible from Gracetown.

5.5 Ellen Brook

The Ellen Brook scheme involves development of a source within the Leeuwin-Naturaliste National Park either by utilising the existing pipehead dam on Ellen Brook or by constructing a new pipehead dam downstream of Ellensbrook Homestead. The work required within the National Park comprises renovation of the existing dam (or construction of a new dam), construction of a pumping station adjacent to the dam, the laying of about 4.2 kilometres of 150 mm below ground pipeline and the construction of a power main extension of about 1.5 kilometres. The pipeline and power main extension would generally follow existing access tracks which would be upgraded to facilitate construction and operation of the scheme. The balance of the work required is within Gracetown townsite (about 2.2 kilometres of 150 mm below ground pipeline, a concrete service tank, town reticulation mains and equipping Bore 1/74) and in private property (the first 2.7 kilometres of power main extension is within location 1199, 886 and 673).

With careful attention to detail and restoration work, either of the Ellen Brook proposals can be constructed with minimum impact on the environment.

Environmental Consultants, Dames and Moore were commissioned to make a biotic survey of the area of the proposed works, to describe the likely impacts of the works on sensitive elements of the environment, and to define and report on management action required to mitigate any impacts. The Consultants' report "Biotic Survey of Ellen Brook", is appended to this Report.

The following paragraphs (Sections 5.5.1 to 5.5.3) discuss the impact of the scheme on particularly sensitive issues within the National Park. Section 5.5.4 examines the effect of further development in the Margaret River region on the economic viability of the Ellen Brook scheme.

5.5.1 Impact on Freshwater Snail

A species of rare freshwater snail, Austroassiminea letha has been found adjacent to Ellen Brook as described in the report in Appendix 6. Apart from Ellen Brook, the only known living populations are located at Turner Brook near Deepdene Cliffs and at Cosy Corner. Extensive searches in the Deepdene Cliffs and Cosy Corner areas have failed to locate additional populations. At Ellen Brook, living populations are reported to have been found in algae growing on the side of the head race to the old water wheel, and at Meekadaribee Cave some 500 metres upstream of the homestead. Dead snails have been found at the downstream toe of the masonry pipehead dam and in the seepage area about 30 metres east of the Homestead.

The most important factor of the snails habitat is the availability of water. During winter, the snails disperse into seepage areas along the north bank of Ellen Brook, but when the seepage areas dry out, they are concentrated closer to Ellen Brook. During summer the major part of the snail populations are believed to be in fissures in the rocks, where either a minor flow of water or very high humidity would prevail even in mid-summer.

Some concern has been expressed about the impact on the snails of developing the existing pipehead dam as a source for Gracetown water supply. This concern relates to the effect of the reduction of stream flow on the snail population downstream of the dam and to the impact of the construction activity on the habitat of the snails.

In respect of water availability, the snail population downstream of the dam would be subjected to a slight reduction in stream flow during summer. This reduction in stream flow would be minimised by the use of Bore 1/74 and would be perceptible for only a short period. Initial peak demands can be supplied entirely from Bore 1/74, so that the opportunity exists to monitor the impact of reduced downstream flow on the snail population as water demands at Gracetown become established. Any such monitoring could be inconclusive because the snails are so small and difficult to find, and are relatively mobile. Pumping from the existing pipehead dam would not affect the snail's habitat in the hillside seepage areas downstream of the dam.

Construction activities in the area of the existing pipehead dam would have some impact on the snail's habitat but with careful planning and execution of the work it would be possible to restrict such impacts to an acceptable level. Development of a vehicular access track (with a hairpin bend) upstream of the dam would avoid traffic in the fissured rock area adjacent to and downstream of the dam. The refuge offered to the snails by these fissures would not be affected. The hillside seepage area about 30 metres east of the Homestead (downstream of the dam) would not be affected by construction activities, but a significant seepage area about 50 metres upstream of the dam would be affected by construction of the access track upstream of the dam. To minimise disturbance of the snail population in this area, this work would be undertaken before the onset of summer while the snails are still dispersed under moist conditions. Preservation of the seepage area as a habitat for the snails would be taken into account in the design of culverts under the proposed access track.

Although utilisation of the existing pipehead dam would have an impact on the snails, the impact is considered to be within acceptable limits. There would be no impact on snails upstream of the project area. Because of the snail's mobility, any areas affected by construction activity could be expected to be repopulated when construction is completed.

No snails have been found downstream of the Homestead. The alternative development of a new pipehead dam will not have any impact on the snail population.

5.5.2 Impact on Aboriginal Sites

The waterfall and cave known as Meekadaribee is understood to be an Aboriginal site with some mythological significance. As this site is located some 400 metres upstream of the existing pipehead dam, it would not be affected by the proposal.

As shown on Figures 2 and 3 and described in Appendix 6, there are two Aboriginal sites adjacent to the proposed pipeline from Ellen Brook to Gracetown. The site nearest the Ellensbrook Homestead is registered as Site S0242 and is considered to be of greater significance. The less important site north of Ellen Brook is registered as Site S2249 has not been thoroughly investigated. Both these sites are sand blow-outs where Aboriginal artifacts which were originally distributed throughout several metres of the soil profile are now concentrated at the surface. The sites are of archeological interest and have no religious significance. The sites do not have clearly identifiable boundaries. Advice from the Registrar of Aboriginal Sites is that the sites extend to cover any Aboriginal artifacts in the immediate vicinity of the sand blow-outs.

Development of the existing pipehead dam as a source for Gracetown water supply would require construction of the pipeline to Gracetown alongside Site S0242 for some 200 metres and in close proximity of Site S2249. One hole has been dug adjacent to Site S0242 as shown on Figure 3. An Aboriginal artifact was found in this hole at a depth of about 300 mm. It is anticipated that further artifacts would be uncovered by the excavation of the pipeline and power main trench along this section of the route. This construction work would not have any adverse impact on the sites. The entire trench excavation adjacent to the sites would be in sand and all excavated material will be used to backfill the trench. Implementation of the scheme will enable knowledge of the sites to be increased. The trench excavation will be inspected by an archaeologist before the pipeline is laid, and any significant artifacts salvaged. This inspection will be arranged in consultation with the Registrar of Aboriginal Sites.

Construction of a pipehead dam downstream of the Homestead will reduce the length of pipeline to be constructed adjacent to the known Aboriginal sites. As shown on Figure 3, some 30 metres of pipeline will be laid alongside Site S0242. It is possible that trench excavation adjacent to the old track now under rehabilitation will show that Site S0242 actually extends further west than presently thought. Nevertheless, like the proposal to use the existing pipehead dam, the pipeline from a new dam will have no adverse impact on Aboriginal sites.

5.5.3 Impact on Historical Values

The Ellensbrook Homestead marks the first European settlement in the Leeuwin-Naturaliste area. The National Trust has recently commenced restoration of the Homestead and is also considering reconstruction of some associated structures. When restoration is completed, it is proposed that a caretaker's house will be built near, but out of sight of the Homestead. Public access to the Homestead will be by an improved access road to a visitors car park to be constructed near the caretaker's house, and then by foot.

Development of supply from the existing pipehead dam will affect historical values in the Homestead area, but this impact is considered to be quite small. There will be an impact on historical values resulting from the provision of vehicular access to the pipehead dam and the pumping station. These works will be out of historical context with the original homestead. The visual intrusion of these works will be minimised by location of the vehicular access upstream of the dam and by installation of the pumps below ground. To avoid any visual impact, the power main extension will be constructed below ground near the dam and any renovation of the dam will harmonise with the existing structure.

Some further impact will arise when the scheme is operating and there is a perceptible reduction in stream flow downstream of the existing dam in both the stream bed and in the head race to the water wheel. This reduction in flow will be minimised by the use of Bore 1/74. The visual impact could be further reduced by the installation of a simple and inexpensive recirculation system in the water wheel head race. This system would not have to be installed at the inception of the scheme but could be delayed until made necessary by rising demand at Gracetown. The recirculation system would only be required to operate for the short period during summer when periods of peak demand and minimum stream flow coincide.

The alternative development of a pipehead dam downstream of the Homestead will not affect the historical values in the Homestead area.

5.5.4 Regional Development

From a purely financial point of view, the Ellen Brook scheme is the preferred option for supplying water to Gracetown. Further growth in the Margaret River - Gracetown area does not affect the selection of Ellen Brook as the preferred source for Gracetown water supply. Provided Ellen Brook is able to supply the demand at Gracetown for at least five years, it is more economical to construct this scheme and augment the supply from Margaret River when required, rather than to supply from Margaret River initially. The Shire of Augusta-Margaret River and the Department of Lands and Surveys have advised that on planning grounds, further development of Gracetown townsite should not be considered. Strong arguments would be required to justify any further development of the town; thus, the adequacy of the supply from Ellen Brook for a minimum period of five years is assured.

The Shire has advised that any future development in the area between Cowaramup and Gracetown would be for a special rural zoning. A reticulated water supply will not be required in this area.

Any future proposals for the provision of public water supplies to Prevelly Park and Wallcliff Wilderness Estate would not affect the choice of Ellen Brook to supply water to Gracetown. Local groundwater resources, if they exist, would be the cheapest source of supply for Prevelly Park and Wallcliff Wilderness Estate. Failing this, a piped supply from the existing headworks at Margaret River could be considered. Adoption of this latter proposal would not affect the cost of a piped supply from Margaret River to Gracetown, but there would be a minimal reduction in cost of upgrading the Margaret River headworks attributable to supplying Gracetown. If the Margaret River headworks are used to supply Prevelly Park and Wallcliff Wilderness Estate, the headworks development cost associated with supply to Gracetown would reduce from $80 000 (see section 4.6) to about $70 000.

The size of Margaret River in relation to Gracetown precludes the growth in this town having any influence on the choice of a source for Gracetown water supply. i.e. the growth rate adopted for future development at Margaret River has only a minimal effect on the overall cost of supplying Gracetown from the Margaret River water supply headworks. Comparative costs based on a 6% discount rate, are:

	Capital Cost $	Present Worth $
<u>Ellen Brook</u>		
Ellen Brook to Gracetown	860 000	860 000
Margaret River Headworks 1992/93	200 000	141 000
	1 060 000	1 001 000

Margaret River

Margaret River to Gracetown	1 210 000	1 210 000
Margaret River Headworks 1988/89	250 000	222 000
	1 460 000	1 432 000

It is concluded that there is a comparative cost differential of $431 000, or 43%, in terms of present worth between the Ellen Brook and Margaret River proposals. Implementation of the Ellen Brook scheme is not a stop-gap measure. It defers the larger capital expenditure on the Margaret River-Gracetown pipeline and avoids early upgrading of the Margaret River headworks. The Ellen Brook scheme is fully justified using normal methods for the economic evaluation of capital works projects.

5.6 Selection of Preferred Proposal

Ellen Brook is the resource preferred by the Water Authority as the source for a reticulated water supply at Gracetown. It is significantly cheaper to use Ellen Brook than other alternative sources. Although construction of a new dam is more expensive than utilisation of the existing pipehead dam, this proposal minimises any impact on the historical, Aboriginal and aesthetic values of the area and eliminates any impact on the freshwater snail. Of the two options for developing Ellen Brook, the proposal to construct a new dam downstream of the Homestead is the option generally preferred by the various parties with an interest in the area. The proposal to construct a new dam downstream of the Homestead has therefore been selected as the Water Authority's preferred proposal.

With sound management, in close liaison with officers of CALM, the preferred proposal can be constructed and operated with minimal impact on the environment at Ellen Brook. The engineering elements of the project are relatively small. The pipehead dam (2 m high) will occupy a small area (0.2 hectares), and the small (30 kilowatts) pumping station will be an unobstrusive below ground installation. The small (150 mm diameter) pipeline will be buried. Access roads and power line to the Homestead area, will be constructed in conjunction with proposals by the National Trust and subject to approval by CALM.

6. DESCRIPTION OF PREFERRED PROPOSAL

6.1 Access Road

The Ellensbrook Homestead area is accessible only by four wheel drive vehicles at present. In conjunction with the restoration of the Homestead, the National Trust in collaboration with CALM proposes to upgrade this access track and establish a visitors parking area within walking distance, but out of sight of the homestead. This upgrading of the access track will proceed in conjunction with the implementation of this proposal.

Construction of the pipehead dam downstream of the Homestead will require upgrading of a section of an old track which is presently under rehabilitation by the Department of Conservation and National Management (CALM) as shown on Figure 3. Use of this upgraded track will be restricted to authorised personnel; its development will not cause any further degradation of the beachfront dune system. This track will not intrude on the general Homestead area.

The suggested location of the visitors car park is shown on Figure 3. Vehicular access beyond the car park will be restricted. For normal operation and inspection purposes Water Authority officers will proceed on foot from the car park. Vehicular access will only be necessary when maintenance work is being carried out or when some heavy equipment is required at the dam.

The pipeline route to Gracetown follows existing tracks which were developed as firebreaks. Some upgrading of the track will be undertaken and the alignment will be rationalised where the existing track meanders unnecessarily. Utilisation of this track by the general public will be prevented by the provision of locked boom gates and rock boulder barriers north of the proposed permanent access track from Caves Road. The general location of these gates is shown on Figure 2. The precise location of the gates will be determined in consultation with officers of the Department of Conservation and Land Management. (CALM)

To minimise the risk of weed or dieback invasion into the Park, the access roads will be constructed, where necessary, using limestone and/or gravel imported from a site, or sites, approved by officers of CALM. To minimise erosion, precautions will be taken to divert runoff from the access track into the surrounding bush at regular intervals.

As noted in para 5.5.3, an improved access road to the Homestead is proposed by the National Trust, irrespective of any decision to proceed with the construction of the Gracetown Water Supply based on Ellen Brook.

6.2 Pipeline

The pipeline from Ellen Brook to the service tank at Gracetown will be of 150 mm nominal diameter, laid below ground with a sand bedding and with a minimum cover of 450 mm. Trench excavation material will be suitable for pipe bedding over most of the pipe route. A sand borrow area will be developed to provide bedding material where sand is not available in situ. Possible borrow areas have not yet been determined, but a suitable site should be readily available outside the National Park.

Sub-surface soil investigations have not yet been carried out along the proposed pipe alignment. Some rock (limestone) excavation is expected to be required. This will be accomplished using an excavator equipped with a hydraulic rock breaker if the use of explosives is not acceptable to CALM because of the existence of caves in the area.

As stated in Section 6.1, the pipeline will be laid adjacent to the existing firebreak track between Ellen Brook and Gracetown. The access corridor will be widened to about 5 metres to provide adequate space for construction work on the pipeline alignment adjacent to the track. After regrowth occurs over the pipe trench there will be no visual impact from the pipeline. Strong regrowth of the native vegetation can be readily achieved as evidenced by the recovery of the areas cleared for drilling exploratory bores in 1974, 1977 and 1978.

Pipeline marker posts will be installed at regular intervals on the pipeline alignment.

6.3 Pipehead Dam

The pipehead dam will be a concrete wall with a crest about two metres above the creek invert level. The dam will be located about 250 metres downstream of the Homestead. The reservoir created by the dam will extend a maximum of about 120 metres upstream of the dam and cover an area of approximately 2000 square metres. Subject to site investigations and detailed design, the concrete wall will be about 15 metres long and will be of trapezoidal section as shown on Figure 3. The reservoir basin will be cleared of all vegetation. A floating offtake will be installed in the reservoir to provide water to the pumps.

Water quality considerations will require that general public access to the watercourse between the Homestead and the dam be prohibited. In addition, the caretaker's residence, visitors car park and public toilet facilities will have to be located some 300 metres north of the Ellensbrook Homestead as shown on Figure 3. A properly designed septic tank and effluent disposal system will be required to protect the water quality at the downstream damsite.

6.4 Pumping Station on Ellen Brook

Two (one duty, one standby) 30 kilowatt electrically driven pumps will be installed below ground in a concrete well liner (approximately 2 metres in diameter) located on the north bank of the reservoir. A chlorinator, comprising a 550 mm x 900 mm x 1 760 mm aluminium cubicle (to house a chlorine cylinder) on a concrete foundation will be installed adjacent to the pump well and will operate in conjunction with the pumps.

The visual impact of the station will be a prime consideration in its design. The area will be landscaped as much as possible to harmonise the station with its surroundings. The below ground installation and careful selection of the equipment will ensure that noise is not a problem.

6.5 Power Main

The development of Ellen Brook will require the construction of a three phase power main from Caves Road to the dam. As shown on Figure 1, the main will traverse private property (locations 1199, 886 and 673) and then follow the proposed access road to the proposed dam site.

The power main extension to the new dam will be an above ground line. The poles will be 10 metres high at 80 to 100 metre spacing, and the standard SEC clearing profile of 20 metres width will apply. However, this is not a rigid requirement, and the cleared width can be reduced where the natural vegetation is lower. Also some larger trees may be left if they are not a threat to the line.

Location 1199 is mainly cleared farmland and the power main will be aligned to avoid a small cluster of trees. In locations 886 and 673, the main will be constructed in an existing firebreak. Apart from scrub regrowth, about three trees in locations 886 and 673 will need to be cleared. About three trees in the National Park abutting location 673 will also need to be cleared in this section of the line.

Within the National Park beyond the north west corner of location 673, the line will be adjacent to the access road to the Homestead. The vegetation over this section of the route is almost entirely peppermint trees of about 5 metres. Due to the lower vegetation, clearing requirements can be relaxed. Including the access road, the total cleared width over this section of the route will approximate 15 metres.

The power main construction will be carried out by the SEC, but the SEC grid will be considered to terminate in the north west corner of location 673. The balance of the power main extension will be under the control of the Water Authority.

The visual impact of the power main extension will be kept to a minimum by construction in already cleared land, and along the alignment of the permanent access road to the Homestead.

6.6 Service Tank

A 1000 cubic metre roofed reinforced concrete circular tank, having a height of 4.0 metres will be constructed on high ground immediately east of the existing development within Gracetown townsite. The tank will be located in a depression on the side of the hill and will not be visible from the residential area of the town or the approach road to the town. Top water level of the tank will be approximately R.L. 100 m A.H.D. This will inhibit any further development of the townsite on higher ground than that already developed.

6.7 Reticulation Mains

Reticulation mains within Gracetown townsite will be buried pipes of 50 to 200 millimetre nominal diameter.

6.8 Bore 1/74

Bore 1/74 will be equipped with an electric drive submersible pump and motor. A chlorinator will be installed to operate in conjunction with the pump. The bore will be equipped to deliver up to 400 cubic metres per day; its operation will be limited to supplying peak demand during summer. The existing standpipe carting supply at the bore will be discontinued when the reticulated supply is commissioned.

The extent of the recharge area of the aquifer is not known. A water reserve will be proclaimed over the likely recharge area to control pollution. This will necessitate closure of the existing rubbish disposal site on high ground immediately south of Gracetown, but no other restrictions on land use are anticipated.

6.9 Management and Rehabilitation

Responsibility for the management of the National Park lies with the Department of Conservation and Land Management. Installation and management of the reservoir, pumping station and pipeline will be the responsibility of the Water Authority. The Water Authority recognises its particular responsibility for sound environmental management and undertakes to minimise impacts on the environment and to clean up and rehabilitate the site following construction. The Authority undertakes to seek and comply with the guidance of officers of CALM with respect to suitable practices for the installation and management of the project.

Specifically, the Water Authority undertakes to make and comply with the commitments related to protection, rehabilitation and maintenance of the environment, made in paragraph 3.4 - "Management and Rehabilitation" - of the Biotic Survey of Ellen Brook by Dames and Moore, which is appended to this Report (Appendix 7).

APPENDIX 1

Gracetown Water Supply

Basis of Design Demands

Town	Average Day of Peak Week Consumption per Service (cubic metres)			
	1982/83	1983/84	1984/85	1985/86
Augusta	2.21	1.91	2.01	2.62
Bremer Bay	2.35	1.74	1.75	2.35
Cervantes (1)	2.63	2.30	2.34	2.36
Cowaramup	2.34	3.13	3.29	2.99
Denmark	2.07	2.10	1.92	2.31
Dunsborough	2.70	3.01	2.57	3.09
Guilderton	2.30	2.11	2.25	2.45
Jurien (1)	3.23	3.00	2.59	3.20
Lancelin (1)	2.95	2.22	2.20	2.26
Ledge Point (1)	2.97	2.38	2.67	2.96
Margaret River	2.42	2.38	2.45	2.56
Quinns Rocks	2.59	2.30	2.76	2.56
Seabird (1)	2.24	2.44	2.65	3.11
Walpole	2.32	2.11	1.73	2.40

Notes:

(1) Crayfishing industry in the towns of Cervantes, Jurien, Lancelin, Ledge Point and Seabird causes slightly higher consumptions than otherwise.

APPENDIX 2

Ellen Brook

Summary of Flow Observations (in cubic metres per day)

Date	Station 610 1017 (Spring on Loc 673)	Station 610 1018 (Pipehead dam at Ellen Brook Homestead)	Station 610 1019 (Spring in National Park - formerly Loc 202)
1/12/74	860	NR	1 470
19/12/74	780	NR	1 470
5/2/75	1 040	NR	950
25/3/75	1 210	NR	390
18/4/75	1 120	NR	400
4/6/75	1 170	NR	970
15/11/78	260	3 370	690
12/12/78	260	1 900	690
9/1/79	260	1 040	690
21/2/79	260	1 640	520
19/3/79	260	1 120	600
1/5/79	260	1 640	600
7/8/80	850	138 000	860
13/11/80	430	4 060	520
10/2/81	350	1 210	600
16/3/81	350	950	600
13/4/81	350	1 640	600
11/5/81	350	1 210	600
4/8/81	350	2 760	690
15/9/81	350	20 000	950
23/11/81	350	3 280	520
18/1/82	260	950	600
23/3/82	170	1 040	430
29/5/82	260	1 640	600
18/8/82	350	14 500	600
13/10/82	260	9 160	780
9/12/82	170	1 300	780
31/12/82	90	1 040	170
3/2/83	170	690	430
28/2/83	90	1 300	350
7/4/83	170	860	520
26/5/83	170	950	350
22/6/83	170	15 200	350
19/7/83	NR	23 600	NR
14/9/83	NR	43 200	NR
22/12/83	NR	780	NR
29/12/83	170	950	350
4/1/84	170	1 810	350
10/1/84	260	780	430
18/1/84	280	570	690
26/1/84	260	1 050	290
1/2/84	220	670	600
8/2/84	130	520	350
13/2/84	120	670	580

22/2/84	120	600	400
27/2/84	160	670	400
7/3/84	150	560	410
14/3/84	130	650	430
21/3/84	160	800	460
27/3/84	160	660	410
5/4/84	170	690	420
13/4/84	170	750	410
26/4/84	150	790	370
23/10/84	260	3 970	520
20/11/84	260	NR	520
28/12/84	260	1 380	520
10/1/85	260	690	350
14/1/85	170	730	430
21/1/85	170	780	350
30/1/85	170	520	NR
7/2/85	170	520	520
13/2/85	90	430	430
20/2/85	130	520	NR
6/3/85	170	520	430
19/3/85	170	600	430
27/3/85	170	520	430
1/5/85	170	600	430
15/5/85	170	520	340
23/10/85	170	4 920	430
10/12/85	140	740	400
31/12/85	140	500	390
8/1/86	140	480	390
28/1/86	110	460	360
5/2/86	110	470	370
12/2/86	110	470	390
24/2/86	90	430	350
5/3/86	90	430	350
10/3/86	90	520	350
21/3/86	90	430	350
9/4/86	90	520	350
21/4/86	90	520	260
29/4/86	90	430	260
7/5/86	90	520	350
12/5/86	90	430	260
27/5/86	170	35 800	520
4/6/86	170	10 400	350
7/7/86	170	40 800	350
5/8/86	260	42 900	260
2/9/86	170	34 600	350
6/10/86	170	21 600	350
18/11/86	170	2 160	260
2/12/86	170	1 120	260
22/12/86	90	520	260
29/12/86	90	520	260
6/1/87	90	430	260
12/1/87	90	520	350
19/1//87	90	520	260
27/1/87	170	430	260
2/2/87	90	350	170

Notes 1. Flow rates in cubic metres per day

2. NR indicates no record i.e.estimate of flow not made

APPENDIX 3

Gracetown Water Supply

Cost of Supply from Margaret River
(Estimated cost at December 1986 price levels)

Access roads	20 000
Upgrade SEC power supply to Margaret River Dam	10 000
Upgrade existing pumping station at Margaret River Dam	80 000
Transfer pumping station	80 000
Supply main: 16 km 150 mm pipeline	480 000
Road, river and creek crossings	60 000
1 000 m^3 R.C.C. service tank	110 000
Reticulation mains	130 000
	970 000
+ 10% contingencies	100 000
	1 070 000
Overhead charges	140 000
	$1 210 000

APPENDIX 4

Gracetown Water Supply

Cost of Supply from Ellen Brook
(Estimated cost at December 1986 price levels)

(Pumping from existing masonry pipehead dam)

	$
Access road	20 000
Power main:	
Overhead line	35 000
Underground line in Homestead area	10 000
Rehabilitate existing dam	40 000
Transfer pumping station	80 000
Supply main: 6.3 km 150 mm pipeline	190 000
1 000 m^3 R.C.C. service tank	110 000
Reticulation mains	130 000
Equip Bore 1/74	15 000
	630 000
+10% contingencies	60 000
	690 000
Overhead charges	80 000
	$770 000

<u>Note</u>

Cost estimates include allowance for restoration after construction.

APPENDIX 5

Gracetown Water Supply

Cost of Supply from Ellen Brook
(Estimated cost at December 1986 price levels)

(Pumping from new pipehead dam downstream of homestead)

Access road	25 000
Power main:	
Overhead line	40 000
Pipehead dam	100 000
Transfer pumping station	80 000
Supply main 6.4 km 150 mm pipeline	195 000
1000 m^3 R.C.C. service tank	110 000
Reticulation mains	130 000
Equip Bore 1/74	15 000
	695 000
+ 10% contingencies	70 000
	765 000
Overhead charges	95 000
	$860 000

Note

Cost estimates include allowance for restoration after construction.

APPENDIX 6

REPORTS ON FRESHWATER SNAIL AND ABORIGINAL SITES

To Mr J. Stone, with the authors' compliments.

Journal of the Royal Society of Western Australia, Vol. 65, Part 4, 1982, pp. 119-129.

Austroassiminea letha, gen. nov., sp. nov., a rare and endangered prosobranch snail from south-western Australia (Mollusca: Prosobranchia: Assimineidae)

by Alan Solem[1], Elizabeth-Louise Girardi[1], Shirley Slack-Smith[2] and George W. Kendrick[2]

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Abstract

A few isolated freshwater seepage areas between Turner Brook north of Augusta and Ellen Brook north of Margaret River in the south-west corner of Western Australia support populations of *Austroassiminea letha*, which is described as a new genus and species of the prosobranch family Assimineidae. Anatomical structures differentiate it from previously described assimineids and suggest strongly that it is a phylogenetic relict. Pleistocene fossils are known from several places on the coast, as far east as Point d'Entrecasteaux. **Each of the three known living populations is small and in danger of destruction from agricultural or other human activity.** Efforts are needed to preserve this important relict component of the Western Australian fauna.

Introduction

Subfossil specimens of a small "terrestrial" prosobranch were taken first at Cosy Corner by Barry R. Wilson in 1963. Subsequent collections by Anne Paterson (Brearley) from Turner Brook in 1971 and by Shirley Slack-Smith from Ellen Brook in 1975, have been supplemented by further collections in 1980 by Shirley Slack-Smith, George W. Kendrick and Mike Ellis. Materials adequate for description and tentative classification are now available.

Assimineids are common in South-east Asia and Indonesia through New Guinea and onto the Pacific Islands, but this is the first anatomically studied species for the family in Australia. A salt-marsh species from Tasmania and New South Wales, "*Assiminea*" *tasmanica* Tenison Woods, 1876, is placed correctly in the family Assimineidae; generic assignment must wait publication on its anatomy by Dr W. F. Ponder. The features of the new taxon, *Austroassiminea letha*, combine characteristics of the two generally recognized subfamilies of the Assimineidae, and no closely related extralimital genera could be identified. There is a long history of exotic organisms having been introduced to Australia. Therefore, considerable efforts were made to compare this species with extralimital taxa. The occurrence of *Austroassiminea letha* in presumed Pleistocene fossil soils from the south-western coast of Western Australia (Fig. 13) is additional strong evidence for it being an endemic faunal element.

The present study is a cooperative effort with different primary responsibilities: Alan Solem provided the systematic descriptions, comparisons, SEM analyses and photographs, and did much of the dissection work and supervision of the illustrations; Elizabeth-Louise Girardi worked extensively with illustrator Elizabeth Liebman and Alan Solem on the anatomical structures and interpretations; Shirley Slack-Smith is primarily responsible for the data on ecological occurrence and field collections; and George W. Kendrick did much of the fossil collecting and provided data on the geology and interpretation of the deposits.

All specimens used in this study are presently located in the collections of the Western Australian Museum (WAM) and the Field Museum of Natural History (FMNH).

Ecological occurrence

All collections of active individuals have been in actual seepage films or splash zones by small freshwater streams near the coast. Fissured rocks or talus through which the water can trickle are present. Aestivating and recently dead individuals have been taken on logs, leaves and rocks immediately adjacent to such areas. These findings probably represent wide-foraging individuals stranded by increasing dryness. The main reservoir of the populations would be inside the boulder fissures or talus, where either a minor flow of water or very high humidity would prevail even in mid-summer drought. The source of this water is runoff and percolation from areas lying further up the drainage basin of each stream. In all cases the water drains from areas of limestone and, in some, directly from the contact zone between the limestone and the underlying granitic rock. The Turner Brook site involves present or proposed agricultural areas that are subject to chemical spraying and/or fertilizer applications. The effects of such chemicals on amphibious snails are not known. They are highly unlikely to be beneficial, and probably are quite harmful. The limited extent and thus small size of this population does not provide a margin for experimentation as to such effects. The immediate steps necessary to minimize the possibility of extinction occurring would be to ban chemical applications on the few hectares immediately involved in seepage drainage through the known live snail area.

Although the snails are clearly associated with freshwater seepage areas, the lack of any gill remnant, and the fact that they will at least temporarily seal to a log, leaf or rock, indicates that they are marginally terrestrial. All known live occurrences of *Austroassiminea letha* are well above tidal or ocean spray influence. These snails are best considered to be amphibious in the same sense as the North American *Pomatiopsis* (see Dundee 1957). The limited and spotty distribution of *Austroassiminea letha* is typical of such taxa, and also reflects the limited number of suitable habitat sites in south-western Western Australia.

Systematic review

The most recent reviews of the Assimineidae (Thiele 1927, 1929) provide a framework for generic reference. Abbott (1958) produced an excellent review of the Philippine members of the genus *Assiminea*, which gives entry to the widely scattered literature on this group. Known habitats range from mudflats through amphibious situations to dry upland forest areas. Habitat occurrence does not correlate with the admittedly form genera currently used. The most obvious anatomical features differentiating assimineids from members of the hydrobioid groups are their pectinate marginal tooth, relatively simple lateral teeth and general lack of basal denticles on the rachidian tooth of the radula. Unfortunately, few assimineids have been dissected in detail, so that only limited anatomical comparisons can be made with other genera.

Family Assimineidae

Genus *Austroassiminea* gen. nov.

Diagnosis: The simple snout without an accessory cape, absence of accessory basal plates for the lateral teeth, lack of basal denticles on the rachidian radular tooth, pectinate single marginal tooth, paucispiral operculum without posterior protrusions, retention of long tentacles, huge penis with bifurcate tip and internal vas deferens but no lateral protrusions, and simple female system combine aspects of the family-level units Assimineinae (= Syncerinae) and Omphalotropidinae as delineated by Abbott (1949, p. 262) and Tutuilanidae of Hubendick (1952). Most genera traditionally referred to these complexes are known from shell and operculum only. Radular cusps, shape of the verge, and external features of the head region have been recorded for a few taxa, but details of the internal anatomy equivalent to those presented here are not recorded in the literature. The form genera *Assiminea* Fleming 1828, *Paludinella* Pfeiffer 1841 and *Omphalotropis* Pfeiffer 1851, with which *Austroassiminea letha* might be associated, differ in most of the above characters (see Abbott 1949, 1958).

Description: Foot not divided, a prominent lateral groove extending from mantle cavity to head. Tentacles long, with raised eyespots lateral to base. Snout of moderate length, no cape or shield present, terminating in two lips reaching slightly beyond mouth, which is a vertical slit. Operculum paucispiral, corneous, nucleus acentric, no trace of calcareous deposits. Radula taenioglossate. Rachidian tooth without basal denticles; normally 7 denticles on upper edge, central largest. Laterals multicuspid; inner with greater variation in denticle size, weak protrusions on inner side of base which is shovel-shaped. No accessory basal plates. Outer lateral with flatter, tapering base, sharply recurved denticles. Marginal tooth fan-shaped, pectinate, with minute recurved denticles. Male with enormous verge having a bifurcated tip and internal vas deferens. An unusual release valve from the vas deferens enters the hindgut. Suprapallial structures of male system relatively simple. Female with small spermatheca, seminal receptacle a kinked area in upper oviduct; pallial oviduct large, U-shaped, with vaginal orifice near anus.

Type species: Austroassiminea letha n. sp.

Remarks: Intertidal, supratidal, freshwater and terrestrial species of similar conchological mien from most continents have been referred to the Assimineidae and to the form genera *Assiminea* Fleming 1828, and *Paludinella* Pfeiffer 1841. Recorded data on these species consist mostly of shell and opercular features that are notoriously subject to convergent simplicity. Occasional outlines of radular denticles and the upper parts of the basal plates, or of the extended head and foot, plus an outline of the cephalic verge complete most available data. Abbott (1958) monographed the Philippine Islands *Assiminea*, greatly extending our knowledge of structure, although he was (p. 224) "...unable to satisfactorily work out the female genital system." In an earlier paper, Abbott (1949) described several new assimineids from the Mariana Islands and provided expanded definitions of the subfamilies Assimineinae (under the name Syncerinae) and Omphalotropidinae, even hinting that they might be separate families. Turner and Clench (1972) recorded some data on *Omphalotropis nebulosa* Pease 1872 and *Pseudocyclotus levis* (Pfeiffer 1855) from the Solomon Islands.

The level of recorded knowledge for extralimital taxa is thus meagre, which makes meaningful comparisons difficult. Since *Austroassiminea* agrees with the Assimineinae in snout and operculum, but with the Omphalotropidinae in length of eye stalk and pectinate marginal tooth on the radula, doubt is cast on the reality of current suprageneric categories in the Assimineidae. We choose to ignore the subfamily and tribal names of Thiele (1927, 1929), since they appear to be artificial pigeonholes based on inadequate evidence, and classify *Austroassiminea* only to family level. It is quite possible that monographic revisions will split the family or attach sections to other family units. Consideration of such changes is well beyond the scope of this study.

Data on the anatomy of some Pacific island taxa are given by Abbott (1949, 1958). Quick surveys of Melanesian and Polynesian assimineids in the alcohol collections at Field Museum of Natural History showed a pattern of these species having both a proboscid cape and a deep posterior slit on the foot, characters that Abbott (1949, 262) used as subfamily features for the Omphalotropidinae. Both of these features are absent from *Austroassiminea letha* (see Fig. 12). While some of the Pacific island taxa have similar-appearing shells, the above differences in external anatomy alone are sufficient to exclude congeneric classification of *Austroassiminea* with any of the genera based on Pacific island taxa that Abbott (1949) included in the Omphalotropidinae (*Omphalotropis* Pfeiffer 1841, *Paludinella* Pfeiffer 1841, *Electrina* Gray 1850, *Quadrasiella*

Moellendorff 1894, *Garrettia* Paetel 1873, *Allepithema* Tomlin 1931, *Thaanumella* Clench 1946, or *Wrayanna* Clench 1948). The pectinate marginal teeth of the radula in *Austroassiminea* are a major difference from the situation in *Assiminea* Fleming 1828, *Acmella* Blandford 1869, *Turbacmella* Thiele 1927, and *Conacmella* Thiele 1927, taxa that although lacking the proboscid cape and posterior foot slit, have much shorter eye-stalks and non-pectinate marginal teeth on the radula.

It is quite possible that these characters considered by Abbott (1949, 1958) as indicative of suprageneric categories will be shown to be less important when the family is revised, but such a revision cannot be undertaken at this time.

The combination of features listed for *Austroassiminea* in the diagnosis is very different from the combinations recorded for any of the above genera. This, combined with the extreme geographic isolation of *Austroassiminea* from potential relatives (see diagnosis of the species for comparisons), makes description of a new genus necessary.

The name *Austroassiminea* refers to both its geographic position and taxonomic relationship to the assimineid complex.

Austroassiminea letha sp. nov.
(Figs. 1-12)

Type locality: Cosy Corner, Hamelin Bay, near Augusta, Western Australia, ca. 34° 15′ 05″ S, 115° 01′ E, under tussocks of grass on granite cliffs near coast wet by seepage from limestone-granitic rock contact above.

Holotype: WAM 71.80, adult shell, probably a female. Collected by Anne Paterson (Brearley), 8 July 1971.

Paratopotypes: WAM 778.66, WAM 472.80, WAM 477.80, WAM 478.80, WAM 479.80, WAM 699.80, FMNH 200985, FMNH 200986.

Paratypes: Deepdene Cliffs, near Augusta, from seepage area, moss and *Agonis* leaf litter, foot of cliffs, ca. 34° 15′ 09″ S. 115° 03′ E, WAM 476.80, FMNH 200987; Deepdene Cave area near Lakes Rat Hole, Cave 3, 0-0.1 m, WAM 1175.69, subfossil; Turner Brook near Deepdene Cliffs, ca. 34° 15′ 09″ S, 115° 03′ E, WAM 475.70, WAM 694.80, FMNH 200989; (entrance to Meekadorabbie Cave, Ellen Brook, 33° 54′ 36″ S, 114° 59′ 40″ E, Leeuwin-Naturaliste National Park, WAM 693.80, WAM 695.80, WAM 696.80; (upstream from Ellensbrook homestead, under logs, 2-3 m above water level, WAM 700.80, WAM 701.80; (below dam on Ellen Brook, WAM 697.80, WAM 698.80, FMNH 200988; (Ellen Brook, ca. 33° 54′ 10″ S, 114° 59′ 30″ E, WAM 473.80; (Sta. WA.284, banks of Ellen Brook, east of homestead, FMNH 200598. Fossil at: on the coast west of Strongs Cave, south end of North Point, 34° 09′ 41″ S, 115° 01′ 23″ E, WAM 68.385, WAM 81.19, FMNH 198759; Donnelly River mouth, ca. 0.5 m (0.8 km) south-east of the river mouth, ca. 34° 29′ 24″ S, 115° 40′ 38″ E, WAM 70.2691, WAM 70.2692; ca. 0.5 m (0.8 km) north of Windy Harbour townsite, quarry on south side of track to Salmon Beach, 34° 49′ 14″ S, 116° 00′ 52″ E, WAM 70.895, WAM 70.897, WAM 70.898.

Diagnosis: The combination of smooth apex, moderate radial ribbing on the upper spire, frequent presence of peripheral spiral cords and weak spiral cords on the shell base, relatively open umbilicus of the shell; paucispiral corneous operculum without posterior projections; absence of basal denticles on the central tooth of the radula, comblike marginal tooth with clear slits; extremely large bifurcated penis without lateral protrusions, small spermatheca, and long tentacles effectively differentiate *Austroassiminea letha* from geographically nearby taxa. *Hydrococcus graniformis* Thiele (1928, p. 374-5, 380, pl. 8, figs 10, a), described from the Swan River, Western Australia, has a multispiral operculum with central nucleus and posterior projection; a hydrobiid, rather than an assimineid radula; and a globose, rather than elongated, shell. "*Assiminea*" *tasmanica* Tenison Woods 1876, reported from Tasmania north to Queensland (Hedley 1906, p. 527-8, Figs 27-30; Iredale and McMichael 1962, p. 43), and also southwestern Australia (*teste* Ponder), has a generally banded shell without radial ribs, a nearly closed umbilicus, more acentric paucispiral operculum with posterior projection, and quite different lateral teeth on the radula. The New Zealand species, "*Assiminea*" *vulgaris* (Webster 1905) and *Suterilla neozelanica* (Murdoch 1899), as summarized by Powell (1933), obviously differ in radula, nearly closed umbilicus, lack of shell sculpture and in basic habitat. Both are marine or strand line in association.

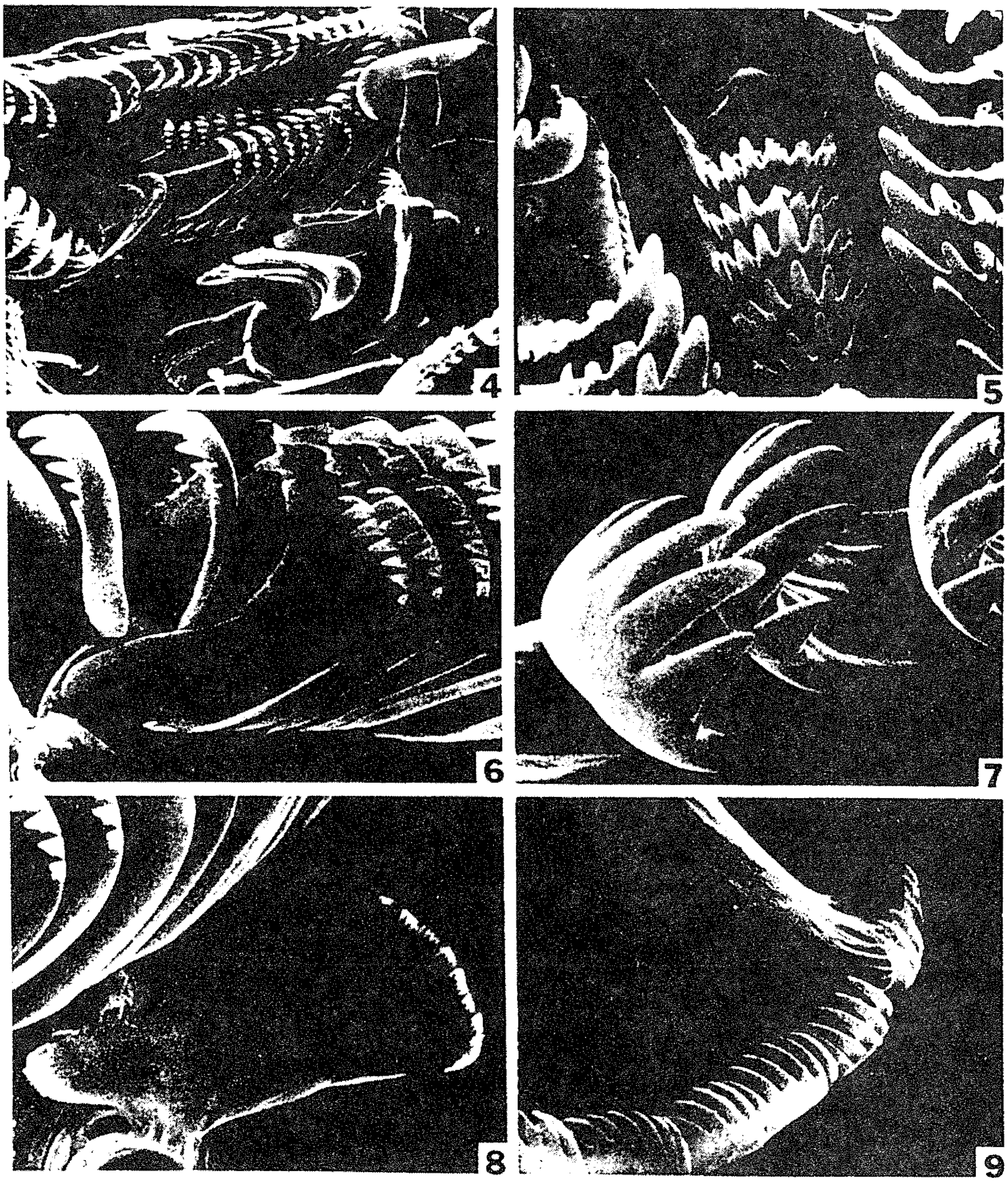
The long tentacles, lack of any lateral protrusions on the male verge, absence of basal denticles on the radular central tooth, open umbilicus, radial ribbing on the spire and freshwater habitat, effectively eliminate the possibility that *Austroassiminea letha* might be based upon introduced examples of the British *Assiminea grayana* Fleming 1828.

Description: Shell variable in shape, from squat ovate-conic to elongate-conic, spire angle generally uniform, H/D ratio 1.23-1.55 (mean 1.38). Males often smaller and squatter than females. Shell height 3.45-5.39 mm (mean 4.50 mm), diameter 2.60-3.78 mm (mean 3.26 mm). Apex (Fig. 2) smooth, upper spire with fine radial ribs that become irregular to absent on lower spire and body whorl (Fig. 1). Whorls 4 7/8– to 6 1/8– (mean 5 1/2–). Sutures well impressed, whorls evenly rounded, a weak (Fig. 1) to prominent spiral keel visible on periphery of penultimate and body whorls, sometimes weak spiral cords on shell base. Umbilicus narrowly open, without carina or keel. Lip of adults expanded, noticeably thickened on columellar and parietal walls (Fig. 1). Based on 227 adult specimens.

Operculum (Fig. 3) corneous, paucispiral, nucleus slightly acentric, without calcareous granules or posterior projections. Head of animal (Fig. 12) without unusual features. Eyespots (EY) lateral to base of tentacles (TE). Snout (SN) relatively short, ending in two expanded superior lobes (L) that extend in front of mouth (M). Edge of snout marked by a groove (BG) from mantle cavity. Foot (F) undivided, truncated in front, tapering posteriorly. Operculum (OP) mounted on a raised flap.

Radula taenioglossate, 7 teeth per row. Rachidian tooth Figs 4, 5) normally with 7 cusps, median cusp slightly enlarged, sides of tooth with weak bumps, but no developed denticles. Centre base of rachidian

Figures 1-3.—*Austroassiminea letha* sp. nov. 1—side view of Holotype WAM 71.80, x20.9. 2—spire of holotype, x54.3. 3—operculum of paratype, WAM 472.80, x42.2.



Figures 4-9.—*Austroassiminea letha* sp. nov. Radula of paratype WAM 472.80. 4—partially fragmented radula, x400. 5—central teeth, x1,335. 6—lateral teeth, x1,110. 7—side view of outer laterals, x4,000. 8—single marginal tooth, x1,270. 9—edge of comb marginal, x3,960.

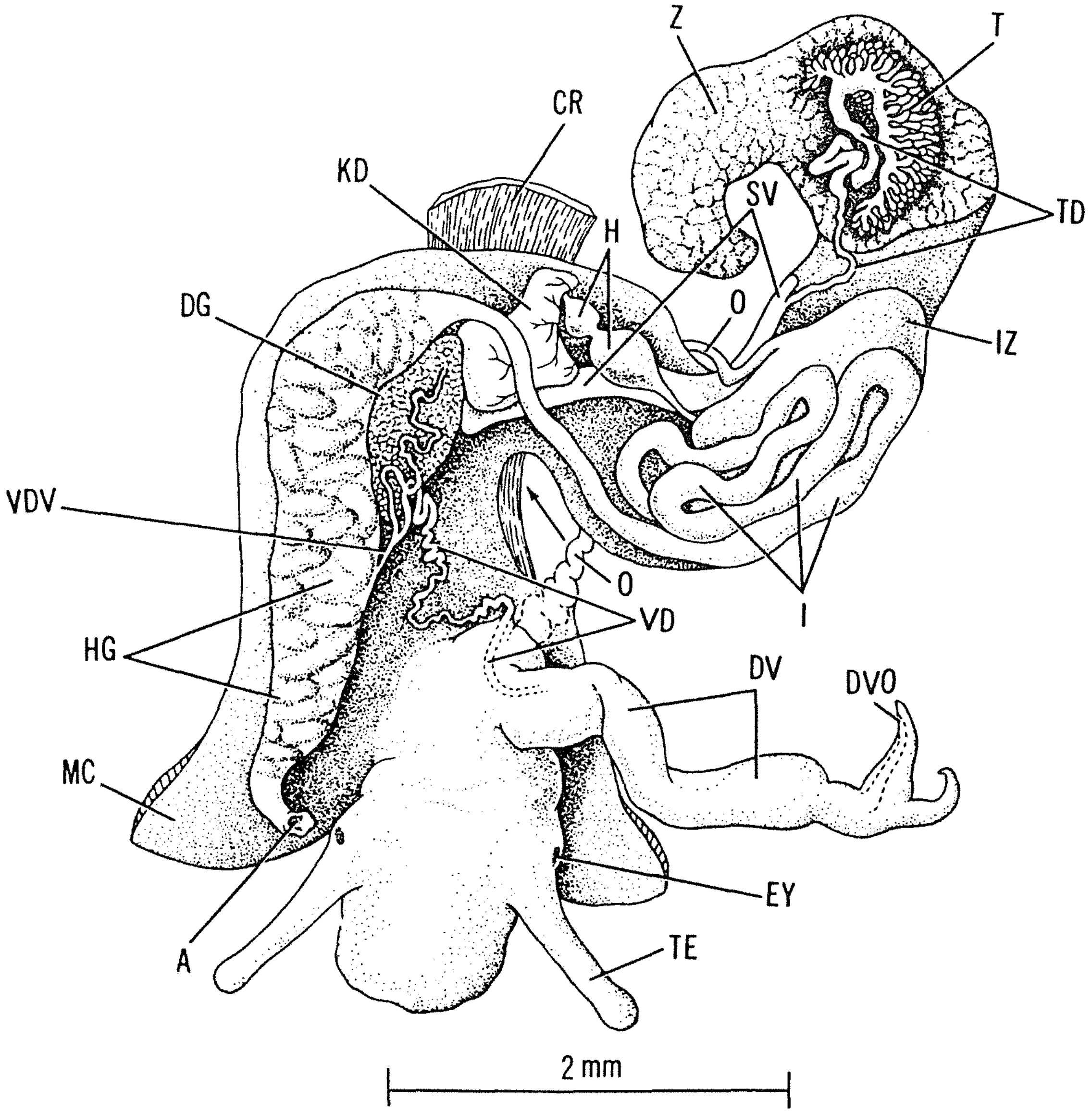


Figure 10.—*Austroassiminea letha* sp. nov. Paratype WAM 472.80. Gross anatomy of male. Arrow indicates apex of mantle cavity. Drawing by Elizabeth Liebman. See Table 1 for explanation of labels.

slightly protruded, but without denticles. Inner laterals (Figs 4-6) with concave, shovel-shaped base; inner side of tooth with a row of low protrusions (Fig. 5, left), denticles asymmetrical with largest 2nd from inner side, gradually reduced in prominence outward, normally totalling six. Outer laterals (Figs 6-7) with base less concave, clearly tapered; sides of tooth without bumps or accessory denticles; upper margin sharply recurved (Fig. 7) and bearing normally seven denticles that are less differentiated in size than those of the inner laterals. No accessory basal plates on either lateral tooth. Marginal (Figs 8-9) broad, relatively flat, base tapering as in outer lateral; edge split 7-8 times and thus pectinate, each pectination edge with sharply recurved, minute denticles, 4-7 in number.

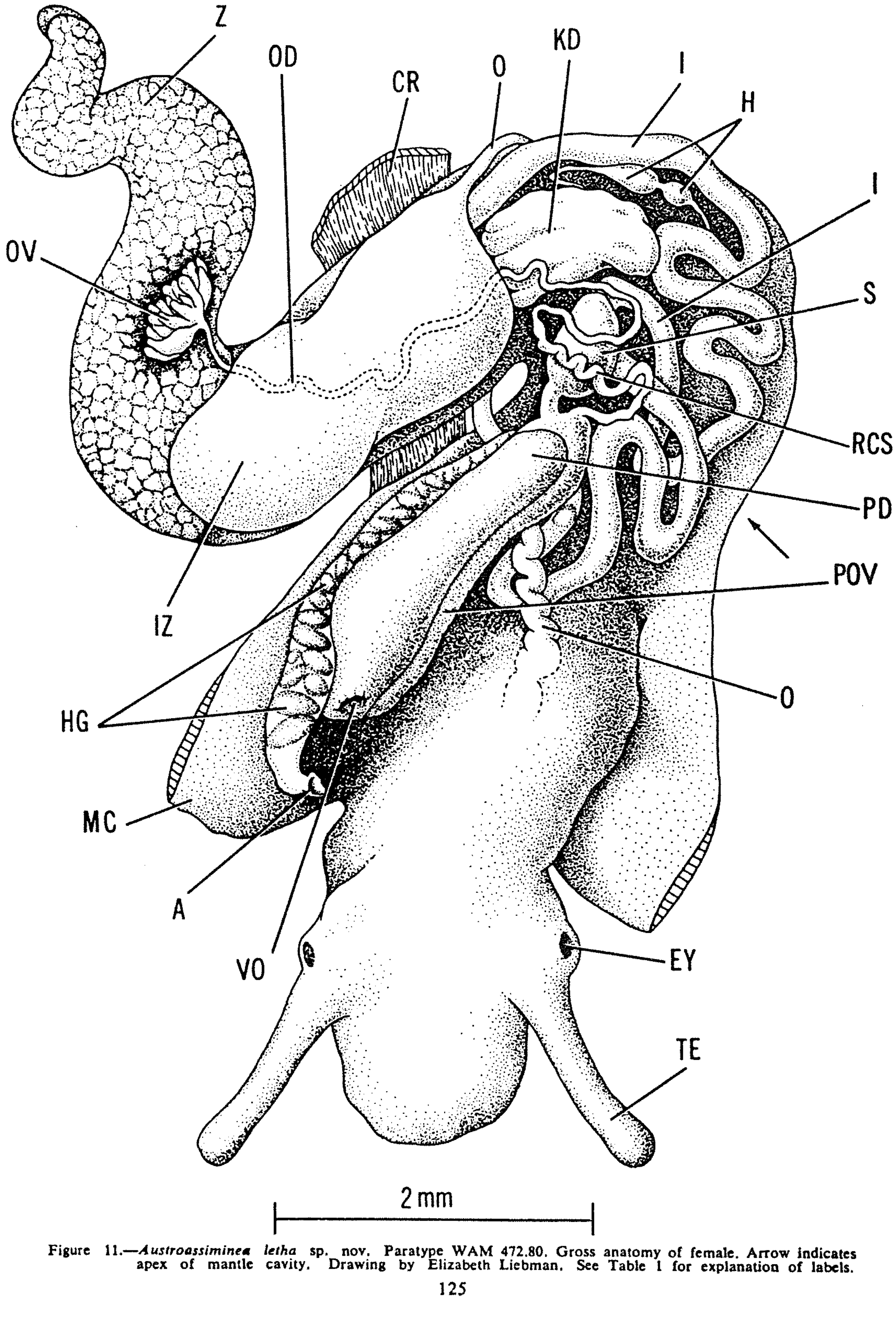


Figure 11.—*Austroassiminea letha* sp. nov. Paratype WAM 472.80. Gross anatomy of female. Arrow indicates apex of mantle cavity. Drawing by Elizabeth Liebman. See Table 1 for explanation of labels.

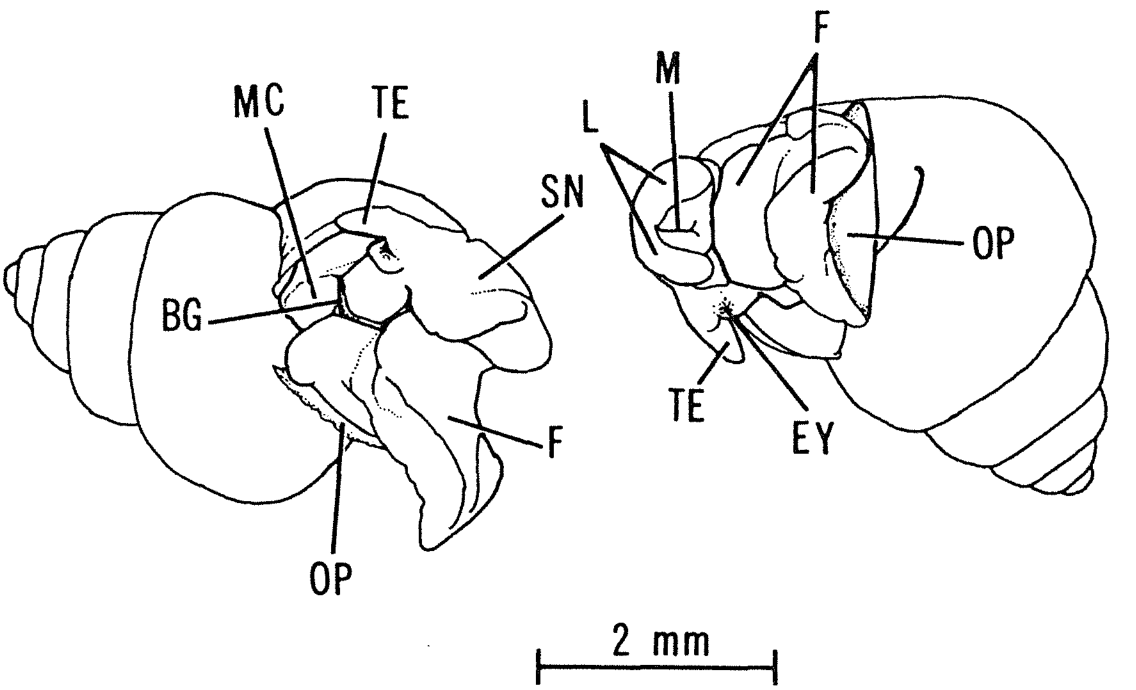


Figure 12.—*Austroassiminea letha* sp. nov. Paratype WAM 694.80. Head and foot of preserved animal. Drawing by Linnea Lahlum. See Table 1 for explanation of labels.

Table 1

Explanation of anatomical labels

A	anus	OD	oviduct
BG	back groove	OP	operculum
CR	columellar retractor muscle	OV	ovary
DG	prostate gland	PD	dorsal lobe of oviduct
DV	verge	POV	ventral lobe of oviduct
DVO	external pore of verge	RCS	seminal receptacle
EY	eye spot	S	spermatheca
F	foot	SN	snout
H	heart	SV	seminal vesicle
HG	hindgut	T	testis
I	intestine	TD	testis duct
IZ	stomach	TE	tentacle
KD	kidney	VD	vas deferens
L	snout lobes	VDV	escape valve of vas deferens
M	mouth	VO	vaginal orifice
MC	mantle collar	Z	digestive gland
O	oesophagus		

Oesophagus (O) entering stomach medially in male (Fig. 10), anteriorly in female (Fig. 11). Looping of intestine (I) also differing, aligned with stomach (IZ) in male (Fig. 10), linearly anterior to enlarged stomach in female (Fig. 11). Hindgut (HG) normally filled with faecal pellets, opening near anterior margin of mantle collar (MC) through a raised anal pore (A) (Figs 10, 11). Digestive gland (Z) distinctly larger in female (Fig. 11) than male (Fig. 10). Details of heart (H) and kidney (KD) not worked out.

Nervous system not studied because of limited material.

Male genitalia (Fig. 10) simple. Testis (T) with branched tubules along an apically running collecting duct, buried in base of digestive gland. Testis duct (TD) kinked apically, wider at first, narrowing after leaving digestive gland, entering seminal vesicle (SV) subapically. Seminal vesicle (SV) a narrow strip of tissue attached loosely to body wall, running just below kidney to enter prostate (DG), which is a mass of acinar tissue lying at apex of pallial cavity next to hindgut (HG). Collecting tubule of prostate zig-zags anteriorly, emerging as vas deferens (VD) at anterior margin of prostate. Branching of vas deferens occurs almost immediately. A slender "escape valve" (VDV) continues anteriorly to enter hindgut and the posteriorly directed main branch of the tube leads to the verge (DV) after complex coiling. Verge massive, located on back of neck, tip bifurcated with opening of vas deferens (DVO) through larger arm of bifurcation. Shaft of verge without bumps or other structures, exact internal passage of vas deferens through verge not determined.

Female genitalia (Fig. 11) simple. Ovary (OV) a single clump of large acini near base of digestive gland (Z). Oviduct relatively narrow and uncoiled down to level of seminal receptacle (RCS), which appears as an area of tight kinking in the oviducal tube. After one major curve, this enters apically into the pallial oviduct (PVO). Latter U-shaped, with a dorsal (PD) and ventral (POV) lobe. Vaginal orifice (VO) slightly posterior to anus (A). Spermatheca small, globose, on short duct.

The holotype, probably an adult female, is 5.00 mm in height, 3.59 mm in diameter, H/D ratio 1.39, with 5 1/2 whorls. Although collected alive, it had dried out subsequently.

Remarks: The name *letha* comes from the Greek *lethos*, referring to forgetting or escaping notice, an appropriate name for this rare and well-hidden species.

The dissected material from Cosy Corner (WAM 472.80) provided the impression that male shells were smaller and slightly squatter than females. This could not be documented by measurements as parts of the shells had been chipped away prior to study by Solem and thus could not be measured. The other live-collected and well-preserved set from Turner Brook (WAM 694.80) had most specimens retracted sufficiently that they could not be sexed without damaging or destroying the shell. Dried out materials from Cosy Corner and Deepdene could not be sexed. Thus, comparative measurements (Table 2) are based on lumped samples. Data is recorded only as mean and range for each area. The actual sex ratios and size differences are unknown.

Adult specimens were defined as those with both thickening of the basal lip and a beginning of irregular, gerontic growth visible behind the palatal lip. This gerontic growth may continue for more than an eighth of a whorl and in the very old and large specimens from Cosy Corner, the inside of the aperture has a substantial callus built up on all walls. All measurements were made with an ocular micrometer at x16, height and diameter accurate to within 2%, and whorls to within 1/8th accuracy. Differences among the samples are summarized in Table 2.

Specimens from Turner Brook below Deepdene Cliffs (WAM 694.80), collected 3 July 1980, are smallest in size and slightly lower in whorl count. They show the shortest area of gerontic growth and may well represent younger examples, rather than indicating a smaller "adult" size for that population. Specimens collected live, but aestivating, and freshly dead in September, October and November from Deepdene Cliffs (WAM 476.80), Ellen Brook (WAM 697.80, WAM 698.80), and Meekadorabbie Cave, Ellen Brook (WAM 696.80) are distinctly larger in size and with noticeably greater thickening to the shell lip. The differences among these populations are not significant. The Cosy Corner samples, nearly all collected dead and many in bleached condition, are large (Table 2) and many show much greater thickening of the shell lip and noticeably longer gerontic growth. We cannot say if this population actually is larger, or if biased samples of mainly gerontic individuals have been taken.

Living specimens of *Austroassiminea letha* are known from three localities just north of Augusta. They are Turner Brook near Deepdene Cliffs, Cosy Corner, and Ellen Brook just north of the Margaret River. At Turner Brook they have been found in seepage areas at the base of limestone cliffs, or in litter near the creek banks in an area located only a few hundred metres from the creek mouth. Near the base of Deepdene Cliffs they were on rocks splashed by a miniature waterfall and on the ground above, a seepage area draining from the high limestone on the southern side of Turner Brook. At Cosy Corner they have been taken in grass tussocks on granite cliffs wet by seepage from the limestone-granitic rock contact above and located less than 200 metres from the beach. Dead shells are common in what we presume to be Holocene deposits, but live material has been found in an area of only a few square metres. At Ellen Brook, live material was taken in algae growing on the sides of concrete and wooden troughs carrying flowing water from Ellen Brook to the Ellensbrook homestead. The snails were in algal growth above the water line in the troughs. This site was several hundred metres from the stream mouth and significantly more elevated than the small sandy delta of Ellen Brook. Additional field work along Ellen Brook in September and October 1980 found specimens alive or freshly dead adjacent to the dam at Ellensbrook homestead and on moss and algal covered limestone forming the sides of the waterfall at the entrance to Meekadorabbie Cave and the banks of the brook above it. Specimens on soil, leaves and twigs were aestivating or recently dead. All of these localities, although near the ocean, are well above storm water marks and are not subject to sea water inundation.

Table 2

Size and shape variation in *Austroassiminea letha*

Locality	No. of adults measured	Mean (and range)			
		Shell Height (mm)	Shell Diameter (mm)	H/D ratio	Whorls
Turner Brook, below Deepdene Cliffs	20	3·94 (3·48–4·67)	2·91 (2·60–3·39)	1·35 (1·23–1·47)	5¼– (4⅞–5½+)
Deepdene Cliffs	25	4·39 (4·01–5·33)	3·20 (2·96–3·68)	1·39 (1·31–1·55)	5⅜– (5–5⅞)
Cosy Corner	120	4·76 (4·08–5·39)	3·42 (2·99–3·78)	1·39 (1·29–1·49)	5⅜– (5⅛–6⅛–)
Ellen Brook	31	4·24 (3·45–5·16)	3·12 (2·70–3·52)	1·36 (1·27–1·47)	5⅜– (5+–5⅞)
Meekadorabbie Cave, Ellen Brook	31	4·14 (3·49–4·97)	3·08 (2·63–3·62)	1·34 (1·23–1·48)	5⅜– (5–5⅞)

Several visits to the Deepdene and Cosy Corner sites since 1963 demonstrate that the populations persist within very small areas. Extensive searches in similar-appearing habitats along the Deepdene Cliffs and near Cosy Corner have failed to reveal additional populations. At both Cosy Corner and Deepdene, ground areas remain moist even during the middle of summer, and live snails have the option of retreating into deeply fissured rocks back to the retracted water trickle that eventually forms the basal ground soak. All localities would be subject to heavy morning dews, another dependable source of water in this area of coast. Living specimens have been taken only at times when flowing water was in the seepage zones, but this may only be indicative of an extended foraging zone bringing them out into areas accessible to prying fingers of scientists. While water associated, they are in damp terrestrial habitats that are close to the water margin.

Because of the very limited populations observed, collections have been restricted mainly to samples of dead shells. Some early collections were dried and the anatomical data recorded here are based upon material from Cosy Corner (WAM 472.80) collected 22 June 1980 specifically for this review.

Fossil records

Evidence that *A. letha* is an endemic relict comes from three fossil occurrences on the lower south-west coast of Western Australia. On the southern side of North Point (34° 09′ 41″ S, 115° 01′ 23″ E), a 25 m sea cliff of Tamala Limestone (Playford *et al.* 1976) rises on a basement of Precambrian gneiss. It shows a sequence of four prominent, brown fossil soils, separated by units of paler aeolian calcarenite. A thin gneiss-calcrete conglomerate underlies the lowest fossil soil and is itself underlain at about HWM by a poorly exposed, marine shelly limestone; the limestone-gneiss contact is partly obscured by an apron of fallen boulders.

The lowest fossil soil, up to 2.3 m thick, lies in the splash zone and is being eroded vigorously. It is a brown, friable clayey to silty calcarenite, without obvious bedding structure and with thin bands of calcareous cementation; rhizoconcretions occur near the top and in the lower part occur pebbles and cobbles of near-black calcrete. This fossil soil contains a sparse land snail assemblage of four species—*Austroassiminea letha, Bothriembryon* sp. and a species each of the Charopidae and Punctidae. Of the first mentioned, 15 specimens (WAM 68.385, WAM 81.19, FMNH 198759) have been collected, of which the largest has a height of 4.84 mm. This species has been found only in the lowest fossil soil and mainly within 0.6 m of its base. Numerous shells of other land snails, notably *Bothriembryon* sp., occur in the overlying fossil soils.

The section at North Point, including the basal marine unit, resembles others from the Cape Leeuwin-Cape Naturaliste coast described by Fairbridge and Teichert (1953) and Fairbridge (1953). The marine units were noted by Lowry (1967) and assigned a late Pleistocene age. All snails from the North Point fossil soils represent living species, which is consistent with a relatively "late" Pleistocene age. The presence of *Austroassiminea letha* only in the lowest fossil soil indicates that the species last inhabited the site during the accumulation of that unit. By analogy with modern occurrences of the present species, it seems likely that the site incorporated a freshwater discharge at the gneiss-limestone contact, which became buried beneath mobile aeolian sands early in the regression following the "Last Interglacial" of the Late Pleistocene. Other land snails were able to maintain populations on the sandy terrains that resulted from this episode of dune building, but not *Austroassiminea letha*, which became extinct locally. With the return of sea level to its modern position about 6000 years ago (Mörner 1976), wave erosion established the fresh cliff section visible today.

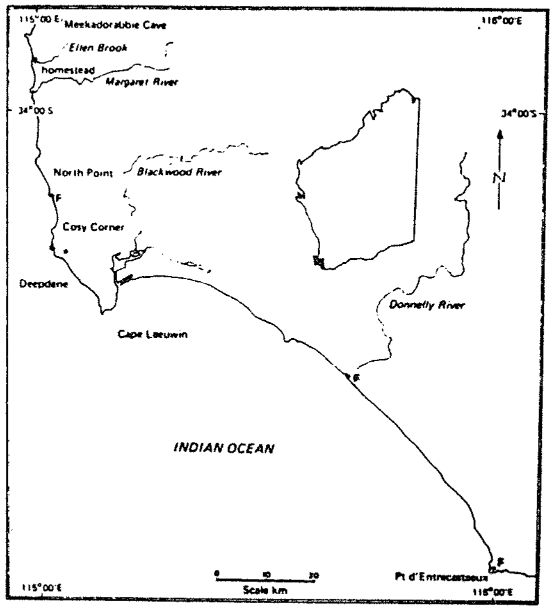


Figure 13.—Part of southwestern Australia with localities of *Austroassiminea letha* sp. nov. shown by •. F denotes fossil locality.

A calcareous, sandy fossil soil, reported to lie at about 2.5 m above sea level is exposed within a coastal cliff of aeolian calcarenite behind a sandy beach about 0.8 km SE from the mouth of the Donnelly River (34° 29′ 24″ S, 115° 40′ 38″ E). Five shells of *Austroassiminea letha* (WAM 70.2691, 70.2692) were collected from this deposit, the height of the largest being 5.07 mm. Other land snails present included species of *Succinea, Bothriembryon*, Charopidae and Punctidae. All of these species appear to be extant and a Late Pleistocene age is probable. We have not examined this isolated locality and are unable to comment on the presence or otherwise of any freshwater discharge, past or present, at the site.

The elevated limestone headland of Pt d'Entrecasteaux (35° 50′ 32″ S, 115° 59′ 40″ E) features several exposures of lithified fossil soils with land snail shells (Kendrick 1978). The assemblage includes species of Charopidae and Punctidae, two extinct species of *Bothriembryon* and *Austroassiminea letha* (WAM 70.895, 70.897, 70.898), height of the largest 4.47 mm. These fossil soils are probably of Pleistocene age and their snail assemblage suggested to Kendrick (1978) "a humid, well-vegetated, probably forested environment . . ., in contrast to the exposed coastal heath that presently characterizes the area". The deposits lie about 100 m above sea level and overlie a substantial thickness of porous, sandy limestone. They are dispersed over several square kilometres of open terrain, with no evidence of concentrated freshwater discharge or seepage, such as those associated with modern populations of *A. letha*. This association of *Austroassiminea letha* with forest litter snails is puzzling. We are not agreed as to whether *A. letha* was either dispersed more or less generally on the leaf litter of a forest floor, under conditions of higher and more sustained levels of humidity than now prevail in the area (Kendrick), or washed in from nearby localities featuring its current habitat (Solem). Of the three fossil localities reported here, only Pt d'Entrecasteaux contains extinct species and we conclude from this that it is the oldest geologically. A more precise dating of this deposit within the Pleistocene is not possible at present. We suggest that the Pt d'Entrecasteaux records of *A. letha* antedate, wholly or in part, the events which led to the severe fragmentation of the species' modern range.

Conclusions

The recent and fossil distribution data indicate that *Austroassiminea letha* had a more extensive range in the geologically recent past. **Three of the six known occurrences are fossil only and indicate a high rate of local extinction by natural processes.** It is now relatively abundant at each of three localities in areas of only a few square metres. Human activities could easily extinguish each extant colony. We thus consider it to be both a rare and endangered species.

The absence of any other amphibious or terrestrial assimineid from Australia is remarkable in view of the wide distribution that terrestrial members of the family have from South-east Asia into Polynesia. We can offer no reasons for the lack of representation in northern and eastern areas of the continent. The presence of a species in the south-western tip of Australia suggests that it is a Gondwanic relict. The fact that the anatomical features of this species combine aspects of both recognized subfamilies of the Assimineidae, may have major phylogenetic implications. If the characters used by Abbott (1949) to delineate subfamily units are significant, the combination in *Austroassiminea letha* of features from both subfamilies may indicate that it is close to the ancestral condition, a phylogenetic relict as well as geographic. It is also possible that the selection of subfamilial characters is in error, but until modern revisions of the Indonesian to Polynesian taxa are available, this question cannot be settled.

Regardless of its exact phylogenetic position, *Austroassiminea letha* represents a significant addition to the fauna of Western Australia, and is a species reduced to remnant populations that can be wiped out by man unless they are afforded protection from environmental pollution and habitat destruction.

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258/77

R E P O R T

TO : Registrar of Aboriginal Sites

FROM : Curator of Archaeology

RE : A PROPOSED PWD WATER PIPELINE AFFECTING SITE S0242 AND POSSIBLY OTHER SITES

For some time the PWD has been planning to construct a water pipeline from Ellen Brook homestead to Gracetown, at Cowaramup Bay (see sketch). Various interest groups and informed individuals believe that the proposed pipeline and attendant facilities would adversely affect or even destroy several features of aesthetic, cultural or environmental significance. This report briefly notes how the proposed pipeline affects site S0242(the Ellen Brook dune site: Bindon and Dortch 1982), and possibly other Aboriginal sites along its route.

The surveyed route of the pipeline extends northward from the existing small dam on Ellen Brook, some 60 m east of the homestead. The first 100 m of the route crosses the Western part of site S0242. After that the pipeline route turns east along the larger track giving access to Caves Road, and then runs cross country to Gracetown, some 4 km to the north. Note that the pipeline will be buried some 30-40 cm below the surface, and that an improved access road will run alongside it.

On 11 June I went to Ellen Brook and there met two PWD engineers and Shirley Slack-Smith, who is concerned about the effect which an improved, larger dam and pump unit would have on a population of rare snails living along this part of the stream. The engineers (Bill Coombes and Alan Parker) and I examined the route along the western part of site S0242. Here we dug a small hole and discovered a fossiliferous chert flake <u>in situ</u> in apparently undisturbed soil at a depth of some 30 cm. We then discussed re-routing the pipeline sufficiently to the west as to avoid the site altogether. I told them also that the entire 4½ km pipeline route would have to be checked by an archaeologist, and then spot checked during the trenching operation.

Bill Coombes informed me of another Aboriginal site in a 1-2 Ha. deflated area 500 m NNE of S0242, and some 100 m west of the pipeline route. Later that day we examined this site and found it to be very similar to S0242, with fossiliferous chert artifacts and other archaeological material lying as a lag on the deflation surface. This site is not as rich in artifacts as S0242, and has been tampered with by persons unknown, judging by the presence of at least one heap of a dozen artifacts recently stacked together (and including two chert pieces chipped along their edges, revealing the unpatinated stone within). Because of the probability of previous unauthorised artifact removal and re-scattering, I decided to collect a dozen archaeologically important chert specimens from this site, including a half-dozen specimens in the one or two "modern" heaps of artifacts. Note that all or most of the artifact scatter has been redeposited by deflation, and that the present configuration of the artifact scatter can have little or no cultural significance. The same is probably true of the artifact scatter at S0242, but not for Quininup Brook, site 4 which has been exposed but not significantly redeposited by deflation (cf. Ferguson 1981).

One of the people in our party discovered a tektite at this site, the first known from south western Australia. This specimen is already under study by Dr B. Mason a visiting tektite expert recently retired from the Smithsonian Institution in Washington, D.C. Dr Mason and I will visit this and other sites in the area within a few days. At that time I would hope to collect charcoal in situ at this site for radiocarbon dating. Any tektites discovered would be collected, since it is not known whether they were brought to the sites by prehistoric people, or were part of a more widespread tektite fall than previously known. During this planned visit I should have a chance to make a better general assessment of this site.

In Perth Shirley Slack-Smith informed me that she and the two engineers examined an alternative position on Ellen Brook for a new dam and pump unit. This second position is some 100 m downstream from the homestead. Placing these facilities there and the consequent re-positioning of the first 100-200 m of the pipeline would greatly lessen the developmental impact on the features of cultural or environmental importance referred to earlier, including S0242.

My recommendations are as follows:

(1) The alternate position for the pump unit and dam and westward shifting of the first 100 or more m of the pipeline is much preferable to the proposed route in that it would minimise risk to S0242.

(2) The 4 km of pipeline route between the main east-west access road and Gracetown should be checked by an archaeologist prior to pipeline construction. However, it seems unlikely that any major sites would be uncovered during pipeline construction. This is because of the shallowness of the pipeline trench. Also I walked the first 1500 m of the proposed route and saw no artifacts exposed in the existing track.

(3) That special attention be paid to the pipeline route where it passes near known sites (i.e. S0242 and the newly discovered dune site).

(4) That once the pipeline route was cleared by the ACMC, that it be spot checked during the trenching operation. If the southernmost 100 m of the present route were retained, then a series of test pits would have to be dug along the western edge of S0242 prior to the trenching operation. Depending upon what was discovered in the pits a relatively large salvage operation may be required.

(5) That no sand be removed from S0242 or other sites for construction purposes.

C. DORTCH
19 June 1985

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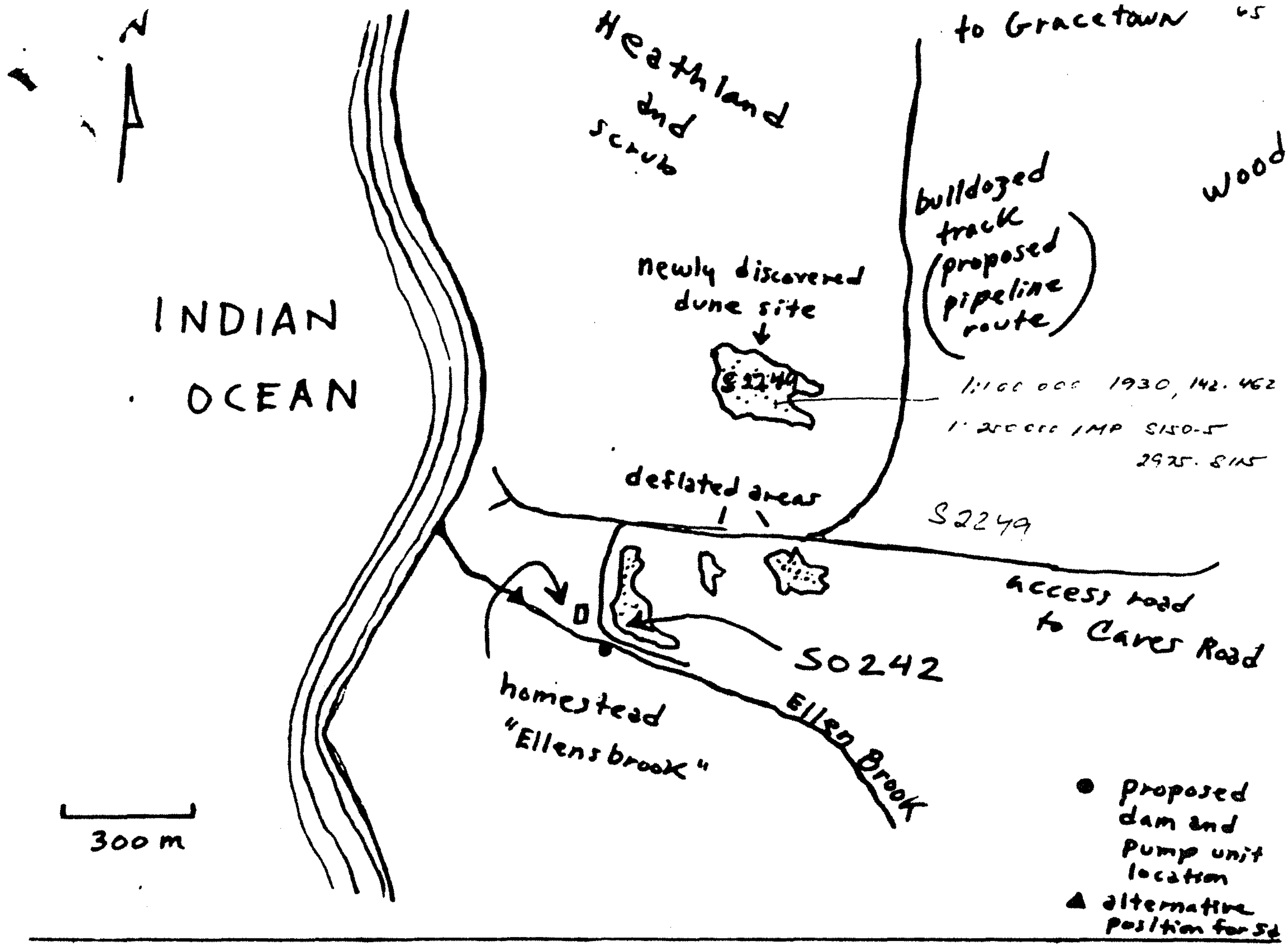
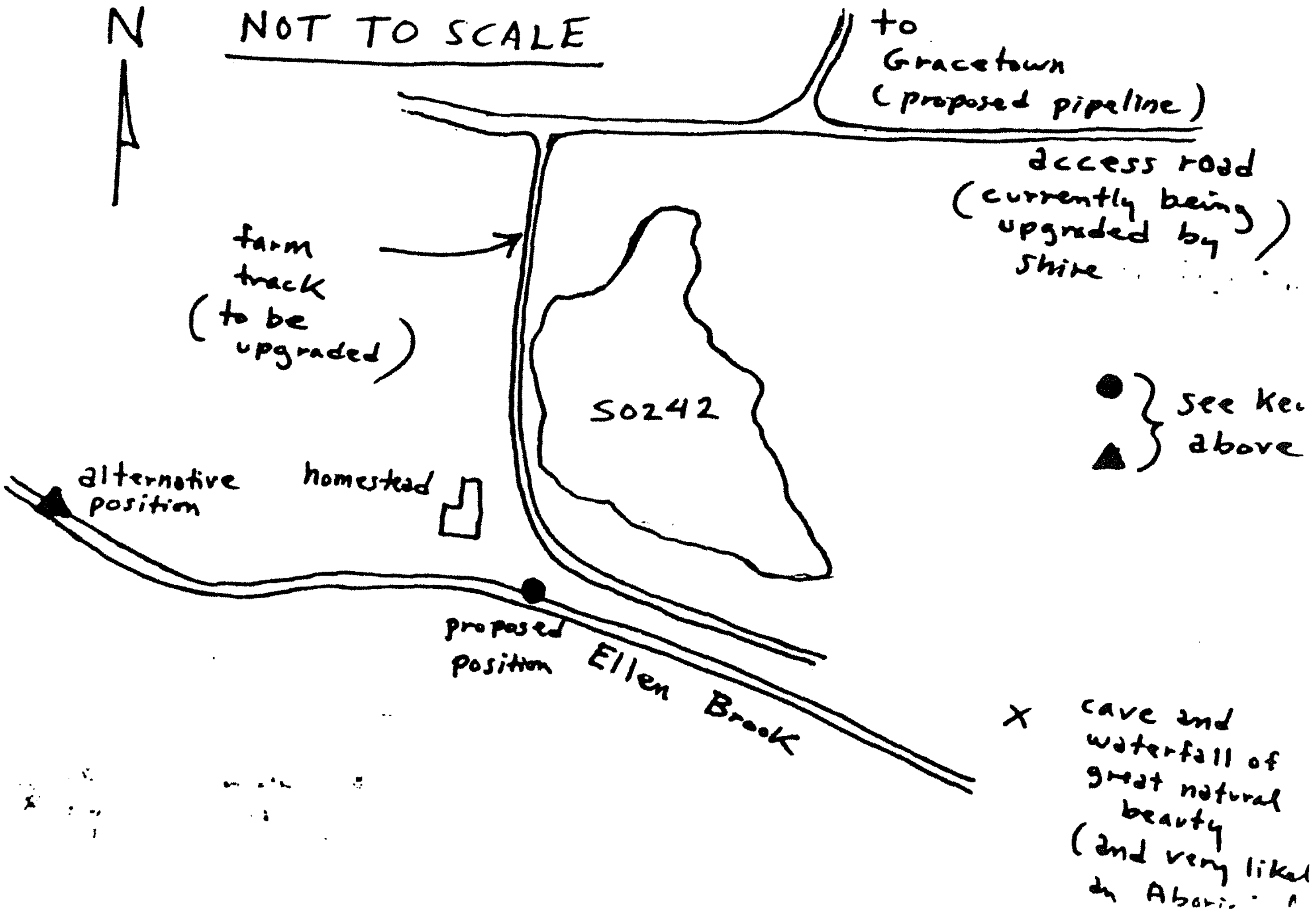


N
Heathland and scrub
to Gracetown
wood
bulldozed track (proposed pipeline route)
newly discovered dune site
INDIAN OCEAN
S2249
deflated areas
access road to Caves Road
SO242
homestead "Ellensbrook"
Ellen Brook
300 m
proposed dam and pump unit location
alternative position for



N
NOT TO SCALE
to Gracetown (proposed pipeline)
access road (currently being upgraded by Shire)
farm track (to be upgraded)
SO242
see key above
alternative position
homestead
proposed position
Ellen Brook
cave and waterfall of great natural beauty (and very likel

APPENDIX 7

BIOTIC SURVEY OF ELLEN BROOK

BIOTIC SURVEY OF ELLEN BROOK

Prepared for
Water Authority of Western Australia

Dames & Moore

Dames & Moore Job No. 08076-042-71

February 1986

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APPENDIX

1.0 INTRODUCTION

This biotic survey has been undertaken as part of the Public Environmental Report (PER) for the proposed pipehead dam at Ellen Brook, five kilometres south of Gracetown. The survey covers the proposed damsite, the reservoir and the transmission and pipeline corridors.

The PER has been prepared at the request of the Environmental Protection Authority (EPA) as part of the environmental impact assessment procedure. The PER is intended to fill the recognised need for a document which permits public participation in project assessment where, in the opinion of the EPA, detailed assessment in the form of an Environmental Review and Management Programme (ERMP) is not warranted.

Four areas of environmental concern in relation to the pipehead dam project were listed in the Notice of Intent (NOI) for the project and four other environmental concerns have been raised subsequently. These eight concerns are:

- the impact on a species of rare freshwater snail that occurs along Ellen Brook,
- the impact on Aboriginal sites in the vicinity of Ellen Brook and along the proposed pipeline route to Gracetown,
- the impact on historical values and the general intrusion into the secluded Ellen Brook area,
- the impact of construction within the Leeuwin-Naturaliste National Park,
- the impact on habitats of Bristlebirds, either Western Bristlebird or Western Rufous Bristlebird,
- the impact on populations of Red-eared Firetails and Red-winged Fairy-wrens,
- the impact on sensitive flora (i.e. plant species that are rare, geographically restricted or poorly collected) and
- the impact on types of vegetation poorly represented in the Leeuwin-Naturaliste National Park or other conservation reserves.

The January 1986 biotic survey was undertaken to:

- survey and report on types and condition of vegetation which will be affected by the dam, pipeline and powerline, with particular reference to sensitivity and representation elsewhere in the National Park.

- prepare a brief resume of the biotic environment in general of the above area, with particular reference to sensitive flora and fauna, especially the Western Bristlebird (Dasyornis brachypterus longirostris) and the Western Rufous Bristlebird (Dasyornis broadbenti litoralis),
- describe the likely impacts of the developments on sensitive elements of the biotic environment and
- define and report on management actions required to mitigate any impacts.

2.0 METHODS

The survey comprised four overlapping and integrated phases, which concentrated on species that are rare, geographically restricted, poorly known, vulnerable, endangered or otherwise considered to be sensitive. The phases were:

- collection and review of relevant published and unpublished articles, reports, 1:15,000 scale aerial photographs and vegetation maps (including the 1:50,000 compilation sheets for Smith's 1:250,000 scale vegetation map Smith 1973),
- interviews with experts, both professionals and amateurs, on sensitive species sightings, habits, habitats and distributions.
- search through collections of the Western Australian Herbarium for identities, geographical ranges, abundances, flowering times and habitats of sensitive plant species and
- field work aimed at determining identity, location, condition, sensitivity and, so far as possible, representation elsewhere in the National Park of vegetation and sensitive species likely to be affected by the proposed project.

3.0 RESULTS AND DISCUSSION

3.1 TYPES AND CONDITION OF VEGETATION IN PROJECT AREA

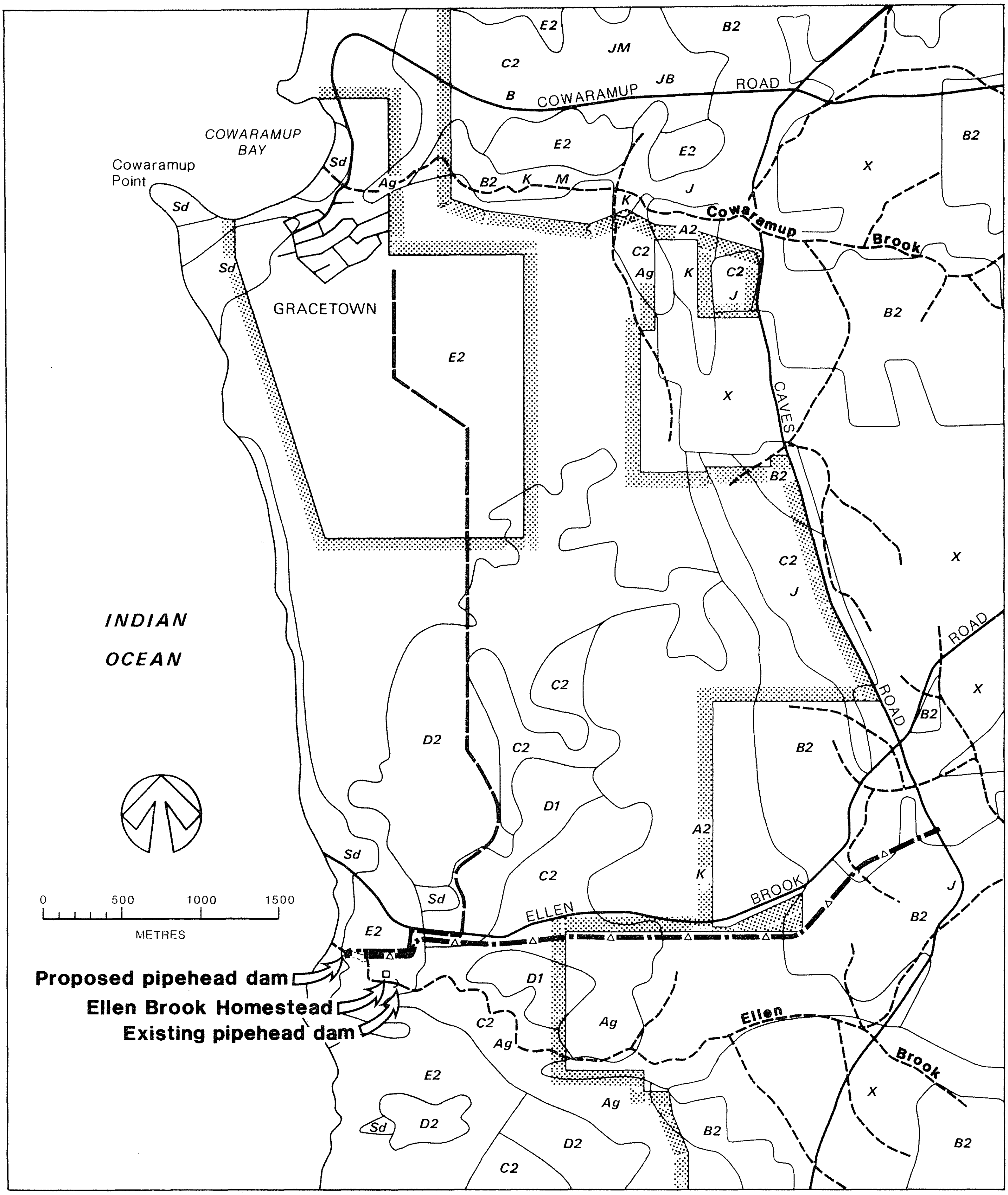
The 1:50,000 scale compilation sheet drawn by Smith shows seven types of vegetation that occur in the project area and which would be affected by the project. Figure 1, based on Smith's map, shows the vegetation of the project area. Table 1 lists these seven types of vegetation along with the project items (dam and reservoir, power main extension, pipeline) that would affect them, the estimated adequacy of their representation elsewhere in the National Park north of Prevelly, representative plate numbers and the dominant or characteristic species of each type.

The sensitivity to disturbance and adequacy of reservation of each type of vegetation varies with the particular features of each stand: its habitat, its age since last being burnt, its density and height, its species composition and its general condition. In general, the low open forests, scrubs and heaths in the southern end of the project area have not been burnt for at least ten years and are in good condition. Exceptions to this generalisation include tracks, firebreaks, gravel pits, blowouts and areas near the homestead that have been cleared and grazed. Some of the tracks are being rehabilitated (Plate 2E), but others are being widened through use by Park visitors, with trackside shrubs and trees being broken off to provide traction for bogged vehicles (Plate 2C). Previously cleared areas near the homestead are regenerating in native vegetation or, more commonly, in tea-tree (Leptospermum laevigatum) thickets and swards of Juncus sp., sedges, Centella asiatica and weedy grasses.

The closed scrub and open heath along Ellen Brook below the homestead and in the valley north of the homestead, through which the track to the beach runs, are less well-represented elsewhere in the National Park than Table 1 and F.G. Smith's maps indicate. The scale of the maps is too small to show the diversity in composition and structure associated with variations in soils, moisture and exposure. These stands, in particular, are mature mosaics of forms characterised by different species and, through absence of burning for a sufficiently long period, have developed structures that appear to make them optimally suitable habitats for Western Rufous Bristlebirds.

There are five principal types of scrub/heath vegetation in the lower Ellen Brook - beach track valley area. The lowest, most wide-spread type and the least likely to support Bristlebirds is the vegetation that clothes the stable dunes: shrub communities less than 2m tall of Olearia axillaris, Rhagodia ? preissii, Ammophila arenaria and, sometimes, Acacia littorea and Acacia cyclops (Plates 1F, 2E and background of 2F).

Taller, denser shrub communities in sheltered areas adjoining the Olearia - Rhagodia stands along the beach track are more likely to be Bristlebird habitat and are, in fact, the vegetation in which there were reported sightings of the bird in 1980. These communities are 2m to 5m tall and dense, but with open ground layers to 0.5m, and they are dominated by Melaleuca huegelii (Plate 2F) or Spyridium globulosum (Plate 2D), often with scattered peppermint. Associated species include Rhagodia ? preissii, Olearia axillaris, Sollya heterophylla, Lepidosperma gladiatum, Acacia cyclops, Boronia alata, Hibbertia cuneiformis, Hardenbergia comptoniana and Exocarpos sparteus. Marram grass appears to be invading some of the stands, although around Perth marram grass covered dunes tend to be invaded by native shrubs (Smith 1985).



PIPELINE ROUTE FOR SUPPLY FROM ELLEN BROOK

PROPOSED POWER LINE ROUTE

BOUNDARY OF LEEUWIN-NATURALISTE NATURAL PARK

VEGETATION UNIT BOUNDARY (FROM F.G.SMITH, UNPUBLISHED)

Ag, A2, B2, C2, D1, D2, E2, Sd, X; VEGETATION SYMBOLS (SEE TABLE 1)

Ag, B, J, K, M; DOMINANT SPECIES (SEE TABLE 1)

VEGETATION OF ELLEN BROOK DAM PROJECT AREA

Figure 1
Dames & Moore

TABLE I
VEGETATION OF THE ELLEN BROOK DAM PROJECT AREA
(after Smith, unpub.)

SYMBOL (Figure 1)	VEGETATION	DAMSITE RESERVOIR	POWERLINE ROUTE	PIPELINE ROUTE	PLATE NO.	REPRESENTATION	SPECIES	COMMENTS
A2	High Open Forest	-	X	-	-	Poor	Karri	Small stand north of eastern end of powerline route, with understorey of bull banksia, bracken and other species.
Ag	Low Open Forest	X	X	X	1E;2B,C	Poor to moderate	Peppermint	Peppermint groves with sword sedges or grassy, often park-like understoreys; in sheltered areas on seaward side of ridge.
B2	Open Forest	-	X	-	-	Moderate to good	Jarrah, Marri	Powerline route crosses tall jarrah-forest with dense though partially burnt understorey west of karri forest.
C2	Low Open Forest	-	X	X	-	Poor to moderate	Marri, Banksia	West of the jarrah-marri forest and also next to the peppermint grove shown in Plate 2B the routes cross low, moderately dense stands of spreading marri and banksia trees.
D1	Closed Scrub	X	X	X	2D,F	Poor to moderate	*Melaleuca huegelii*, Parrot bush, *Spyridium globulosum*, Peppermint	Stream banks and in valleys and other sheltered areas on lower parts of the terrain. Variable in height, composition and age. Often dominated by a single species.
D2	Open Scrub	-	X	-	2A	Good	Peppermint, Parrot bush *Jacksonia horrida*, Bullich, Yate, Jarrah, Marri, Blackboy, *Melaleuca acerosa*	Variable, open, 2 to 3 layered scrub, with scattered mallees (±), on the Leeuwin-Naturaliste ridge.
E2	Open Heath	X	-	-	1C,D,F	Moderate	*Spyridium globulosum*, grey *Olearia axillaris*, *Leucopogon pariviflorus*, *Rhagodia* ? *preissii*	Variable in height, density, age and composition. Groves of introduced tea-tree (*Leptospermum laevigatum*) near homestead.

Also in Figure 1

Ag Peppermint
B Banksia
J Jarrah
K Karri
M Marri
Sd Sand dunes (barren)
X Cleared of native vegetation

The scrub bordering Ellen Brook in the damsite and reservoir site area is dominated principally by Spyridium globulosum or peppermint, often with Acacia cyclops and Acacia rostellifera. The two communities vary widely in structure and often grade into each other, into small patches of Oxylobium lanceolatum and Trymalium floribundum and into the swards of Lobelia alata, Juncus sp., Stenotaphrum secundatum, Pelargonium capitatum, Centella asiatica and other weedy aliens that have become established along the stream. There are a few patches, particularly near peg 'E', with a Spyridium globulosum overstorey over 3m tall and Lepidosperma gladiatum ground layer which might be suitable habitat for the Western Rufous Bristlebird, but no one can be sure because no one knows what range of vegetation is suitable habitat for the bird. The optimum habitat appears, however, to be a type of heath or scrub that has not been burnt for at least 8 to 10 years (Carter 1924; Smith 1977). Comparable scrub communities were not found along Turner Brook, which has conditions that are probably more similar to Ellen Brook's than anywhere else in the Leeuwin-Naturaliste strip. Turner Brook is privately owned and runs through Deepdene, between Cosy Corner and Augusta.

3.2 SENSITIVE SPECIES

Twenty species of plants considered, on the basis of surveys of herbarium collections and field work by Department of Conservation and Land Management staff (Rye and Hopper 1981; Rye 1982; Patrick and Hopper 1982), to be sensitive have been recorded from the broader area that includes Ellen Brook. The 20 species of sensitive plants are listed in Table 2, along with their families, number of collections in the Western Australian Herbarium and recorded habitats, flowering times and distributions. None of the species was recorded during the January survey, nor did the Western Australian Herbarium have any collections of sensitive plant species from the project area. It is possible, though not likely, that species of sensitive plants would be found in the project area at the times when they are in flower; flowering specimens of only one of the 20 species have been previously collected in a January.

Two species of very rare and geographically restricted fauna and two species of otherwise sensitive fauna have been recorded from the Ellen Brook project area. The two very rare and restricted species of fauna are a freshwater snail and a species of Bristlebird. The two species that are otherwise sensitive are the Red-eared Firetail and the Red-winged Fairy-wren. None of the four species were seen during the January survey.

TABLE 2
RARE, GEOGRAPHICALLY RESTRICTED AND POORLY COLLECTED SPECIES OF VASCULAR PLANTS THAT MIGHT OCCUR IN OR NEAR THE ELLEN BROOK REGION

SCIENTIFIC NAME	FAMILY	HABITAT	FLOWER[1]	DISTRIBUTION	NO.[2]
Acacia inops	MIMOS	Swampy	4-9, 8-9	Yallingup - Margaret River	7
A. mooreana	MIMOS	Swamps; jarrah-marri forest		Yallingup - Stewart Road	19
A. semitrullata	MIMOS	Swamps; jarrah-marri-banksia open forest	9-10	Yarloop - Karridale	22
Banksia meisneri var. *ascendens*	PROTE	Sandy (semi-) swamp	2,4,10	Busselton - Scott River	7
Caladenia excelsa	ORCHI	Jarrah-marri-banksia woodland	10	Mammoth cave, Yallingup	8
Eucalyptus calcicola	MYRTA	Stabilised dune western slopes	5-6	Hamelin Bay area	-
Grevillea brachystylis	PROTE	Jarrah-banksia-*Xanthorrhoea* woodland	6,8-9	Yoongarillup - Scott River	5[3]
Hodgsoniola junciformis	ANTHE	Sandy (semi-) swamp	10-11	Cape - Scott River	14
Hybanthus volubilis	VIOLA	Stream bank thickets	10-12	Margaret River	5
Isopogon sp.	PROTE	-	-	-	-
Jansonia formosa	PAPIL	Jarrah-marri forest; swampy riverbank	8,10-1	Margaret River - Walpole	15
Prasophyllum triangulare	ORCHI	Jarrah-marri-banksia low woodland	10-11	Margaret River - Albany	4
Pultenaea drummondii	PAPIL	Jarrah-marri forest	7,9-11	Ludlow - Augusta	17
P. pinifolia	PAPIL	Marri woodland, swampy	10-12	Busselton - Karridale	8
Restio amblycoleus	RESTI	Sandy (semi-) swamp	9-10	Ambergate - Scott River	7
R. ustulatus	RESTI	Open grass plain; sandy (semi-) swamp	9-5	Ambergate - Scott River	10
Samolus valerandi	PRIMU	Damp coastal sand	3,10-11	Margaret River - Augusta	3
Stylidium barleei	STYLI	Sandy jarrah forest	10	Busselton - Brockman Highway	3
Thomasia laxiflora	STERC	Jarrah forest	10-11	Cowaramup	2
Verticordia lehmannii	MYRTA	Swampy sedge and heath	12-5	Scott River Road - Quindalup	8

1. Numbers of the months (e.g. 12 = December) when flowering specimens were collected.
2. Number of collections in the Western Australian Herbarium.
3. Some specimens may be on loan and not in herbarium.

3.2.1 The Freshwater Snail (Austroassiminea letha)

The rare and endangered species of freshwater snail, Austroassiminea letha, was first collected at Ellen Brook by Slack-Smith in 1975 and subsequently in 1980 (Solem et al., 1982). The species is only known from three locations, each of only a few square metres in area, on the Leeuwin-Naturaliste coast in the far southwestern corner of Western Australia. The snail was found upstream of the proposed damsite, and although well searched for, none have been recorded downstream of the homestead. This is probably due to a lack of suitable habitat. The snail's habitat is the wet/splash zone where water seeps along the contact between igneous rock and overlying strata. Feeding on organic detritus, the snails prefer soils rich in organic matter rather than the highly leached siliceous sands downstream (Slack-Smith, pers. comm.). It is highly unlikely that the proposed pipehead dam will have any detrimental impact on the snail's abundance or survival.

3.2.2 Western Rufous Bristlebirds (Dasyornis broadbenti litoralis)

Ellen Brook is one of the few positively identified sites for the very rare Western Rufous Bristlebird (Dasyornis broadbenti litoralis). First discovered by Milligan in 1901 at Ellensbrook, the Western Rufous Bristlebird appears to have been confined to a narrow strip of coastal country between Cape Naturaliste and Cape Leeuwin. The most recent collection of a Western Rufous Bristlebird was in 1906, from Cape Naturaliste, but there are more recent reported sightings (and hearings), including ones in 1908 by C. Conigrave, in 1940 by G. Storr, in 1954 by K. Highman and in the late 1970s and early 1980s by J. Malone, E. West, N. Dunlop and others (Serventy and Whittell 1976; S. McNee, J. Talbot, G. Chapman, J. Malone, and E. West, pers. comms.).

The most recent reported sightings of Western Rufous Bristlebirds were in 1980 by J. Malone, who made two sightings at the edge of valley scrub along the track to the beach north of Ellen Brook homestead between 100m and 300m northwest of the pipeline-powerline route. One bird was seen at each of two visits in January 1980, and the bird and habitat were photographed during the first visit. Although the photographs were indistinct and out of focus, one was sufficiently clear to confirm that the bird was indeed a Bristlebird (G. Chapman, pers comm: Appendix). The likeliest species of Bristlebird is the Western Rufous, since the Western Bristlebird has not been recorded closer to the project area than 100km (Smith 1977).

The Western Rufous Bristlebird is a shy, elusive bird that dwells largely on the ground in tall, dense coastal scrub or heath that has not been burnt for many years. It prefers to run through the dense scrub rather than fly. It is difficult to see and, apparently, seldom calls, even during the breeding season. Its most common call is reported to be a single, short high-pitched call sounding like a squeeky cartwheel, which is soon followed by a similar reply (Talbot, pers. comm.).

3.2.3 Red-eared Firetails (Emblema oculata) and Red-winged Fairy-wrens (Malurus elegans)

Red-winged Fairy-wrens and Red-eared Firetails were once common in the Leeuwin-Naturaliste area and in dense scrub in swamps and along streams (Carter 1924; West, pers. comm.; Talbot, pers. comm.), but settlement, clearing and burning have severely reduced available habitats and, consequently, the abundance and range of the birds (Serventy and Whittell 1976). However, Red-eared Firetails have been found to be more abundant and widely distributed in the northern jarrah forest than previously thought (Nichols et al., 1982) and Firetail populations are increasing in Margaret River areas where appropriate habitat is encouraged to regenerate (West, pers. comm.).

Both species are known to occur in the vegetation along Ellen Brook in the vicinity of the homestead (Talbot, pers. comm.) and would probably be affected by clearing of the reservoir site.

3.3 POSSIBLE IMPACTS

The possible impacts of the project on sensitive elements of the biota can be considered in four sections:

- o construction of the dam,
- o clearing of the reservoir and impoundment,
- o construction of the pipeline and
- o construction of the powerline.

Although the project will undoubtedly have some impacts on the native biota, probably the only sensitive species of plants or animals that might be affected are the Western Rufous Bristlebird, the Red-eared Firetail and the Red-winged Fairy-wren. The most likely effect, if any, on these species would be through destruction of habitat and reduction of habitat availability.

3.3.1 Dam Construction

Approximately 0.25ha will require clearing to accommodate the dam, pump and construction work site. It is assumed that construction of the dam will involve the use of heavy equipment, the clearing of an area for a worksite and pumping station, the widening of the existing track in order to bring in the equipment and the clearing of an additional track to link the existing track and the damsite, presumably along the old track being rehabilitated by the Department of Conservation and Land Management. There should be no need to fell any trees, to disturb the trackside peppermint grove or to disturb any possible Bristlebird scrub habitat except, possibly, at the damsite itself, where there is Spyridium globulosum - peppermint scrub of a type described in Section 3.1.

3.3.2 Reservoir

The reservoir site is about 100m long by 20m wide; thus about 0.2ha would, be cleared of vegetation. The vegetation to be cleared would probably include portions of the Spyridium, peppermint and Spyridium - Lepidosperma scrub described in Section 3.1 and discussed as possible Bristlebird habitat. The thicket vegetation in the reservoir site may also support Red-eared Firetails and Red-winged Fairy-wrens. Preparation of the reservoir would involve clearing more than 50% of this thicket. Additional portions of the scrub might be cleared if the reservoir is fenced to keep out swimming and other incompatible uses.

3.3.3 Pipeline Construction

Construction of the pipeline in an access corridor 5m wide by about 5km long should have minimal impact except where the access track is widened or where the pipeline deviates from existing tracks. About 2.5ha will be affected. Aside from the southern end of the pipeline route, discussed in Section 3.3.1, pipeline construction will not affect any poorly reserved vegetation except marri low open forest north of the peppermint grove. It will, however, be possible to avoid most of the woodland by locating the pipeline in the track or on the side of it opposite the woodland.

The existing track which follows the top of the ridge to Gracetown meanders slightly, apparently to follow the contours and to avoid scattered trees and mallees of jarrah, marri, bullich and yate. Keeping the pipeline close enough to the existing track to use it for access would minimise disturbance to the open scrub and open heath vegetation on the ridge.

3.3.4 Powerline Construction

The clearing width in the powerline corridor will, according to the NOI, be approximately 15m. According to the State Energy Commission of Western Australia (SECWA) there will be a 20m easement, within which 6m will be cleared to allow vehicle access etc. An area of about 0.6ha within the National Park will be cleared. Within the 20m width there will be selective pruning and lopping and possible removal of any large trees which might fall across or otherwise interfere with the powerline. To minimize fire risks, trees outside the 20m easement may also be pruned if they are likely to interfere with the powerline. Minor impacts may therefore, occur outside the 20m easement. There are, however, very few if any large trees in the section of the powerline that runs inside the current boundaries of the National Park. It avoids the Park's jarrah and karri forests by running through private property south of them.

3.4 MANAGEMENT AND REHABILITATION

Responsibility for the management of the National Park lies with the Department of Conservation and Land Management (CALM). Installation and management of the reservoir, pump station and pipeline route will be the responsibility of the Water Authority. The Water Authority recognises its particular responsibility for sound environmental management and undertakes to minimise impacts on the environment and to clean up and rehabilitate the site following construction. Consistent with sound environmental management and the efficient and reliable operation of the water supply, the Water Authority undertakes to seek and comply with the guidance of CALM with respect to suitable practices for the installation and management of the project.

Specifically. the Water Authority undertakes to make and comply with the following commitments related to protection, rehabilitation and maintenance of the environment. Close liaison will be maintained with officers of CALM at all times.

3.4.1 Dam Construction

The area to be cleared will be kept to the minimum required for safe operations. Approximately 0.25ha will require clearing to accommodate the dam, pump and construction work site. Construction sand and crushed rock will be imported from outside the National Park. Clean, weed free sand will be used. Vegetation and topsoil from the work site will be separately cleared and stockpiled.

The worksite will be rehabilitated by:

- removal of all waste material from the site including excess sand, rock or concrete,
- reprofiling and grading,
- return of topsoil and
- respreading of cleared vegetation.

Experience with the regeneration of drill sites in the area suggests that effective re-establishment of vegetation will result from these practices.

3.4.2 Reservoir

Clearing within the reservoir area will be kept to the minimum requirement to accommodate top water level. Approximately 0.2ha will require clearing. All equipment will be washed down for dieback control prior to entry on-site. Machinery operations will be confined to the site and cleared material pushed to the inside of the cleared area. Any large timber will be removed from site. Shrub and understorey vegetation will be stockpiled for return to areas, such as the construction site, which require rehabilitation. Additional topsoil may be recovered from this area if required. The natural surface profile of the reservoir bed will be retained to avoid slumping or undercutting.

3.4.3 Pipeline Construction

Pipeline construction will involve the separate removal and windrowing of understorey vegetation and topsoil from approximately 2.5ha of land. The route will parallel existing tracks/firebreaks throughout and will avoid all trees.

Rock removed during trenching will be returned to the surface to discourage access, or will be removed from site, as directed by CALM. Where sand padding is necessary for the pipe, clean, weed free sand will be imported from outside the National Park. Following backfilling of the trench, any excess soil will be graded out or removed as required. Erosion of the trench or surface is not expected due to the porous nature of the soil and rock in the area. Windrowed topsoil and brush will be returned to the route and vegetation will be allowed to regenerate throughout. The existing tracks and firebreaks will be retained as access to the route.

3.4.4 Powerline Construction

The State Energy Commission of Western Australia will be responsible for the provision of power. The Commission has indicated that it recognises the environmental sensitivity of the proposed route. Therefore, it is proposed that officers from CALM inspect the route with SECWA. The route will cross private property for the most part and about 1km of the National Park. Clearing of about 0.6ha within the Park will be limited to a 6m wide access track. The removal of trees will be avoided wherever possible. Pruning will be restricted to those trees which could interfere with the line and create a fire hazard. Elsewhere, shrub and peppermint tree vegetation will be retained outside the access track. Standard timber poles 10m high will be used to limit visual intrusion of the powerline on the natural landscape. Any waste materials will be removed from the site following construction. The SECWA will regularly inspect and maintain the line to minimise the risk of electrical ignition of fires.

Key elements of sound environmental practice will be:

- minimal clearing,
- recognition of the need to prevent fires,
- disturbed sites which are not required in the long term will be revegetated with native vegetation,
- limitation of opportunities for weed and dieback invasion and
- general tidiness and cleanliness.

As well as the commitments detailed earlier, the Water Authority undertakes to ensure that its employees and contractors are aware of the points given above and will ensure that they do not light unauthorised fires, that they wash down all equipment before entry to site and that they will clean up any waste materials and litter.

4.0 ACKNOWLEDGEMENTS

The list of people who contributed time, information and suggestions during the preparation of this report include Jeremy Talbot, Graeme Chapman, Ernie West, Shappelle McNee, Paul Frewer, John Malone, Kathrine Highman, Graeme Smith, Stephen Hopper, Greg Keighery, Shirley Slack-Smith, John Lack, Paul Wilson and several staff members of the Water Authority of Western Australia.

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PLATES

CAPTIONS - PLATE 1

VEGETATION AND HABITATS

A General view of vegetation between rehabilitation sign on homestead track/pipeline - powerline corridor and around damsite. Mainly tea-tree thickets (mid-ground), coastal open heath of Acacia cyclops, Olearia axillaris and Acacia littorea (back-ground), peppermint thickets and Dryandra sessilis (foreground). (ASW-042-16).

B Ellen Brook below damsite, with Juncus ? kraussii, Lobelia alata and Zantedeschia aethiopica. (ASW-042-18).

C Looking west from below damsite across coastal open heath. (ASW-042-24).

D Spyridium globulosum - peppermint scrub at damsite 'B', with Leucopogon parviflorus, Boronia alata, Hibbertia cuneiformis and, upslope, Olearia axillaris - Acacia cyclops open heath. (ASW-042-26).

E Downstream in Ellen Brook from peg 'D' towards peg 'B', in reservior site. Stream vegetation herbaceous, very dense and weedy and including Isolepis nodosus, Juncus sp., Centella asiatica, Plantago lanceolata and Cynodon dactylon. (ASW-042-27).

F Looking across Ellen Brook below damsite, at peg '60'. Dense open heath with Olearia axillaris, Acacia cyclops and Acacia littorea on stable dune and dense, weedy, herbaceous vegetation in foreground. (ASW-042-22).


A


B


C


D


E


F

Plate 1
Dames & Moore

CAPTIONS - PLATE 2

VEGETATION AND HABITATS

A Open scrub along track to Gracetown. Bullich (Eucalyptus megacarpa) in background, 4m-5m tall. In foreground: Agonis flexuosa 3m-5m tall, with proteaceous - myrtaceous heath, patches of Dryandra sessilis, scrub marri, scrub jarrah, Jacksonia horrida and blackboys. (ASW-042-33).

B Peppermint (Agonis flexuosa) low open forest at edge of pipeline and powerline routes. Low herbaceous, mainly weedy understorey. (ASW-042-35).

C Steep, sandy section of track to homestead and beach at peppermint grove (Plate 2D). Peppermint grove on right and Jacksonia horrida over 3m tall on left. Down track on left: mosaic of Jacksonia, peppermint, Dryandra sessilis and, towards bottom, Spyridium globulosum and Leptospermum laevigatum. (ASW-042-36).

D Closed scrub 1.5m-4m tall at head of beach-track valley, of Agonis flexuosa, Spyridium globulosum, Acacia littorea, Rhagodia ? preissii, Hibbertia cuneiformis, Muehlenbeckia adpressa, Boronia alata, Olearia axillaris and some deadwood and Ammophila arenaria. Possible Bristlebird habitat; Bristlebird was sighted nearby by Malone, 1980. (ASW-042-31).

E Rehabilitation area at head of valley at bend in beach-track and open heath of grey Olearia axillaris, Rhagodia ? preissii and grass introduced to stability dunes, Ammophila arenaria. Bristlebird was sighted near here in 1980. (ASW-042-32).

F Dense closed scrub (1-)3-5m tall in beach-track valley of Melaleuca huegelii, Spyridium globulosum, Olearia axillaris, Rhagodia ? preissii, Agonis flexuosa, Exocarpus sparteus, Muehlenbeckia adpressa, Sollya heterophylla, Boronia alata, Acacia cyclops, Hibbertia cuneiformis, Hardenbergia comptoniana and Lepidosperma gladiatum. Probable Bristlebird habitat. Bristlebird was sighted about here in 1980. (ASW-042-30).

A

B

C

D

E

F

APPENDIX

Transcription of Letter from Graeme Chapman to John Malone

P.O. Box 10,
Glen Forrest, 6071,

25 October, 1981

Dear John,

I was down at Two Peoples Bay reserve recently and managed to photograph a Western Bristlebird, my first real encounter with this species. Having spent some time taking pictures and also on looking at the slides (sample of reject enclosed) I am now quite convinced that the bird you photographed at Ellen Brook was a Bristlebird.

The birds Mike Bamford refers to at Fitzgerald River are Western Bristlebirds, not Rufous Bristlebirds and they were seen there a couple of years ago by Les Moon and Graeme Smith.

I'm sorry you haven't been able to visit your Bristlebird spot recently. I am now quite sure they are there and assume that they must do most of their calling earlier in the year, probably in July and August.

I can't see my way clear to visit Ellen Brook in the near future, much as I would like to. I do hope you will be able to get down there again and see the bird again; and also get the credit for re-discovering the species there after 40 + years.

Cheers

Graeme Chapman

Note: One of Graeme Chapman's photographs of the Western Bristlebird appears in an article by Malcom Taylor (1985).

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FIGURES

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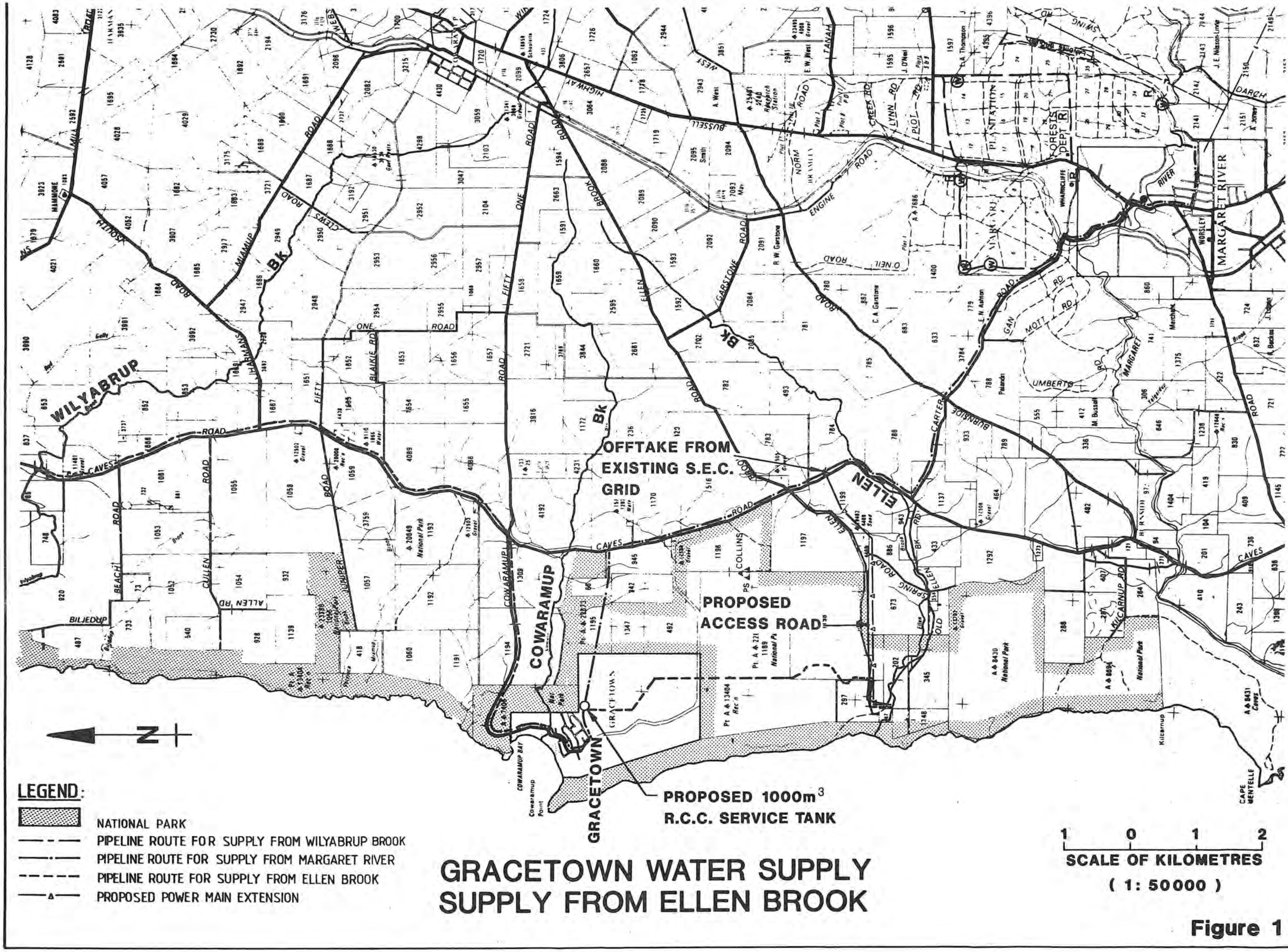
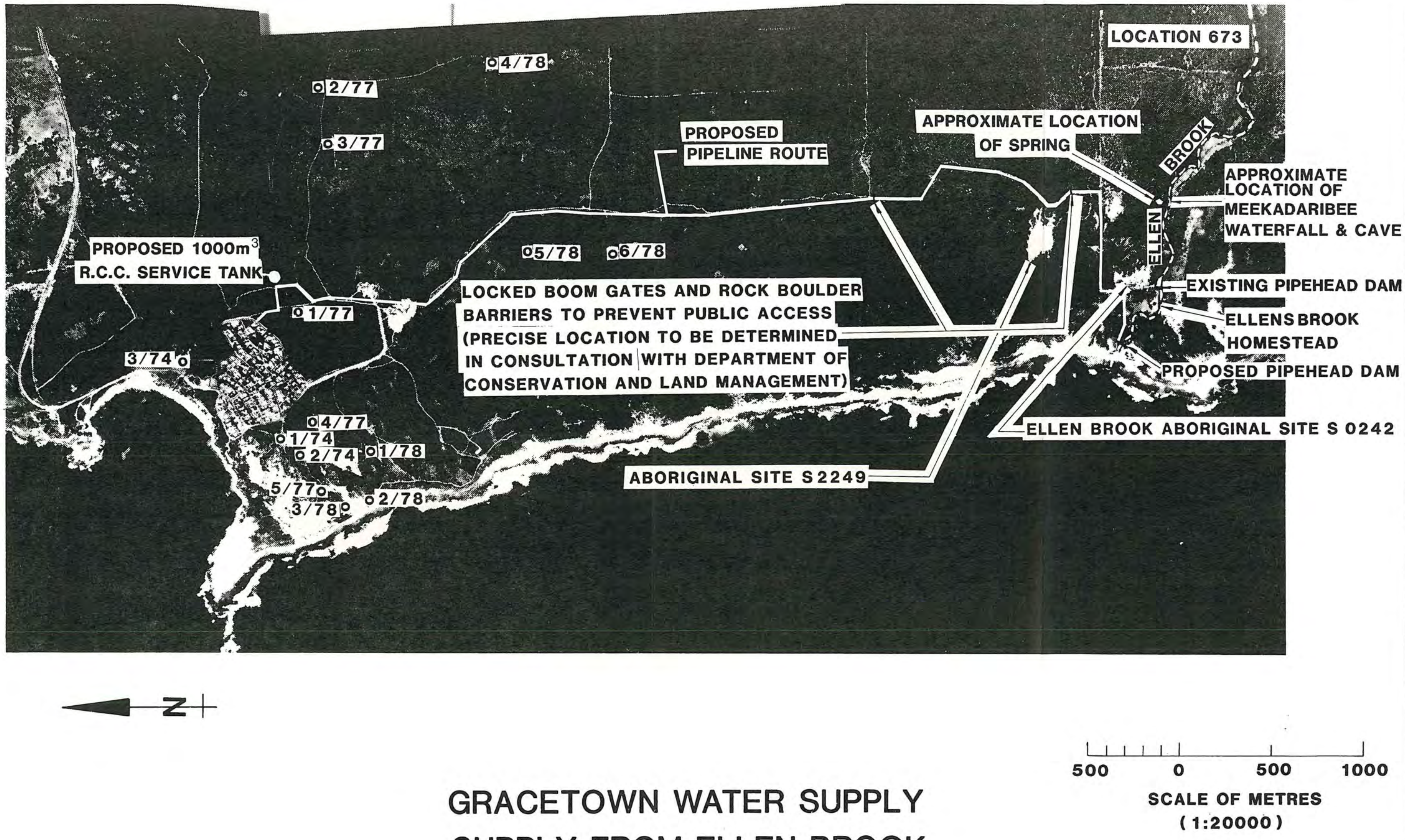


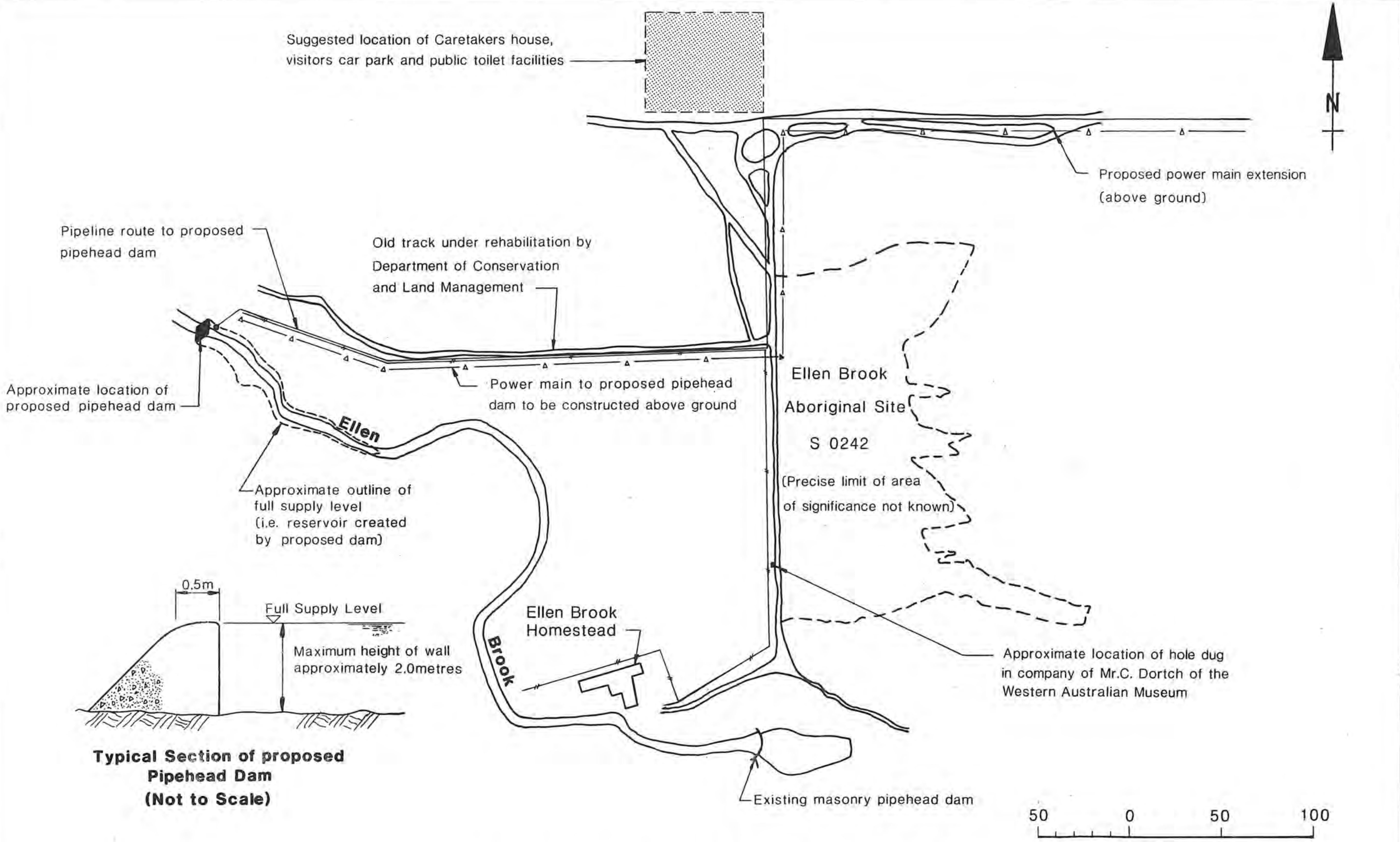
GRACETOWN WATER SUPPLY
SUPPLY FROM ELLEN BROOK

Figure 1



GRACETOWN WATER SUPPLY
SUPPLY FROM ELLEN BROOK

Figure 2



GRACETOWN WATER SUPPLY
SUPPLY FROM ELLEN BROOK

Figure 3