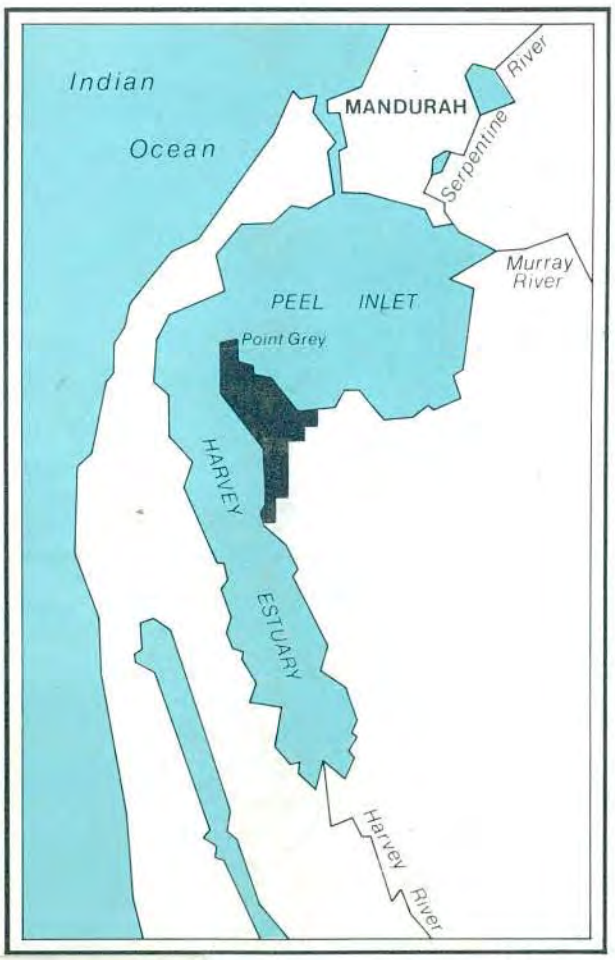
POINT GREY DEVELOPMENT PROJECT

ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME



APPENDICES

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VOLUME OF APPENDICES

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LIST OF APPENDICES - SEPARATE DOCUMENT

A	Terrestrial Environment
B	Report on Archaeological Survey of the Point Grey Development Study Area. Prepared by G. Quatermaine, December 1986
C	Report on an Ethnographic Survey of Point Grey. Prepared by R O'Connor, February 1987
D	Estuarine Environment
E	Thomas Peel College
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APPENDIX A

APPENDIX A

TERRESTRIAL ENVIRONMENT

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1.0 INTRODUCTION

Point Grey retains a mixture of vegetation types. The presence of fauna in its native setting, especially large numbers of waterbirds, adds further interest to the locality and the region.

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

2.0 VEGETATION AND FLORA

2.1 VEGETATION UNITS

Vegetation types and condition are shown on Figure 1. Vegetation units are closely associated with soil units and a general description of the relationship between the two is contained in Table 1.

Clearing and pasture development have resulted in the establishment of exotic species, both intentionally and unintentionally, on disturbed areas throughout the site.

Brown (1980) noted the presence of the native species Anthocercis littorea and a large amount of dead vegetation amidst the thicket formation on the western edge of the peninsula. These features were interpreted as indicative of regular fire and disturbance in these areas. However, most of the native vegetation shows no sign of having been burnt for at least several years.

Eight native vegetation units were recognised on the Point Grey site by Brown (1980). **Tuart woodland** (Eucalyptus gomphocephala) dominated the areas of yellow Karrakatta sand over limestone, with an understorey of Banksia grandis and B. attenuata. Proteaceous species, Acacia spp. and Blackboy (Xanthorrhoea spp.) are common shrubs. Much of this unit has now been cleared for grazing. **Banksia/Eucalypt woodland** occurs on the grey and yellow phase of Karrakatta sand. This unit comprises Tuart, Jarrah (E. marginata) and Marri (E. calophylla) in the overstorey, with Banksia grandis and B. attenuata common in the understorey.

TABLE 1

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

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

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

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

Proteaceous species again occur in the shrub layer. This unit has also been subject to clearing but large, good quality stands exist on the southern half of the site. **Flooded Gum woodland** (E. rudis) occurs on low lying areas of grey sand and the parallel ridges. Banksia littoralis and Swamp Paperbark (Melaleuca rhaphiophylla) are characteristic of the understorey and occur separately, often with sedge species prevalent as groundcover. This unit often intergrades with swamp vegetation. **Banksia over limestone** occurs where limestone outcrops. B. attenuata and B. grandis are dominant with Dryandra sessilis, Acacia pulchella, Blackboy and Templetonia retusa in the understorey. This unit grades into **Heath** where the overstorey is absent. Dryandra sessilis and Templetonia retusa are characteristic, with occasional E. leptophylla occurring in mallee form.

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

Dune vegetation is distinguished by small paperbark (Melaleuca cuneata) trees and Acacia saligna with a mixture of groundcover species. The beach supports Sheoak (Casuarina obesa) and Saltwater paperbark (Melaleuca cuticularis) with salt tolerant samphires (Sarcocornia sp. and Halosarcia sp.) characteristic of salty flats. The rush, Juncus kraussii often fringes the water's edge and plays an important role in stabilising the shore. The last two units are largely uncleared.

2.2 COMMON AND CHARACTERISTIC FLORA

A list of common and characteristic perennial plants was compiled by Brown (1980) during earlier studies at Point Grey. This list has been extended and appears here as Table 2.

TABLE 2

PARTIAL LIST OF COMMON AND CHARACTERISTIC PERENNIAL NATIVE PLANT SPECIES - POINT GREY DEVELOPMENT SITE
JUNE, 1980

SPECIES	HABITAT ON POINT GREY	LANDFORM UNITS
Eucalyptus marginata (jarrah)	Western slopes	Ky, Kgb
E. calophylla (marri)	Throughout; on high ground	Ky, Kgb
E. gomphocephala (tuart)	Throughout; on high ground	Ky, Kgb
E. rudis (flooded gum)	Lowlands on eastern shore, swamps	Kgb, Pr, Ksw
E. leptophylla	Limestone	Kls
Banksia attenuata	Throughout	Ky, Kgb
B. grandis (bull banksia)	Scattered throughout	Ky, Kgb, Pr
B. ilicifolica (holly-leafed banksia)	Scattered throughout	Ky, Kgb
B. littoralis	Swampy areas	Ksw, Pr
Kunzea ericifolia	Lowlands on white sand	Pr
Melaleuca cuticularis (saltwater paperbark)	Kunzea shrublands, swampy areas	Pr
M. rhaphiophylla (common paperbark)	Swamps and shore areas	Kgb, Ksw, Pr
M. lateritia	Swamp (south-east)	Ksw
M. urceolaris	Limestone heath	Kls
M. huegelii	Swamps (south-east)	Ksw
M. cuneata	Dune community	Pr
Regelia ciliata	Jarrah-banksia woodland	Ky, Kgb
Casuarina obesa	Water's edge, swamps	Pr, MEA
Allocasuarina fraseriana	Banksia woodlands	Ky, Kgb, Pr
Agonis flexuosa	Western slope	Ky
Acacia saligna	Near shore on point; scattered throughout	Pr, Ky
A. rostellifera	Lower slopes	Pr, Ky
A. pulchella	Limestone and banksia woodland	Kls, Ky, Kgb
Hakea lissocarpha	Limestone and banksia woodland	Kls, Ky, Kgb
H. auriculata	Lowlands on eastern shore	MEA
H. prostrata	Limestone	Kls
Xylomelum occidentale (woody pear)	Tuart-banksia woodland	Ky
Jacksonia furcellata	High areas in banksia woodland	Ky
J. sternbergiana	Banksia woodland	Ky, Kgb
J. signorum	Near shore on point	Pr
J. horrida	Dune community	Pr
J. hakeoides	Limestone	Kls
Astartea fascicularis	Swampy areas near point	Ksw, Pr
Brachyloma preissii	Dune community	Pr
Pericalymma ellipticum	Swampy areas near point	Ksw, Pr
Dryandra sessilis	Limestone areas	Kls
D. nivea	Limestone areas	Kls
Templetonia retusa	Limestone areas	Kls
Hibbertia polystachya	High areas and banksia woodland	Ky
Pittosporum phylliraeoides	Dune areas on point	Pr
Leucopogon glaucifolius	Limestone	Kls
Hardenbergia comptoniana	Throughout bush on point; limestone; eucalypt woodlands	Pr, Kls
Persoonia saccata	Eucalypt woodland	Ky, Kgb
Drosera spp.	Scattered throughout; damp areas	Ksw
Olearia axillaris	Dune community; tuart-banksia woodland	Pr
Calytrix empetroides	Dune community	Pr
Conostylis aculeata	Dune community	Pr
Styphelia tenuiflora	Tuart-banksia woodland	Ky
Adenanthos meissneri	Banksia-jarrah woodland	Ky, Kgb
Carpobrotus sp.	Beach areas	Pr
Solanum simile	Low areas on eastern shore	Pr, MEA
Adriana quadripartita	Low areas near Point Grey	Pr, MEA
Anthocercis littorea	Disturbed low-lying areas	Ksw
Nuytsia floribunda	Few on western slopes	Ky
Sarcocornia sp. and Halosarcia sp. (samphire)	Intermittently on water's edge	Pr, MEA
Macrozamia riedlei	Throughout	Kg, Ky
Xanthorrhoea preissii	Throughout, prefers higher areas	Ky, Kgb
Petrophile sp.	Limestone	Kls
Oxylobium sp.	Near shore on point	Pr
Phyllanthus calycinus	Limestone	Kls
Gahnia trifida	Shore areas	Pr
Lepidosperma longitudinale	Swamps near point	Ksw, Pr
L. gladiatum	Jarrah-banksia woodland	Ky, Kgb
Juncus kraussii	Shore areas	Pr
J. pallidus	Swampy areas	Ksw
Acanthocarpus preissii	Dune areas near shore	Pr
Baumea juncea	Shore area	Pr
Isolepis nodosa	Shore area	Pr
Dasypogon bromeliifolius	Jarrah-banksia-Kunzea woodland	Ky, Kgb, Pr
Sollya heterophylla	Tuart woodland	Ky
Cassytha sp.	Swampy areas	Ksw
Arthropodium capillipes	Limestone	Kls

Source: Brown, 1980, with additions 1987

2.3 SENSITIVE FLORA

Surveys of plant collections held in the Western Australian Herbarium, from the development area and sites within 20km of it, identified two species currently gazetted as rare flora under the Wildlife Conservation Act, 1950-1980. Four other species recorded within 20km of the development area are, though not gazetted, regarded as probably rare or geographically restricted. These six species are listed in Table 3 and, because of their restricted distributions or limited numbers, may be considered to be sensitive.

Likely habitats for two of the species do occur within the development area, although neither of these have yet been recorded there. These species are Drakea jeanensis and Jacksonia gracilis. The habitats occupied by these species are well represented in reserves around the Harvey Estuary (Table 3) and the development is not expected to affect their status.

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

2.4 DIEBACK

Jarrah dieback disease, Phytophthora cinnamomi, has recently been noted by officers of CALM in reserves in the Point Grey region (Towers, pers. comm.) and possible sites of infection were noted in the project area, however, no detailed mapping has been carried out. A number of susceptible plant species are present in the Point Grey area, notably members of the Proteaceae such as Banksia spp., suggesting that precautions to prevent the spread of the disease will be appropriate during development.

TABLE 3

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

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

* Gazetted Rare Species

2.5 WEED SPECIES

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

2.6 VEGETATION SYNTHESIS

Most of the Point Grey project area has been cleared of native vegetation and now supports grazing pastures (Figure 1). Significant portions of the site still carry native vegetation, in good condition, which has value for its conservation and amenity value. The vegetation units present on the project area are closely allied to the landform units, which are all represented in reserves in the local region, as outlined in Table 1.

3.0 FAUNA

3.1 MAMMALS

Although no intensive surveys have been undertaken within the Point Grey study area the habitats present, especially the more pristine ones, are expected to support viable populations of mammals. Table 4 is a list of species which possibly occur in the study area and is based on known distribution and habitat preferences.

3.2 REPTILES AND FROGS

As is the case with mammals, no intensive surveys of the reptile and frog fauna have occurred on the site. A list is available from a study undertaken along the Sticks Channel shore of Peel Inlet (K. Youngson, pers. comm.). The species of reptiles and frogs possibly occurring in the study area are listed in Table 5 and is compiled from known habitat preferences and distributions, plus information from the above mentioned list.

TABLE 4

MAMMALS POSSIBLY OCCURRING ON POINT GREY

	PREFERRED HABITAT	COMMENTS
Monotremes		
Echidnas - Tachyglossidae		
Short-beaked Echidna - Tachyglossus aculeatus	Woodland	
Marsupials		
Marsupial carnivores - Dasyuridae		
Western Quoll - Dasyurus geoffroii	Woodland	R & E
Brush-tailed Phascogale - Phascogale tapoatafa	Woodland	
Yellow-footed Antechinus - Antechinus flavipes	Steamside vegetation	
Grey-bellied Dunnart - Sminthopsis griseoventer	Woodland and shrubland	
Fat-tailed Dunnart - S. crassicaudata	Woodland and shrubland	
Bandicoots - Peramelidae		
Southern Brown Bandicoot - Isoodon obesulus	Swamps and moist areas	
Possums (Brushtails) - Phalangeridae		
Common Brushtail Possum - Trichosurus vulpecula	Woodland	
Possums (Pygmy Possums) - Burramyidae		
Western Pygmy Possum - Cercartetus concinnus	Woodland and shrubland	
Honey Possum - Tarsipedidae		
Honey Possum - Tarsipes rostratus	Shrubland and heath	
Kangaroos - Macropidae		
Western Brush Wallaby - Macropus irma	Woodland and shrubland	
Western Grey Kangaroo - M. fuliginosus	Most habitats	
Placental Mammals		
Bats - Molossidae		
White-striped Mastiff-bat - Tadarida australis	Woodland	
Little Mastiff Bat - Mormopterus planiceps	Woodland	
Bats - Vespertilionidae		
Greater Long-eared Bat - Nyctophilus timorensis	Woodland	
Goulds Long-eared Bat - N. gouldii	Woodland	
Lesser Long-eared Bat - N. geoffroyi	Woodland	
Goulds Wattled Bat - Chalinolobus gouldii	Woodland	
Chocolate Wattled Bat - C. morio	Woodland	
Great Pipistrelle - Pipistrellus tasmaniensis	Woodland	
King River Eptesicus - Eptesicus regulus	Woodland	
Mice and Rats - Muridae		
Water Rat - Hydromys chrysogaster	Swamps and shoreline	
Bush Rat - Rattus fuscipes	Swamps and moist areas	
Introduced Mammals		
Black Rat - Rattus rattus	Swamps and human habitation	
House Mouse - Mus musculus	Most habitats	
Rabbit - Oryctolagus cuniculus	Sandy habitats	
Fox - Vulpes vulpes	Most habitats	
Feral Cat - Felis catus	Most habitats	

R & E Gazetted as being "rare and endangered or otherwise in need of special protection"

TABLE 5

REPTILES AND FROGS POSSIBLY OCCURRING ON POINT GREY

	PREFERRED HABITAT	COMMENTS
Frogs		
Hylid Frogs - Hylidae		
Slender Tree Frog - Litoria adelaidensis	Swamps and streams	
Moores Tree Frog - L. moorei	Swamps and streams	
Ground Frogs - Leptodactylidae		
Moaning Frog - Heleioporus eyrei	Sandy habitats	
Banjo Frog - Limnodynastes dorsalis	Sandy habitats	
Turtle Frog - Myobatrachus gouldii	Sandy habitats	
Guenthers Toadlet - Pseudophryne guentheri	Sandy habitats	*
West Coast Froglet - Ranidella insignifera	Swamps and streams	*
Glauerts Froglet - R. glauerti	Swamps and streams	*
Lizards		
Geckoes - Gekkonidae		
Western Spiny-tailed Gecko - Diplodactylus spinigerus	Heath and shrubland	
Western Marbled Gecko - Phyllodactylus marmoratus	Woodland and shrubland	*
Legless Lizards - Pygopodidae		
Fry's Worm Lizard - Aprasia repens	Sandy habitats	
Fraser's Legless Lizard - Delma fraseri	Most habitats	
Burtons Legless Lizard - Lialis burtonis	Most habitats	*
Common Scaly-foot - Pygopus lepidopodus	Most habitats	
Dragon Lizards - Agamidae		
Western Bearded Dragon - Pogona m. minor	Most habitats	
Skink Lizards - Scincidae		
No common name - Cryptoblepharus plagiocephalus	Woodland and shrubland	*
Eleven Striped Skink - Ctenotus impar	Sandy habitats	*
Red-legged Striped Skink - C. labillardieri	Limestone outcrops	
Lesueurs Striped Skink - C. lesueurii	Sandy habitats	
King's Skink - Egernia kingii	Swamps	
Napoleons Skink - E. napoleonis	Woodland and shrubland	
No common name - Hemiergis quadrilineata	Most habitats	*
Three-striped Swamp Skink - Leiolopisma trilineatum	Swamps and streams	*
- Lerista elegans	Most habitats	*
- L. lineata	Sandy habitats	R & E
Greys Skink - Menetia greyii	Most habitats	*
- Morethia lineoocellata	Sandy habitats	
- M. obscura	Swampy areas	
Bobtail - Tiliqua r. rugosa	Most habitats	*
Monitor Lizards - Varanidae		
Gould's Monitor - Varanus gouldii	Most habitats	
Rosenbergs Monitor - V. rosenbergi	Most habitats	
Snakes		
Blind Snakes - Typhlopidae		
Southern Blind Snake - Ramphotyphlops australis	Sandy habitats	*
Pythons - Boidae		
Carpet Python - Morelia spilotes imbricatus	Woodland and shrubland	R & E
Elapid Snakes - Elapidae		
Yellow-faced Whipsnake - Demansia psammophis reticulata	Shrubland	
Crowned Snake - Notechis coronatus	Swampy areas	
Bardick - N. curtus	Swampy areas	
Western Tiger Snake - N. scutatus occidentalis	Most habitats	
Dugite - Pseudonaja a. affinis	Most habitats	*
Gould's Snake - Rhinoplocephalus gouldii	Most habitats	
Black-backed Snake - R. nigriceps	Damp areas	
Jan's Banded Snake - Vermicella bertholdi	Sandy habitats	*
Black-naped Snake - V. bimaculata	Sandy habitats	

* Recorded by Youngson

R & E Gazetted as being "rare and endangered or otherwise in need of special protection"

3.3 BIRDS

The Point Grey peninsula does not possess any restricted bird habitat nor is it expected to support large populations of species considered to be rare or otherwise in need of special protection, though undoubtedly birds in that category will utilize the peninsula from time to time. These species are indicated in Table 6.

Much of the peninsula is of a semi-cleared parkland nature and provides habitat for more open country species such as the Magpie, Richards Pipit and Ravens. The more valuable undisturbed bushland areas should, however, provide good habitat for a typical assemblage of south-west forest species. Table 6 has been compiled using known distributions and habitat preferences, and the Consulting Zoologist (G. Harold) personal records from the peninsula and observation from Lake Meelup (J. McLaren pers. comm.).

3.4 RARE AND ENDANGERED FAUNA POSSIBLY OCCURRING ON POINT GREY

In Tables 4 to 6, which list animal species possibly occurring in the study area, only four are gazetted as being "rare or otherwise in need of special protection" (Fisheries and Wildlife, 1983): These are:

- Western Quoll - Dasyurus geoffroii. This marsupial predator sometimes known as the Western Native Cat or Chudich once ranged widely across Australia. "In the early 19th century it was found from Shark Bay to Esperance, WA and across the continent into western NSW and Queensland. It is now restricted to the south western corner of Western Australia and to Papua New Guinea" (Arnold, 1983). In recent times in the south west it has made a minor recovery with most specimens being trapped in the vicinity of rocky ridges. It has been gazetted as a "species with drastically reduced range since European settlement" (Fisheries and Wildlife, 1983).
- Peregrine Falcon - Falco peregrinus. This fast flying predator ranges "Throughout Australia and Tasmania : generally uncommon, probably declining in settled regions : still well established in remote areas. Sedentry, nomadic or part migratory. Almost cosmopolitan, but not New Zealand" (Pizzey, 1980). It has been gazetted in category J, "in need of special protection" (Fisheries and Wildlife, 1983) probably in recognition of the need to protect the eggs and young.

TABLE 6

LAND BIRDS POSSIBLY OCCURRING ON POINT GREY

	J. McLaren Obs	G. Harold Obs	Comment
Casuariidae			
Emu - Dromaius novaehollandiae	*		
Accipitridae			
Black-shouldered Kite - Elanus caeruleus	*		
Square-tailed Kite - Lophoictinia isura			
Whistling Kite - Haliastur sphenurus	*		
Brown Goshawk - Accipiter fasciatus	*		
Collared Sparrowhawk - A. cirrocephalus			
Little Eagle - Aquila morphnoides	*		
Wedge-tailed Eagle - A. audax	*	*	
White-breasted Sea Eagle - Haliaeetus leucogaster			
Spotted Harrier - Circus assimilis			
Marsh Harrier - C. aeruginosus	*		
Osprey - Pandion haliaetus			
Falconidae			
Peregrine Falcon - Falco peregrinus			R & E
Australian Hobby - F. longipennis	*		
Brown Falcon - F. berigora	*		
Australian Kestel - F. cenchroides	*		
Phasianidae			
Stubble Quail - Coturnix novaezelandiae			
Turnicidae			
Painted Button Quail - Turnix varia			
Columbidae			
Common Bronzewing - Phaps chalcoptera	*		
Psittacidae			
Regent Parrot - Polytelis anthopeplus	*		
Ring-necked Parrot - Platyceceus zonarius	*	*	
Red-capped Parrot - P. spurius	*		
Western Rosella - P. icterotis	*		
Elegant Parrot - Neophema elegans			
Rock Parrot - N. petrophila			
Baudins Cockatoo - Calyptorhynchus baudinii	*		
Red-tailed Black Cockatoo - C. magnificus			
Galah - Cacatua roseicapilla	*		
Cuculidae			
Pallid Cuckoo - Cuculus pallidus	*		
Fan-tailed Cuckoo - C. flabelliformis			
Horsfield's Bronze Cuckoo - Chrysococcyx basalis			
Shining Bronze Cuckoo - C. lucidus			
Strigidae			
Barn Owl - Tyto alba			
Barking Owl - Ninox connivens			
Boobook Owl - N. novaeseelandiae	*		
Podargidae			
Tawny Frogmouth - Podargus strigoides			
Aegothelidae			
Australian Owlet-nightjar - Aegotheles cristatus			
Caprimulgidae			
Spotted Nightjar - Eurostopodus guttatus			
Apodidae			
Fork-tailed Swift - Apus pacificus			
Alcedinidae			
Laughing Kookaburra - Dacelo gigas	*	*	
Sacred Kingfisher - Halcyon sancta	*		
Meropidae			
Rainbow Bee-eater - Merops ornatus	*		
Hirundinidae			
White-backed Swallow - Cheramoeca leucosterna			
Welcome Swallow - Hirudo neoxena	*		
Tree Martin - H. nigricans	*		
Fairy Martin - H. ariel			

Table 6 Continued

	J. McLaren Obs	G. Harold Obs	Comment
Motacillidae			
Richards Pipit - Anthus novaeseelandiae	*	*	
Campephagidae			
Black-faced Cuckoo-shrike - Coracina novaehollandiae	*	*	
Pachycephalidae			
Scarlet Robin - Petroica mulicolor			
Red-capped Robin - P. goodenovii	*		
Rufous Whistler - Pachycephala rufiventris	*		
Golden Whistler - P. pectoralis	*		
Grey Shrike-thrush - Colluricincla harmonica	*	*	
Monarchidae			
Grey Fantail - Rhipidura fuliginosa	*	*	
Willie Wagtail - R. leucophrys	*	*	
Restless Flycatcher - Myiagra inquieta	*		
Acanthizidae			
Western Flyeater - Gerygone fusca	*		
Weebill - Smicrornis brevirostris	*		
Broad-tailed Thornbill - Acanthiza apicalis	*		
Western Thornbill - A. inornata			
Yellow-rumped Thornbill - A. chrysorrhoa	*	*	
White-browed Srub-wren - Sericornis frontalis	*	*	
Maluridae			
Splendid Fairy-wren - Malurus splendens	*	*	
Daphoenosittidae			
Australian Sittella - Daphoenositta chrysoptera	*		
Climacteridae			
Rufous Tree-creeper - Climacteris rufa	*		
Dicaeidae			
Mistletoebird - Dicaeum hirundinaceum	*		
Pardalotidae			
Spotted Pardalote - Pardalotus punctatus	*		
Striated Pardalote - P. striatus	*	*	
Zosteropidae			
Grey-breasted White-eye - Zosterops lateralis	*		
Meliphagidae			
Brown Honeyeater - Lichmera indistincta	*		
Singing Honeyeater - Meliphaga virescens	*		
White-plumed Honeyeater - M. penicillata	*		
Western Spinebill - Acanthorhynchus superciliosus	*		
White-naped Honeyeater - Melithreptus lunatus			
New Holland Honeyeater - Phylidonyris novaehollandiae			
White-cheeked Honeyeater - P. niger	*		
Yellow-throated Miner - Manorina flavigula			
Little Wattlebird - Anthochaera chrysoptera	*		
Red Wattlebird - A. carunculata	*	*	
White-fronted Chat - Epthianura albifrons			
Grallinidae			
Magpie-lark - Grallina cyanoleuca	*	*	
Artamidae			
Black-faced Woodswallow - Artamus cinereus	*		
Dusky Woodswallow - A. cyanopterus			
Cracticidae			
Grey Butcherbird - Cracticus torquatus	*	*	
Australian Magpie - C. tibicen	*	*	
Grey Currawong - Strepera versicolor	*		
Corvidae			
Australian Raven - Corvus coronoides	*	*	

- Carpet Python - Morelia spilotes. This species has a distribution in "south western Western Australia, north to Geraldton and Yalgoo and east to Pinjin, Kalgoorlie, Norseman and Cape Le Grand" (Storr et al. 1986). It also occurs on various islands off the west and south coasts and also as a different sub-species in the northern Kimberley. Other sub-species occur in eastern and central Australia and southern Papua New Guinea. Although gazetted, the Carpet Python has not been categorized though it surely falls under category G, "species with widespread distribution but which are very rare" (Fisheries and Wildlife, 1983).
- Lerista lineata. This is a small sand swimming species of skink lizard. It is distributed coastally from the Swan River to about Mandurah. So far it has not been reported south of Mandurah though much suitable habitat is present and its existance in this area cannot be discounted. It has been gazetted under categories C, "species with drastically reduced range since European settlement" and E, "species with very restricted geographic range" (Fisheries and Wildlife, 1983).

It is not expected that the proposed development will have any serious adverse effects on the first three species mentioned above, species as they all range widely across south western WA and much of the study area is already in a very degraded state. Lerista lineata is in a different category to the first three species as its distribution is entirely west costal from the Swan River to Mandurah, an area already much destroyed by urban, industrial and agricultural development. The reserves that exist in this region are under constant threat from accidental and deliberate burning, feral predators and invasion by exotic weeds. If in fact Lerista lineata exists on the Point Grey Peninsula, strict attention should be given to protection of the reserves particularly by the maintenance of fire breaks along-side the reserves abutting the development area.

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FIGURE

APPENDIX B

REPORT OF AN ARCHAEOLOGICAL SURVEY OF THE POINT GREY DEVELOPMENT STUDY AREA

Prepared by
G. Quartermaine
for Dames & Moore
December 1986 (c)

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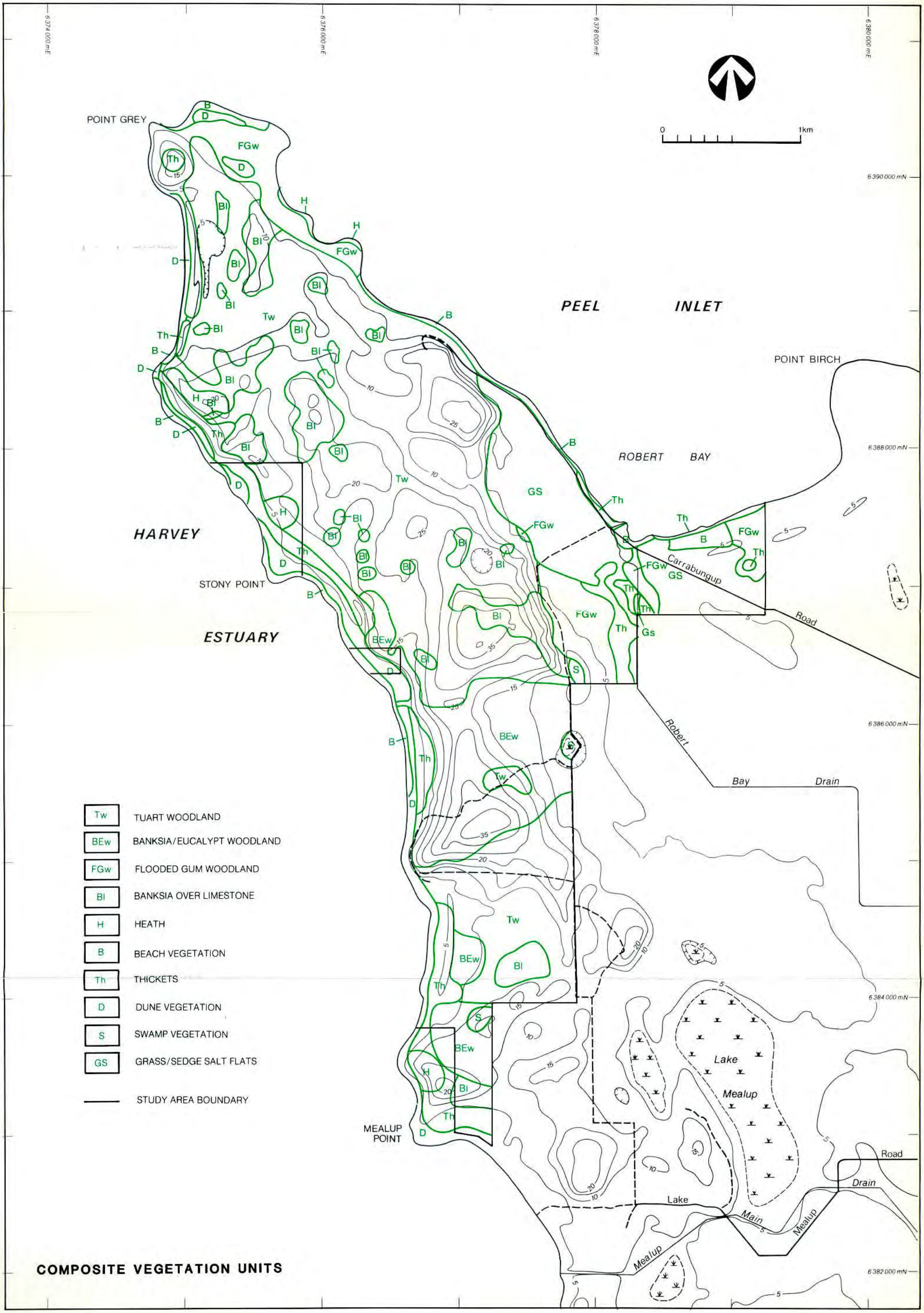
Dames & Moore



COMPOSITE VEGETATION UNITS

Figure 1

APPENDIX B

1.0 INTRODUCTION

1.1 BACKGROUND TO SURVEY

An Aboriginal survey of the Point Grey Development Study Area, was commissioned by Dames & Moore. The fieldwork for the archaeological component of this survey was executed in December 1986 by Gary Quartermaine, Archaeological Consultant and Emma Quartermaine, Archaeological Assistant.

Discussions were conducted with Warren Tacey of Dames & Moore, who provided background information and maps for the project, and co-ordinated field work arrangements. Members of the staff of the Department of Aboriginal Sites, Western Australian Museum, were also consulted to investigate previous archaeological work in the project area.

The objectives of the archaeological survey were to:

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

1.2 LOCATION

The Point Grey Development Study Area is located 20km west of Pinjarra on a promontory separating Peel Inlet and the Harvey Estuary. The designated survey area encompasses 1083ha of land (Figure 1).

1.3 OBLIGATIONS UNDER THE ACT

The Western Australian Aboriginal Heritage Act, 1972-1980, makes provision for the recording and preservation of places and objects customarily used by, or traditional to, the original inhabitants of Australia. The Act defines the obligations of the community relating to sites (Addendum B-II and B-III).

The Aboriginal survey is aimed at identifying the potential for disturbance of the physical environment to affect archaeological sites. Aboriginal consultation is being conducted by Rory O'Connor in recognition of the possible significance of the survey area to contemporary Aboriginal people.

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

1.4 CONSULTANCY BRIEF

The archaeological survey of the Point Grey Development Study Area was to provide a systematic sample coverage of the designated survey area with a purposive sample of areas of high site discovery potential.

1.5 FORMAT OF REPORT

The format of this report is based on the requirements of the Western Australian Museum.

The next section, on regional background, discusses the environment of the area, land integrity and previous archaeological research. Section 3 details the methodology and results of the survey. Finally, Section 4 discusses the results of the survey, assesses the significance of sites and offers for consideration a series of recommendations based on the results of the survey.

1.6 ACKNOWLEDGEMENTS

The information and assistance given by Rhonda Sinclair and Warren Tacey, of Dames & Moore, Liz Bloor of the Western Australian Museum, and Glen Davies, caretaker at Kensington Farm is acknowledged.

2.0 REGIONAL BACKGROUND

2.1 ENVIRONMENT

The Point Grey Development Study Area is situated 20km west of Pinjarra, to the south of Peel Inlet and east of the Harvey Estuary.

The Swan Coastal Plain, on which the survey area is situated, is subject to a warm Mediterranean climate, which is characterised by a dry summer and a wet winter. The average annual rainfall for Pinjarra is 957mm. The temperature ranges from an average maximum of 29^{o}C in February to an average minimum of 8.8^{o}C in August (Beard, 1979).

The Swan Coastal Plain is part of the Perth Basin geological formation. The Perth Basin is a deep trough filled with Phanerozoic sedimentary rocks with a surface mantle of Quaternary deposits (Playford, et al. 1975).

The study area is characterised by landforms of the Spearwood Dune System. This is mostly a low hilly landscape with a grey brown sandy surface. Some areas of yellow sand occur over limestone, which outcrops in several places. The shoreline of the Peel Inlet and Harvey Estuary includes sandy terraces and beach ridges and some areas of saline flats (McArthur and Bartle, 1980).

The vegetation of the area appears to be in three units:

(i) Jarrah (Eucalyptus marginata), Marri (E. calophylla) and Tuart (E. gomphocephala) with Banksia attenuata and B. ilicifolia, and, where not cleared for pasture, a shrub layer including Xanthorrhoea spp., Macrozamia reidlie, Daviesia spp., plus others. This vegetation association occurs on most of the survey area.

(ii) Shoreline vegetation includes Melaleuca spp., some scattered Banksia and Eucalypts plus Carpobrotus spp. and other ground cover, backed by thickets of Kunzea ericifolia.

(iii) Melaleuca thickets surround a few small swampy areas that contain dense sedges and rushes (McArthur and Bartle, 1980).

2.2 LAND INTEGRITY

The northern half of the designated survey area is mostly cleared pasture land currently used to graze sheep. It is subdivided into a number of paddocks with fences and firebreaks.

The southern half is largely uncleared or regrowth, but is also fenced into paddocks.

2.3 PREVIOUS ARCHAEOLOGICAL RESEARCH

The earliest evidence for prehistoric occupation of the south-west of Australia is dated at 38,000 year ago, for a statified site at Upper Swan, located 25km northwest of Perth (Pearce and Barbetti, 1981). A number of Holocene sequences have yielded data on possible cultural/environmental changes during, and after, the recent transgression of the sea (Clarke and Dortch, 1977; Hallam, 1974 and Pearce, 1978). This work postulates increased populations on the coastal plain, rising to a peak just before European contact. It was previously thought that the jarrah forest belt, to the east, was little used. However, evidence now exists for a least ephemeral occupation of this area up to 6,000 years in the past (Anderson, 1984; Pearce, 1982).

Prehistoric stone tool industries in the south-west have been classified into earlier and later phases (Dortch, 1977). The early phase industries have only been documented from a few well dated sites. They include small, thick flake scrapers, bipolar cores, notched-denticulated pieces, flakes from discoidal cores and single and multi-platform cores. These artefacts have been manufactured from a range of lithic materials, including a distinctive Eocene fossiliferous chert. It appears that access to this chert was lost after the last marine transgression (Dortch, 1979; Glover, 1975).

Later phase industries, generally found in archaeological contexts from 6,000 to 3,000 years ago, include the addition of geometric microliths, bladelets and backed blades, and a variety of adze flakes, which are part of the Australian "small tool tradition" (Dortch, 1977; Mulvaney, 1975).

Anderson (1984) has proposed a land use model for prehistoric exploitation of the Swan Coastal Plain and its hinterland, based on regional research that investigated the relative proportions of variously sized, known surface artefact scatters and their associated artefact densities. This model suggests that, due to the variation in the resources available in the three different environmental zones investigated, there was more intensive use of the coastal plain than either the adjacent forest or open woodland plateau to the east.

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

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

3.0 ARCHAEOLOGICAL SURVEY

3.1 METHODOLOGY

The survey design involved three stages as follows:

1. **Background research:** This involved familiarisation with previously recorded sites in the region, and maps and environmental data for the survey area.

2. **Survey strategy:** A preliminary reconnaissance was conducted to determine if the proposed survey strategy would be suitable. It involved an inspection of the designated survey area to check access, condition of tracks, and surface visibility.

Access was through a series of tracks and along fencelines, which allowed all parts of the survey area to be reached. Surface visibility was very restricted because of the ground cover vegetation and pasture throughout the designated survey area. Firebreaks and small devegetated sandy areas, plus the sandy foreshore of the Harvey Estuary, provided the best surface visibility. The general sandy nature of the soil made artefact location potentially easy, as the only lithic material occurring naturally was the limestone which outcropped in various parts of the survey area.

The designated survey area was systematically sampled from north to south using east-west transects, concentrating on areas with good surface visibility or high site discovery potential. The shoreline was surveyed, where vegetation cover permitted, in traverses parallel with the shore. Survey work was conducted mainly on foot, but also with the use of a slow-moving 4WD vehicle in some parts.

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

A site recording form, compiled prior to the field survey using information from previous research, was used in the field. This type of form enables a standardised set of data to be obtained from each site in an efficient manner. Such a recording format is of use for analysis and may have relevance to other researchers. Categories under which site data are normally recorded are as follows:

(i) Site description - type, dimensions, components, stratification potential, and features
(ii) Environmental setting - landform, geology, soil, vegetation, proximity to water, surface visibility and disturbance
(iii) Artefact assemblage - numbers, density, types, lithic materials, artefact dimensions and retouch. A controlled sample of artefacts would be recorded, in this way, in the field
(iv) Site location and sketch map.

3. **Report preparation:** This brings together all the data into a form suitable to the client and the Western Australian Museum.

3.2 RESULTS

No archaeological sites were located as a result of a systematic sample survey of the designated survey area. One isolated find, a quartz flake, was recorded on an eroding slope of yellow sand 50m east of the shoreline of the Harvey Estuary, at a point approximately 1.0km south of Stoney Point.

An underground cave, named Avalon Cave and mapped in 1974 by the Western Australian Speleology Society, was located. It is in a limestone ridge and appears as a sink-hole at surface level with a shaft, about one metre maximum diameter, going down for 4-5 metres and then becoming horizontal. The surface area and entrance were examined but no archaeological material was found. The cave has two underground chambers, both about 10 x 5m and 1-2m high however, these were not investigated as it was considered unlikely that Aboriginal people would have utilised them because of the long, narrow, vertical entrance. No information of archaeological significance had been recorded when the cave was mapped previously.

4.0 CONCLUSIONS

4.1 DISCUSSION

The Point Grey Development Study Area is the proposed location for the Thomas Peel College, a tertiary college for overseas students. The College will only take up a small area of the designated survey area. Residential lots and nature reserves are also planned for the area.

After preliminary research, the designated survey area was subjected to a systematic sample survey, mainly on foot. No archaeological sites were located during this process, although one isolated find, a quartz flake, was recorded but not registered as an Aboriginal site.

The location of the survey area adjacent to the resources of the Peel-Harvey Estuary system indicates a reasonably high site discovery potential. However, visibility of the ground surface is severely restricted over most of the area due to pasture growth, natural vegetation and forest litter. Areas of devegetated sand had often been well trampled over by sheep.

A previous survey (Novak, 1975) in the area indicated that areas cleared for development provide the highest site discovery potential. Nevertheless few sites were found to the east of Harvey Estuary either by Novak (1975) or during this survey, although archaeological material may still be present. A survey on the Mandurah-Pinjarra Road (O'Connor and Quartermaine, 1986) failed to locate any archaeological material at known ethnographic sites because of disturbance and/or vegetation cover.

European settlement of Pinjarra goes back almost to the date of the founding of the British colony at Perth in 1829. The Aboriginal population was severely depleted, in the Pinjarra area, by the so-called "Battle of Pinjarra". This may also help account for the lack of archaeological material in the survey area.

4.2 RECOMMENDATIONS

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

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

Human interference to Aboriginal sites is an offence (unless authorised under the Act) as outlined in Section 17 of the Western Australian Aboriginal Heritage Act, 1972-1980. Therefore, it is recommended that the principal take adequate measures to inform any personnel working on the project, of this requirement.

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ADDENDUM B-I

GLOSSARY

ADZE

Stone tool used as a wood-making 'chisel' usually mounted in a handle.

ARTEFACT

Any object made by human agency.

ASSEMBLAGE

Set of artefacts found in close association with each other.

BACK POINT, BACK BLADE

A point or blade with one margin deliberately blunted to form a penknife-like back.

BLADE

A parallel-sided flake, at least twice as long as it is wide.

BLADELET

A smaller version of a blade.

BULB OF PRECUSSION

The rounded swelling left on the inner face of a flake or blade directly below the point of impact on the striking platform.

CHIP

A flake or fragment less than 1cm in length.

CHOPPER

A large heavy core tool used for chopping.

CONCHOIDAL FRACTURE

Shell-like, curved surface with ripple marks formed in certain types of rock fracture.

CORE

A lump or nodule of stone from which flakes have been removed.

FLAKE

A piece of stone detached by striking a core with a hammerstone.

GEOMETRIC MICROLITH

A microlith of triangular, trapezoidal or other geometric shape, with an abruptly trimmed thick margin.

GRIDING STONE

A millstone for grinding up ochre, seeds, fruits or other foodstuffs.

HAMMERSTONE

A lump of stone or river pebble used in fashioning small stone tools.

LEILIRA BLADE

Either a long, pointed blade triangular in section, or an elongated rectangular blade trapezoid in section.

MICROLITH

A small stone artefact, less than 3cm in its maximum dimension.

PEBBLE TOOL

Chopping tool made by flaking one or both faces of a large river 'pebble' or cobble.

RETOUCH

Flaking or trimming of a stone artefact after detachment from a core, usually by trimming or re-sharpening the edges.

SCRAPER

Stone tool made on a flake, with one or more working edges, generally used for chiselling, cutting, gouging or planing wood. Hence, its various forms such as notched, nosed, steep, concave, end, side or flake.

UTILIZED PIECE

Any otherwise unaltered piece of stone that has at least, part of, one edge intentionally modified.

REFERENCE: Flood, J. (1983), Archaeology of the Dreamtime. Collins, Sydney.

ADDENDUM B-II

OBLIGATIONS RELATING TO SITES UNDER THE
ABORIGINAL HERITAGE ACT, 1972-1980

(Provided by the Western Australian Museum)

"Report of Findings

15. Any person who has knowledge of the existence of anything in the nature of Aboriginal burial grounds, symbols or objects of sacred, ritual or ceremonial significance, cave or rock paintings or engravings, stone structures or arranged stones, carved trees, or of any other place or thing to which this Act applied or to which this Act might reasonably be suspected to apply, shall report its existence to the Trustees, or to a police officer, unless he has reasonable cause to believe the existence of the thing or place in question to be already known to the Trustees.

Excavation of Aboriginal Sites

16. (1) Subject to Section 18, the right to excavate or to remove anything from an Aboriginal site is reserved to the Trustees.

(2) The Trustees may authorise the entry upon and excavating of an Aboriginal site and the examination or removal of any thing on or under the site in such manner and subject to such conditions as they may direct.

Offences relating to Aboriginal sites

17. A person who -

(a) excavates, destroys, damages, conceals or in any way alters any Aboriginal site, or

(b) in any way alters, damages, removes, destroys, conceals, or who deals with in a manner not sanctioned by relevant custom, or assumes the possession, custody or control of, any object on or under an Aboriginal site, commits an offence unless he is acting with the authorisation of the Trustees under Section 16 or the consent of the Minister under Section 18.

Consent to certain uses

18. (1) For the purposes of this section, the expression "the owner of any land" includes a lessee from the Crown, and the holder of any mining tenement or mining privilege, or of any right or privilege under the Petroleum Act 1967, in relation to the land.

(2) Where the owner of any land gives to the Trustees notice in writing that he requires to use the land for a purpose which, unless the Minister gives his consent under this section, would be likely to result in a breach of Section 17 in respect of any Aboriginal site that might be on the land, the Trustees shall, as soon as they are reasonably able, form an opinion as to whether there is any Aboriginal site on the land, evaluate the importance and significance of any such site, and submit the notice to the Minister together with their recommendation in writing as to whether or not the Minister should consent to the use of the land for that purpose, and, where applicable, the extent to which and the conditions upon which his consent should be given.

(3) Where the Trustees submit a notice to the Minister under subsection (2) of this section he shall consider their recommendation and having regard to the general interest of the community shall either -

(a) consent to the use of the land the subject of the notice, or a specified part of the land, for the purpose required, subject to such conditions, if any, as he may specify; or

(b) wholly decline the consent to the use of the land, the subject of the notice for the purpose required, and shall forthwith inform the owner in writing of his decision.

(4) Where the owner of any land has given to the Trustees notice pursuant to subsection (2) of this section and the Trustees have not submitted it with their recommendation to the Minister in accordance with that subsection the Minister may require the Trustees to do so within a specified time, or may require the Trustees to take such other action as the Minister considers necessary in order to expedite the matter, and the Trustees shall comply with any such requirement.

(5) Where the owner of any land is aggrieved by a decision of the Minister made under subsection (3) of this section he may, within the time and in the manner prescribed by rules of court, appeal from the decision of the Minister to the Supreme Court which may hear and determine the appeal.

(6) In determining an appeal under subsection (5) of this section the Judge hearing the appeal may confirm or vary the decision of the Minister against which the appeal is made or quash the decision and substitute his own decision which shall have the effect as if it were the decision of the Minister, and may make such order as to the cost of the appeal as he sees fit.

(7) Where the owner of any land gives notice to the Trustees under subsection (2) of this section, the Trustees may, if they are satisified that it is practicable to do so, direct the removal of any object to which this Act applies from the land to a place of safe custody.

(8) Where consent has been given under this section to a person to use any land for a particular purpose nothing done by or on behalf of that person pursuant to, and in accordance with any conditions attached to, the consent constitutes an offence against this Act."

ADDENDUM B-III

NOTES ON THE RECOGNITION OF ABORIGINAL SITES

(Provided by the Western Australian Museum)

There are various types of Aboriginal sites, and these notes have been prepared as a guide to the recognition of those types likely to be located in the survey area.

An Aboriginal site is defined in the Aboriginal Heritage Act, 1972-1980 in Section 5 as:

"(a) any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;

(b) any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;

(c) any place which, in the opinion of the Trustees, is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the State;

(d) any place where objects to which this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed."

Habitation Sites

These are commonly found throughout Western Australia and usually contain evidence of tool-making, seed grinding and other food processing, cooking, painting, engraving or numerous other activities. The archaeological evidence for some of these activities is discussed in detail under the appropriate heading below.

Habitation sites are usually found near an existing or former water source such as a gnamma hole, rock pool, spring or soak. They are generally in the open, but they sometimes occur in shallow rock shelters or caves. It is particularly important that none of these sites be disturbed as the stratified deposits which may be found at such sites can yield valuable information about the inhabitants when excavated by archaeologists.

Seed Grinding

Polished or smoothed areas are sometimes noticed on/near horizontal rock surfaces. The smooth areas are usually 25cm wide and 40 or 50cm long. They are the result of seed grinding by the Aboriginal women and indicate aspects of the past economy.

Habitation Structures

Aboriginal people sheltered in simple ephemeral structures, generally made of branches and sometimes tussocks of grass. These sites are rarely preserved for more than one occupation period. Occasionally rocks were pushed aside or used to stabilise other building materials. When these rock patterns are located they provide evidence of former habitation sites.

Middens

When a localised source of shellfish and other foods has been exploited from a favoured camping place, the accumulated ashes, hearth stones, shells, bones and other refuse can form mounds at times several metres high and many metres in diameter. Occasionally these refuse mounds or middens contain stone, shell or bone tools. These are most common near the coast but examples on inland lake and river banks are not unknown.

Stone Artefacts Factory Sites

Pieces of rock from which artefacts could be made were often carried to camp sites or other places for final production. Such sites are usually easily recognizable because the manufacturing process produces quantities of flakes and waste material which are clearly out of context when compared with the surrounding rocks. All rocks found on the sandy coastal plain for example, must have been transported by human agencies. These sites are widely distributed throughout the State.

Quarries

When outcrops of rock suitable for the manufacture of stone tools were quarried by Aborigines, evidence of the flaking and chipping of the source material can usually be seen *in situ* and nearby. Ochre and other mineral pigments used in painting rock surfaces, artefacts and in body decoration are mined from naturally occurring seams, bands and other deposits. This activity can sometimes be recognised by the presence of wooden digging sticks or the marks made by these implements.

Marked Trees

Occasionally trees are located that have designs in the bark which have been incised by Aborigines. Toeholds, to assist the climber, were sometimes cut into the bark and sapwood of trees in the hollow limbs of which possums and other arboreal animals sheltered. Some tree trunks bear scars where sections of bark or wood have been removed and which would have been used to make dishes, shields, spearthrowers and other wooden artefacts. In some parts of the State, platforms were built in trees to accommodate a corpse during complex rituals following death.

Burials

In the north of the State it was formerly the custom to place the bones of the dead on a ledge in a cave after certain rituals were completed. The bones were wrapped in sheets of bark and the skull placed beside this. In other parts of Western Australia the dead were buried, the burial position varying according to the customs of the particular area and time. Natural erosion, or mechanical earthmoving equipment occasionally exposes these burial sites.

Stone Structures

If one or more stones are found partly buried or wedged into a position which is not likely to be the result of natural forces, then it is probably that the place is an Aboriginal site and that possibly there are other important areas nearby. There are several different types of stone arrangements ranging from simple cairns or piles of stone to more elaborate designs. Some were constructed in connection with food gathering. Low weirs which detain fish when tides fall are found in coastal areas. Some rivers contain similar structures that trap fish against the current. It seems likely that low stone slab structures in the south-west jarrah forests were built to provide suitable environments in which to trap some small animals. Low walls or pits were sometimes made to provide a hide or shelter for a hunter.

Elongated rock fragments are occasionally erected as a sign or warning that a special area is being approached. Heaps of alignments of stones may be naturalistic or symbolic representations of animals, people or mythical figures.

Paintings

These usually occur in rock shelters, caves or other sheltered situations which offer a certain degree of protection from the weather. The best known examples in Western Australia occur in the Kimberley region but paintings are also found through most of the State. One or several coloured ochres as well as other coloured pigments may have been used at a site. Stencilling was a common painting technique used throughout the State. The negative image of an object was created by spraying pigment over the object which was held against the wall.

Engravings

This term describes designs which have been carved, pecked or pounded into a rock surface. They form the predominant art form of the Pilbara region but are known to occur from the Kimberleys in the north to about Toodyay in the south. Most engravings occur in the open, but some are situated in rock shelters.

Caches

It was the custom to hide ceremonial objects in niches and other secluded places. The removal of objects from these places, or photography of the place or objects or any other interference with these places is not permitted.

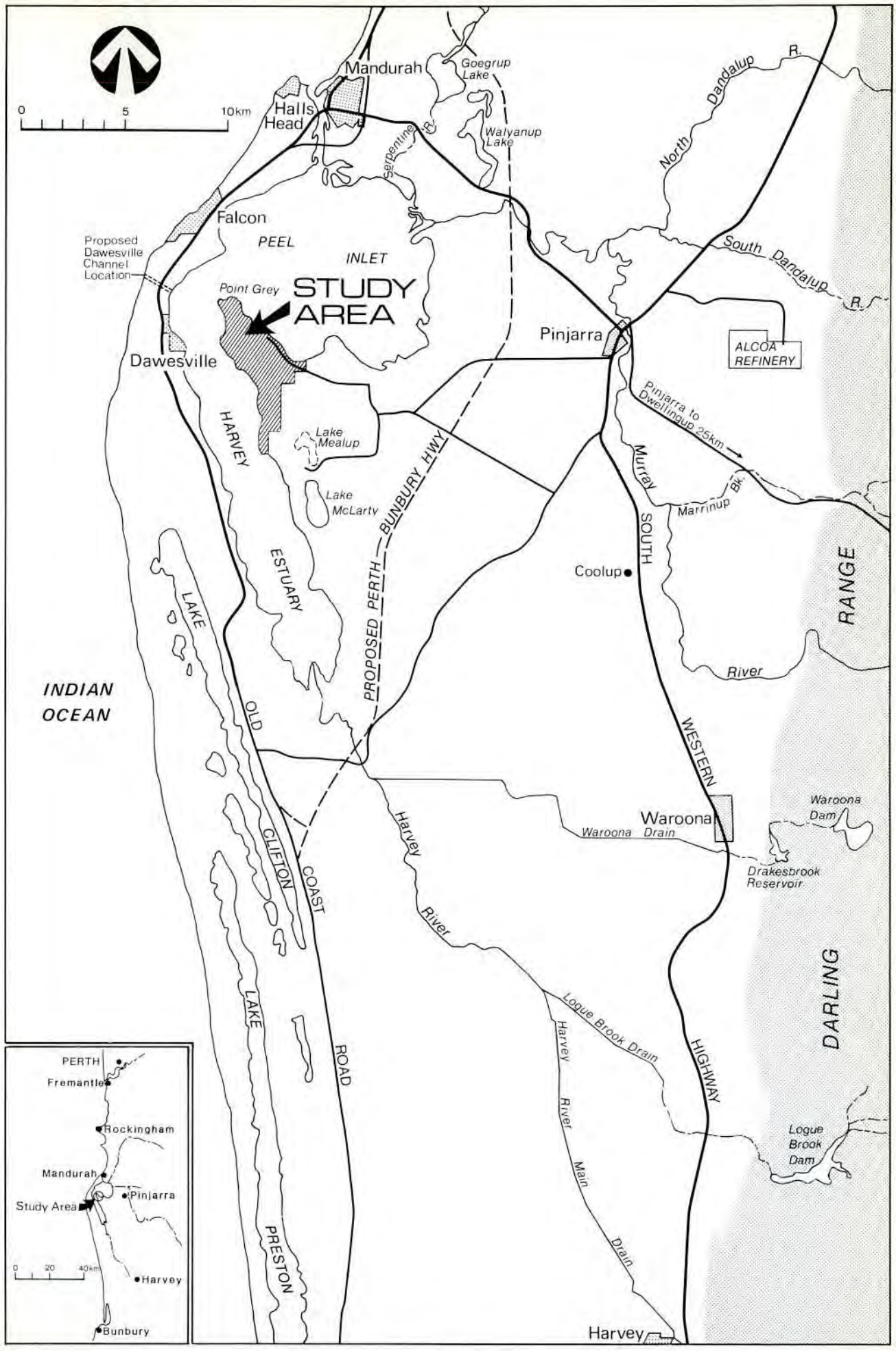
Ceremonial Grounds

At some sites the ground has been modified in some way by the removal of surface pebbles, or the modelling of the soil, or the digging of pits and trenches. In other places there is no noticeable alteration of the ground surface and Aborigines familiar with the site must be consulted concerning its location.

Mythological Sites

Most sites already described have a place in Aboriginal mythology. In addition there are many Aboriginal sites with no man-made features which enable them to be recognised. They are often natural features in the landscape linked to the Aboriginal account of the formation of the world during the creative 'Dreaming' period in the distant past. Many such sites are located at focal points in the creative journeys of mythical spirit beings of the Dreaming. Such sites can only be identified by the Aboriginal people who are familiar with the associated traditions.

FIGURE



LOCATION OF POINT GREY STUDY AREA

Dames & Moore

Figure 1

APPENDIX C

APPENDIX C

REPORT ON AN ETHNOGRAPHIC SURVEY OF POINT GREY

Prepared by
Rory O'Connor
for Dames & Moore
February 1987

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1.0 INTRODUCTION

1.1 BACKGROUND TO REPORT

This report is based on a period of field research carried out in the vicinity of Point Grey, near Pinjarra, in January 1987. It was commissioned by Dames & Moore, 26 Lyall Street, South Perth, on behalf of Mallina Holdings Limited with the specific aim of locating the traditional Aboriginal custodians of the area, or their successors, and consulting with them to ensure that the proposed development of a residential/educational/tourist complex did not pose a threat to Aboriginal sites, as defined by the Western Australian Aboriginal Heritage Act, 1972-1980.[1,2]

In consideration of the possible archaeological significance of the area, a survey for archaeological sites was also commissioned. This was conducted by Mr G. Quartermaine, registered archaeological consultant.

1.2 ACKNOWLEDGEMENTS

The author gratefully acknowledges assistance and advice given by officers of the Department of Aboriginal Sites (WA Museum), by Mr K. Colbung, Mr F. Nannup, Mr P. Bennell, Mrs J. Bennell (nee Walley), Mrs E. Little, Mr O. Little, Mr V. Little and Mr S. Hume.

Information previously supplied by Mr T. Bennell, Mr F. Collard, Mr J. Coomes, Mr T. Cooper, Mr T. Corbett Snr, Mr S. Dinah, Ms V. Little and Mr A. Sutton has also been incorporated into this report.

1.3 FORMAT OF REPORT

Section 2 of this report, which follows, considers regional history of relevance to the question of the cross-generational transfer of cultural information. This question is especially pertinent in view of the fact that the traditional Aboriginal population of the survey region has been totally replaced by a population of persons of mixed Aboriginal and European descent. Section 3 describes the methodology employed during the survey and details the results of that survey. Finally, Section 4 offers for consideration a series of recommendations based on the results of the research.

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1. The location of the study area is shown in Figure 1
2. Relevant sections of the legislation are included as Addendum B-II

2.0 ABORIGINAL SITES IN SOUTH-WESTERN AUSTRALIA

2.1 POPULATION MOVEMENTS (Aboriginal History)

The Aboriginal inhabitants of the south-western corner of this state appear to have been a distinct socio-cultural group in precontact times (Howard, 1980:90). Linguistic variation occurred, and was used by them to delimit and identify sub-groups within this larger collectivity. These labels probably identified different dialectal units of a common south-west language, although they were taken by early settlers to signify separate 'tribal' groups (Berndt, 1980:81-82). Figure 2 shows a reconstruction of these pre-contact Aboriginal 'tribal' boundaries, which suggests that the area under survey falls in the north-central sector of the lands of the group identified as Bindjareb.

Brown (1983:3-4), quoting from early settlers' accounts, points out that a strong sense of territorial ownership of land existed, and that each group had its own distinct ground. These early accounts appear to refer, however, not to the larger dialectal units, but to the estates of local descent groups. Salvado wrote in 1846 that:

> ". . . an individual risks his life whenever he leaves the district where he was born, or where his friends assure his safety . . . nothing would convince them (to accompany him from New Norcia to Perth) . . . fear, amounting to panic, of being killed by other natives forced them to turn back."
>
> (trans. Stormon, 1977:57)

Also Nairn (1976:8) quotes records from the WA Historical Society as revealing that:

> ". . . the local natives were annoyed by the Murray River tribesmen for the 'trespassing' on Swan River territory. The raiders had also stolen flour which could well have been taken by the Swan River natives, so as a reprisal, local native trackers speedily identified several of the raiders by footprints left in the spilt flour."

It would appear, therefore, that apart from the separateness of estates, the groups referred to as dialectal units also maintained a degree of territorial separation.

These divisions disappeared soon after contact. Thus, Salvado noted in 1848 that:

> ". . . the enmity between natives from widely separated parts disappeared, so that they could be trusted to take letters for distances of more than a hundred miles."
>
> (Op.cit.:85)

Berndt (1980:81) points out that the merging of social units occurred when people of different dialectal units were forced to live in mixed membership settlements. Thus, settlements such as those at Carrolup or at Moore River have been instrumental in forging a south-western Aboriginal identity; a widely-scattered population of mixed-ethnic background who live in the South-West of this state, see themselves as sharing a common identity and refer to themselves as Nyungars. For example, Colbung (1980:100) writes that:

> ". . . my particular country is the territory of the Nyungars located in the South-West of Western Australia."

2.2 THE BATTLE OF PINJARRA

The single most important event in the history of Aboriginal-European contact in the survey region is undoubtedly the so-called Battle of Pinjarra, which took place in 1834 on the banks of the Murray River, where Pinjarra Hospital is now situated. Friction between settlers and Aborigines in the Murray River region had led to a punitive expedition being despatched under the command of Lieutenant Stirling. The onesided battle, which resulted in heavy Aboriginal casualties, was the culminating point of this expedition - although historical records vary, the Aboriginal account relates that up to 150 men, women and children died in this fight. The demoralized survivors offered no further active resistance to the settlers. One hundred and fifty years on, the site of the battle has become a symbol of resistance among Nyungars, thereby locating the Murray River as an area of potential conflicts.

Despite the near extinction of the Murray River Aborigines, however, continuity with the traditional past was maintained. The two people who contributed most to the transmission of knowledge were George Windjan, who settled in a camp near Sandalwood Parade in Mandurah, and Kitty, who settled in Pinjarra. Both were survivors of the Battle. Parents of the present senior generation (all of whom are now of mixed ethnic descent), were young adults when Windjan and Kitty were still alive. One elderly man who now lives in Pinjarra was born in that period and retains an impressive amount of traditional knowledge. Widely respected throughout the South-West as a faith healer, he also speaks an amount of the traditional language, an accomplishment shared by few of his fellow Nyungars.

In the early years of this century, an Aboriginal fringe developed around the main townships of the South-West; a fringe that lasted until the 1950s, when Nyungars began to move into State Housing Commission and occasionally privately rented houses.[3] The main regional fringe camp developed into the Pinjarra Reserve. Other smaller camps were located at Halls Head, Barragup, Ravenswood, Adam Road and Robert Bay. Long-term residents of these camps still live in Pinjarra, Mandurah and the Perth Metropolitan area.

2.3 REGIONAL FRAMEWORK (Mythological)

Waugal (also Wagal, Wagyl, or Uocol) is the Dreaming ancestor who, according to local tradition, created the Murray and Serpentine river system, and still retains a presence in some deep pools in the area. Waugal beliefs, widespread throughout the South-West, refer to a water-creative spiritual force with a serpentine physical manifestation. In some cases, the spiritual aspect is emphasized; in others, the physical.

Waugal beliefs are certainly not a latter-day phenomenon; they were noted and recorded by early settlers. George Fletcher Moore in 1885 wrote of the Waugal as a "huge winged serpent" who lived in deep dark waters. Salvado (1977 trans.:128) wrote of the Waugal as follows:

---

3. All of these matters have been dealt with in detail in O'Connor, Bodney and Little (1985). The very brief "potted history" supplied here is designed merely as a framework for the survey results and as an answer to the inevitable question: "do these Aborigines living today really know anything about the traditional past?"

> ". . . they dread even more going near large pools of water, in which they believe there lurks a great serpent called 'Uocol', who kills them if they dare to drink there or draw water during the night. A large number of natives came to me one evening asking for water. The first one took all I had and drank it, and the others, about fifteen of them, asked me to go to a pool nearby to get some for them. I showed them the bucket and told them to go themselves. They all fell silent, and no-one dared take the bucket, or tell me what they were afraid of, until, about an hour later, one of them said respectfully: 'n-alla cape uoto, chetchet cuaragn: nunda uoto quaraga inad' [if we go and take water, very soon we will be killed, but if you go you will be alright]. . . however much the natives of both sexes like to swim 'dogpaddle' style in summer, they will never go into water that is dark and deep, because they say that the serpent Uocol is there, and they are afraid of him even during the daytime."

So far as could be ascertained, there are no Waugal beliefs associated with the survey area. To the south of Point Grey, however, the small island located between Herron Point and the west bank of Harvey Estuary, some 800m off the eastern shore, is a site of religious significance. According to Aboriginal tradition, this island was the site of a ceremonial ground, the focal point of which was a white egg-shaped stone a little larger than an emu egg. The island is south of a crossing of the estuary formerly marked by a line of poles, which was originally discovered by settlers on horseback who were pursuing an Aboriginal fugitive and saw him ford the estuary at this point.

The egg-stone was reputedly removed by two European-Australians (McLarty family ?), but was returned when they fell ill; its power is said to be so great that a person falls ill if his or her shadow crosses it. The stone, though still on the island is not nowadays visible, as it has been covered by sands lifted in the winter winds.

3.0 RESULTS OF SURVEY

3.1 PREVIOUSLY RECORDED SITES

There are no previously recorded ethnographic sites of significance in the survey area. Nearest sites are Waugal areas on the Murray and Serpentine Rivers and Egg Island (see Section 2.3).

3.2 NEWLY RECORDED SITES

The possibility that a native burial ground may be situated in Carrabungup Nature Reserve (C2707) near Point Birch was mentioned by informats in the course of the survey. As this Reserve is outside the study area, however, the matter was not pursued further.

Independent evidence collected by the author in 1985 suggested that Point Grey had been used as an Aboriginal camping ground in traditional times and that a degree of sentimental attachment was still associated with it among living people (O'Connor, et al. 1985). The existence of the Estuary crossing and associated camps at Herron Point and also traditional camps at Coodanup would tend to verify this evidence.

Evidence collected during the present survey has also shown that Aborigines from Pinjarra and Mandurah have continued to camp until quite recent times in discreet and private nooks on the shores of Austin and Robert Bays. Contact with Point Grey Peninsula, however, was not lost, despite the fact that this area is fenced private property. The existence and approximate location of the cave mentioned in the archaeological survey is known to local Aborigines.

Tc establish the location and dimensions of Aboriginal sites in the survey region, the author interviewed Aboriginal people who are socially acknowledged as having rights of custodianship over regional sites and are also known to have knowledge of Aboriginal religion and patterns of land use in the area. The survey region was then visited with two groups of informats. In accordance with normal practice, the names of these informants will be listed at the Department of Aboriginal Sites, when the author fulfils his obligations under Section 15 of the Aboriginal Heritage Act.

The area thus identified as a traditional camping ground constitutes the northern point of the peninsula and a narrow strip of land which extends down the western side. This land has been fenced, presumably to keep stock away from the limestone outcrops.

4.0 CONCLUSIONS

A survey of the Point Grey region has revealed the existence of a traditional Aboriginal camping ground on the northern shores of the peninsula. The camping ground has been defined as an Aboriginal site and has been recorded as such in accordance with the Aboriginal Heritage Act, 1972- 1980.

The area of land encompassing the northern tip of Point Grey and the western foreshore area is to be ceded to the Crown free of cost. The area approximates 40ha and has been nominated as part of the Point Grey Concept Development Plan and incorporated in the Town Planning Scheme Amendment No. 58. It is recommended that this significant foreshore area be named the Windjan Memorial Reserve.

No disturbance to the Aboriginal site can take place without first obtaining the necessary approvals in accordance with the Aboriginal Heritage Act, 1972-1980.

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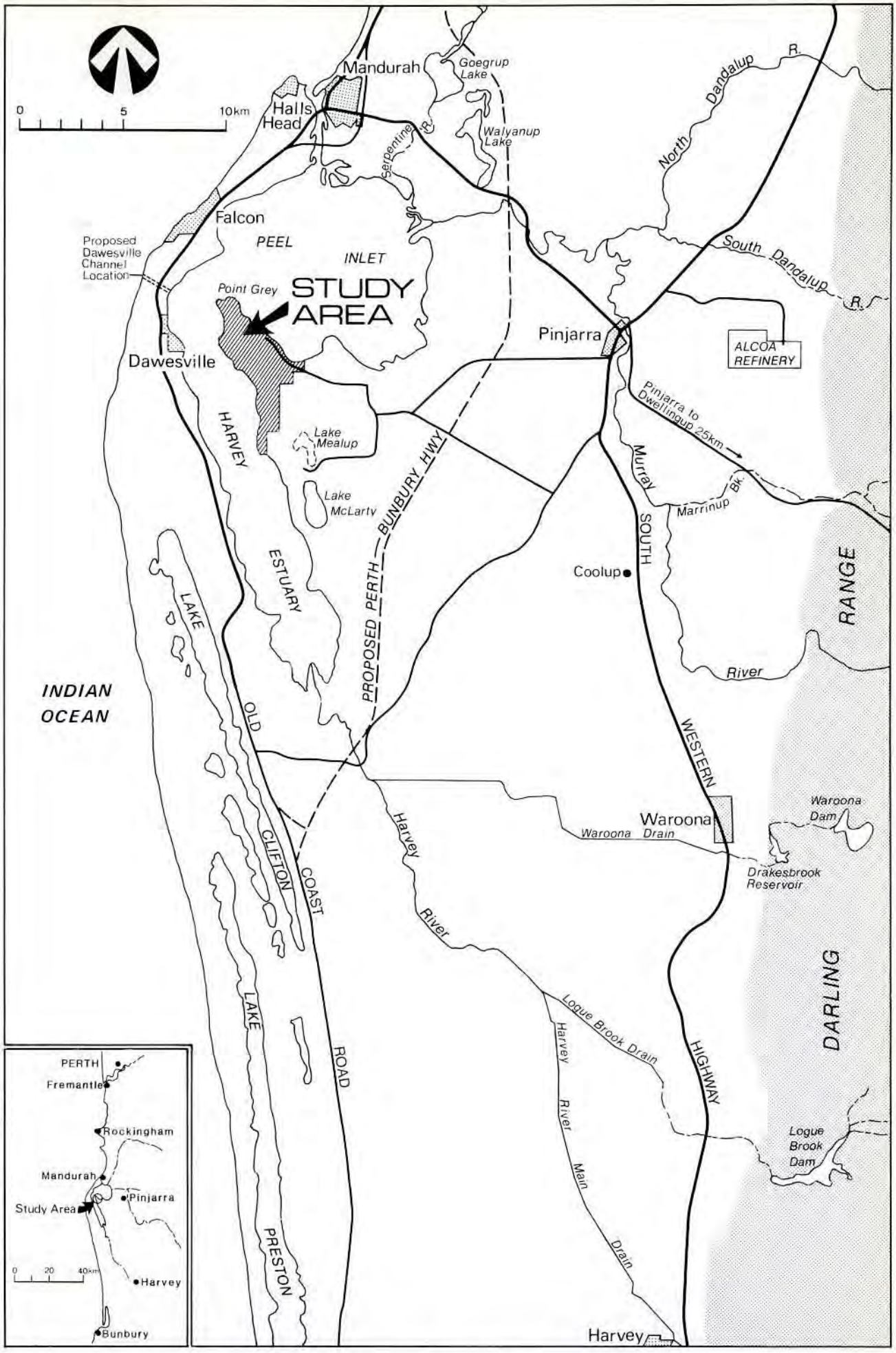
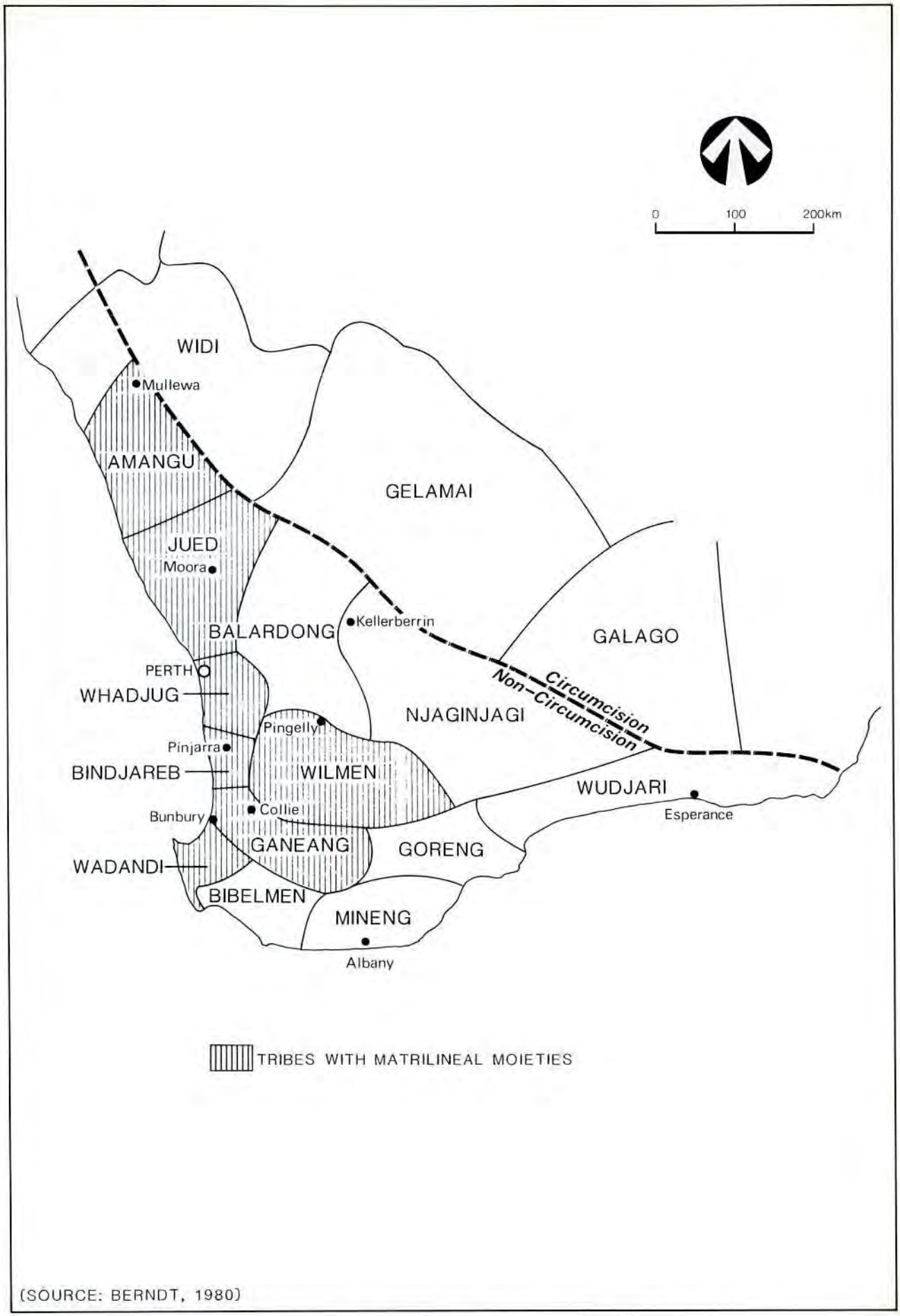
FIGURES



LOCATION OF POINT GREY STUDY AREA

Dames & Moore

Figure 1



TRIBAL BOUNDARIES OF THE SOUTH WEST

APPENDIX D

APPENDIX D

ESTUARINE ENVIRONMENT

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1.0 INTRODUCTION

This Appendix describes the estuarine biological environment and existing biological status of the Peel-Harvey Estuary.

2.0 ESTUARINE PHYSICAL FEATURES

2.1 MORPHOLOGY AND BATHYMETRY

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

The Peel Inlet and Harvey Estuary are coastal lagoons that have undergone a sequence of terrestrial, marine and estuarine phases in response to world wide changes in sea level that have occurred during recent geological history. Peel Inlet exists today as a circular waterbody approximately 70km^2 in area, with a central basin that does not exceed 2.5m below AHD (approximately mean sea level) in depth. The Inlet comprises a broad, intertidal and shallow sub-tidal marginal shelf (less than 0.5m AHD) that constitutes 37% of the area of Peel Inlet (Hodgkin and Birch, 1986). The Harvey Estuary is an elongated waterbody, aligned north-northwest/south-southeast. It is approximately 20km long and 3 to 4km wide. It has an area of 60km^2. Water depth also rarely exceeds 2.5m AHD, and marginal shallows of less than 0.5m below AHD constitute approximately 14% of the Estuary's area (Figure 1).

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

2.2 HYDROLOGY

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

The Serpentine River has a catchment area of 1800km^2 that comprises forested land east of the Darling Scarp and agricultural land on the Swan Coastal Plain. The Serpentine is dammed at the western edge of the Plateau, so much of its input to the Peel Inlet is derived from rainfall on the coastal plain. This water is relatively fresh.

The Murray River has a catchment area of approximately 8300km^2 which comprises a mixture of agricultural and forested land. This river is not dammed, and since it derives water from the lower rainfall agricultural areas east of the escarpment, where soil salt storage levels are high, water salinities are generally high (Collins, 1974).

The Harvey River discharges into the southern end of the Estuary and has a catchment area of approximately 700km^2. The catchment on the Coastal Plain is intensively developed for irrigated agriculture. The River and its tributaries are dammed by the Logue Brook Dam, the Harvey Weir, the Samson Brook Dam, the Drakesbrook Reservoir and the Stirling Dam. Consequently, much of the flow to the Estuary is derived from rainfall on the agricultural land, west of the escarpment. Nutrient loads are often high. As was the case for the Serpentine River, this water is generally fresh.

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

2.3 SALINITY

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

The salinity range tends to be greater in the Harvey Estuary than the Peel Inlet. This is due to the long residence times for water in the Harvey Estuary that occur as a result of restricted exchange with the ocean. During the winter months, the restricted exchange has the effect of minimizing dilution of the fresh water with water from the marine-influenced Peel Inlet. During summer, the high evaporation rates result in hypersaline conditions (45 to 50ppt) in the shallow, southern extremity of the Harvey Estuary, and restricted exchange with oceanic water (34ppt) through tidal exchange, ensures that high salinities persist until the onset of winter rains.

2.4 TIDAL REGIME

The astronomic daily tides in the ocean near Mandurah are small (0.2 to 0.9m) and seldom exceed 0.1m in the Peel-Harvey Estuary because of the restriction of flow imposed by the Mandurah channel.

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

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

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

In summary, the short term astronomic tidal variations that occur along the coastline are attenuated by approximately 90% in the Peel-Harvey Estuary by the restrictions imposed by the inlet channel and therefore generally do not exceed 0.1m. The longer period tidal variations generated by continental shelf waves are not attenuated by the inlet channel, but even when combined with meteorological effects, generally do not exceed 0.5m.

3.0 ESTUARINE BIOLOGICAL ENVIRONMENT

3.1 FLORA

3.1.1 Phytoplankton

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

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

3.1.2 Benthic Macro-Algae

Benthic algal populations were dominated by Cladophora aff. albida, a green alga which grew as small ball-like clumps of densely branched, radiating filaments. These clumps were often unattached on the Estuary floor, where they decomposed to form an anaerobic ooze. A detailed summary of the biology of Cladophora is given by Hodgkin et al. (1980). Cladophora is now rarely seen in the Peel-Harvey Estuary.

Since 1981, Cladophora has been replaced by Chaetomorpha, Enteromorpha, Chondria, Gracilaria and Ulva (Lukatelich and McComb, 1986). A complete list of species is provided in Table 1. It is these algae which contribute to summer algal accumulations on the shores of the Estuary, and cause widespread problems for local residents and managing authorities.

The problems experienced during these algal accumulations include:

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

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

3.1.3 Aquatic Angiosperms

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

TABLE 1

AQUATIC MACRO-ALGAE OF THE PEEL-HARVEY ESTUARINE SYSTEM

CHLOROPHYTA

Acetabularia calyculus. Quoy and Gaim.
Acetabularia peniculus. (R.Br), Solma.
Chaetomorpha aurea. (Dillw.), Kuetz.
Chaetomorpha linum. (Muell.), Kuetz.
Cladophora spp. - several species.
Enteromorpha spp. - several species.
Ulva sp.

CHAROPHYTA

Lamprothamnium papulosum. (Wallr.), J.R.em.R.D.W.

PHAEOPHYTA

Caulocystis uvifera. (Ag.), Areach.
Cystoseira trinodis. (Forsk.), Ag.
Dictyota sp.
Hormophysa triquetra. (L.), Keuta.

RHODOPHYTA

Chondria spp.
Corynospora australis. Harv.
Gracilaria verrucosa. (Huds.), Papenfuss
Polysiphonia spp.
Laurencia spp.

Source: Hodgkin et al. 1980

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

3.2 FAUNA

3.2.1 Invertebrates

The invertebrate fauna can be broadly grouped into zooplankton and benthic invertebrates. Zooplankton are microscopic animals that live suspended in the water column and feed on microscopic plants and/or other zooplankton. Benthic invertebrates are small animals that live on or within sediments and benthic flora on the bottom of the Estuary. Their diet generally comprises decaying material known as detritus.

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

- Zooplankton

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

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

- Benthic Invertebrates

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

  The Peel-Harvey benthic invertebrate composition is reasonably small, probably as a result of the large salinity range. The common species are summarized in Table 2, and of these, approximately 90% of the biomass is made up of four species of molluscs, three species of worms and three species of amphipods (Hillman, 1985).

3.2.2 Fish and Large Crustaceans

The fish fauna have been comprehensively documented by Potter et al. (1983) and Lenanton et al. (1985). These studies identified 29 families and 55 species of fish, which is comparable to the fish fauna of the Swan River Estuary.

The fish population can be arbitrarily grouped according to the way they utilize the Estuary. These groupings have been described by Hillman (1985) as follows:

- species capable of spending their entire life in the Estuary,
- species which spawn at sea, but use the Estuary as a nursery for juveniles, and
- species which only use the lower reaches of the Estuary as mature or maturing adults, during months when marine salinities prevail.

These groupings have been used to describe the life cycle characteristics of the fifteen most abundant species of fish found in the Estuary (Table 3). Nine of these species are marine and spend variable periods of their life cycle in the Estuary. These species, including the mullets and whitings, form the basis of the amateur and professional fishing industry.

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

TABLE 2

COMMON BENTHIC INVERTEBRATES OF THE PEEL-HARVEY ESTUARY

ANNELIDA:	Polychaeta	
	Capitellidae	*Capitella sp.*
	Orbinidae	*Scoloplos simplex*
	Spionidae	*Prionospio sp.*
	Serpulidae	*Mercierella enigmatica*
	Nereidae	*Ceratonereis erythraeensis*
	Eunicidae	*Marphysa sanguinea*
MOLLUSCA:	Bivalvia	
	Mytilidae	*Mytilus edulis*
		Xenostrobus securis
	Erycinidae	*Arthritica semen*
	Tellinidae	*Tellina deltoidalis*
	Psammobiidae	*Sanguinolaria biradiata*
	Mactridae	*Spisula trigonella*
	Lyonsiidae	*Anticorbula amara*
MOLLUSCA:	Gastropoda	
	Hydrobidae	*Potamopyrgus sp.*
		Hydrococcus braxieri
	Nassidae	*Nassarius pauperatus*
	Amphibolidae	*Salinator fragilis*
CRUSTACEA:		
	Amphipoda	*Corophium sp.*
		Paracorophium sp.
		Melita sp.
	Mysidae	*Mysid*
	Decapoda	*Palaemonetes australis*
INSECTA:		
	Chironomidae	*Chironomus sp.*

Source: Hodgkin et al. 1980

TABLE 3

LIFECYCLE CHARACTERISTICS OF THE MOST ABUNDANT FISH SPECIES ON THE PEEL-HARVEY ESTUARY

SPECIES NAME	COMMON NAME	LIFECYCLE CHARACTERISTICS
MARINE SPECIES WHICH ENTER ESTUARY FOR VARIABLE PERIODS OF THEIR LIFECYCLE (in order of abundance)		
Hyperlophus vittatus	Sandy sprat	In Estuary when young; moves out as it gets bigger
Pelates sexlineatus	Six-lined trumpeter	Enters Estuary when young; moves away from shallows and to deeper water as it gets bigger
Aldrichetta forsteri	Yellow-eye mullet	In Estuary mainly when young, spawns offshore
Mugil cephalus	Sea Mullet	Prefers riverine habitats when young, then moves out to sea as it gets bigger
Torquigener pleurogramma	Barded toadfish	Only very young are found in the Estuary
Favonigobius lateralis	Long-finned goby	Only very young are found in the Estuary
Pranesus ogilbyi	Ogilby's hardyhead	Most stages are found in the Estuary
Gymnopistes marmoratus	Devil fish	Uses Estuary as a nursery over a very restricted period
Sillago schomburgkii	Western sandwhiting	In Estuary mainly when young
SPECIES CAPABLE OF PASSING THEIR WHOLE LIFECYLE WITHIN THE ESTUARY (in order of abundance)*		
Apogon ruepellii	Gobbleguts	Sensustricto
Atherinosoma elangata	Elongate hardyhead	Sensustricto
Nematalosa vlaminghi	Perth herring	Semi-anadromous
Atherinosoma wallacei	Hardyhead	Sensustricto
Cnidoglanis macrocephalus	Cobbler	Sensustricto
Amniataba caudavittatus	Yellow-tailed trumpeter	Sensustricto

* These species may exist as marine elsewhere, but in this particular area, they are an estuarine population

Sensustricto: Species capable of passing through their whole lifecycle within the Estuary

Source: Potter et al. 1983

The blue manna crab (Portunus pelagicus) occurs throughout the Estuary, and aspects of this species' biology have been reported by Potter et al. (1983). The blue manna crab is known to be highly seasonal in abundance and distribution. The species is widely dispersed throughout the Peel Inlet, Harvey Estuary and the saline regions of tributary rivers during summer and autumn. Following the onset of winter rains, when salinity levels in the Peel-Harvey Estuary decrease, the range of P. pelagicus contracts to the mouth of the Estuary where salinities remain favourably high.

Two species of prawn are important within the Estuary. The larger of the two is the western king prawn (Penaeus latisulcatus). Data collected by Potter and Manning during 1985/86 (Potter and Manning, 1986) indicate that this species spawns offshore between November and April, with peak activity occuring in January. New post-larval recruits move into the Estuary during this period. The mature prawns evidently commence migration out of the Estuary in February, and continue to do so through to May.

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

3.3.3 Waterbirds

The Peel-Harvey Estuary and adjacent lakes are very important areas for water birds especially in times of drought when inland lakes dry out (Anon, 1962). Each year tens of thousands of aquatic birds spend the summer on the Peel Inlet, though during droughts these numbers are dramatically increased. Indeed it is during such adverse conditions that the Estuary becomes crucial to their survival. The Estuary becomes even more valuable when it is considered that up until 1966, approximately 500,000 acres of wetland had been drained in the south-west (Riggert, 1966). This figure does not include the large areas of wetlands in the south-west that have been degraded by high levels of salt.

Also to be noted is that the Estuary supports a breeding colony of pelicans, one out of a known total of only eight in Western Australia, plus it is the only colony south of Shark Bay.

This local population is the largest on any Estuary in the south-west and surveys done by the former Department of Fisheries and Wildlife (now part of CALM) in 1975-76 showed figures ranging from 600 in August 1975 to 1100 in January 1976. This population represents approximately 60% of all pelicans known to occur on all south-western estuaries (Lane, 1976). The above survey also noted an estimated peak of 8 to 10,000 ducks and swans, many thousands of resident migratory wading birds including 15 to 20,000 stilts (both Banded and Pied). "Though accurate surveys of migratory wader poplulations were not possible, Peel-Harvey Estuary appears to support larger numbers of these birds than any other Estuary in the south-west, with the possible exception of Wonnerup - Vasse" (Lane, 1976).

3.3.3.1 Value of the Point Grey Peninsula to Aquatic Birds

Further Fisheries and Wildlife studies (1976-77) concluded that the most valuable areas to waterbirds were the Sticks Channel area, the south-eastern area of Peel Inlet (including Robert Bay) and the southern portion of the Harvey Estuary. Large parts of Peel Inlet and Harvey Estuary have now been recommended as conservation reserves (DCE, 1983). Although not as critical, the western shores of the Point Grey peninsula are however still areas of considerable importance. During the aerial surveys, (Lane, pers. comm.) various points between Robert Bay and Mealup Point were noted to provide little disturbed roosting sites for cormorants, pelicans, and to a lesser extent ducks and waders (see Figure 2). Birds observed at the most important of these points are tabulated in Table 4.

The shallows and bays surrounding the peninsula were also monitored and it was found that the western shores supported fewer numbers of waterfowl (in a Peel Inlet context) than the eastern side. Robert Bay was the richest area. Table 5 shows the numbers of birds, dates observed and locations (see Figure 2).

Tables 4 and 5 demonstrate the obvious value of the roosting sites, shallows and mudflats of the Point Grey peninsula, especially the eastern side. While specific data on numbers of species utilizing the area is lacking, it is expected that most species listed on the Estuary could be present in habitats near to the Point Grey peninsula. This list is presented in Table 6. None of the species listed in Table 6 are gazetted as "rare or otherwise in need of special protection" though 18 are listed in the Japan - Australia Treaty on Migratory and Endangered Birds, and are indicated in the table.

TABLE 4

AQUATIC BIRDS OBSERVED ON POINT GREY PENINSULA (POINTS AND CAYS)

Point C	Ca 200 Cormorants	August 1976
	Ca 200 Cormorants	April 1977
	Ca 200 Cormorants	June 1977
	Ca 100 Migratory Waders	December 1976
	100 Ducks	December 1976
Point D	Ca 1000 Cormorants	April 1977
	Ca 200 Cormorants	October 1976
	Ca 200 Cormorants	February 1977
Point E	Ca 300 Grey Teal	June 1977
Point F (Point Grey)	Ca 200 Cormorants	April 1977
	Ca 100 Migratory Waders	December 1976
	122 Pelicans	February 1977
	Ca 100 Ducks	February 1977
Point G	Ca 200 Cormorants	February 1977
	28 Pelicans	January 1976
Point H	Ca 500 Cormorants	June 1977
Point I	Ca 250 Cormorants	February 1977
	83 Pelicans	March 1976
Point L (Stony Point)	Ca 50 Ducks	December 1976
	62 Pelicans	March 1977

Source: Lane (pers. comm.).

The tourist value of the Inlet is due partly to the abundance of fish, crabs and prawns though of equal charm is its scenic beauty which includes the tree-lined shores and wildflowers. The presence of waterfowl further enhances these areas. "Extensive mudflats and shallows are essential to the survival of many forms of water life including fish, prawns, and crabs, and the preservation of long stretches of natural foreshore are important as shelter belts and breeding areas for both land and waterbirds" (Jenkins, 1971). Consequently, damage and undue disturbance to these areas will be detrimental to not only the wildlife, but also in the longer term, the tourist and recreational value of the Peel Inlet.

TABLE 5

AQUATIC BIRDS OBSERVED ON POINT GREY PENINSULA (BAYS)

A-B	260 Black Swans	April 1977
B-C	100 Black Swans	August 1976
	85 Black Swans	October 1976
	50 Migratory Waders	December 1976
	75 Grey Teal	December 1976
	148 Black Swans	February 1977
	12 Pelicans	February 1977
	300 Black Swans	April 1977
B-D	7 Pelicans	August 1976
	16 Greenshanks	October 1976
	139 Black Swans	April 1977
C-E	1000-1100 Migratory Waders	December 1976
D-E	500 Cormorants	August 1977
H-I	30 Cormorants	August 1976
	6 Pelicans	October 1976
	7 Black Swans	December 1976
	20 Cormorants	February 1977
	1 Egret	February 1977
	1 Darter	February 1977
	25 Red-necked Avocets	February 1977
	7 Black Swans	February 1977
	4 Black Swans	April 1977
I-J	40 Black Swans	December 1976
J-K	10 White-faced Herons	December 1976
L-M	2 Shelducks	August 1976
	1 Greenshank	December 1976
	12 Black Swans	December 1976
	Ca 50 Migratory Waders	February 1977
	50 Red-necked Avocets	February 1977
	Ca 350 Grey Teal and Shelducks	February 1977
	Ca 140 Grey Teal and Shelducks	April 1977
	20 Shelducks	April 1977
M-N	25 Cormorants	August 1976
	3 Black Ducks	August 1976
	150 Migratory Waders	February 1977
	Ca 55 Grey Teal	April 1977

Source: Lane (pers. comm.).

3.3.3.2 Recommendations

It is recommended that:

- Human (and canine) disturbance should be excluded from a minimum of 50m both sides of roosting sites. If the Dawesville Cut eventuates, some roosting sites may be submerged by the resultant higher tidal fluctuations causing the remainder to be of even greater importance.
- Disturbance levels should be minimized in the Robert Bay area and around points C to G.
- Tables 4 and 5 demonstrate that bird activity on the western side of the peninsula in terms of both numbers and species diversity, is relatively low in the bays between points H and I; and M and N (see Figure 2). It is therefore recommended that the proposed boat ramps be situated midway between these points to allow roosting birds to remain undisturbed.

- The proposed eastern boat ramp site between D and C may have higher potential impact due to both the importance of the points and the bay between them (see Tables 4 and 5). It is therefore recommended that if the eastern boat ramp were placed between points B and C (much closer to B than C) the impact could be lessened for the following reasons:

    - Point B is unimportant as a roosting site.
    - Although the bay B-C is important, most birds would congregate in the shallows in the vicinity of point C and the siting of the boat ramp closer to point B would leave this area undisturbed.
    - Deep water access is still good and would not entail an unreasonable amount of dredging.

TABLE 6

WATERBIRD SPECIES RECORDED ON PEEL-HARVEY ESTUARY

SPECIES	PEEL-HARVEY ESTUARY FEB 1976	
Hoary-headed Grebe (Podiceps poliocephalus)	X	
Crested Grebe (P. cristatus)	X	
Australian Pelican (Pelecanus conspicillatus)	X	
Black Cormorant (Phalacrocorax carbo)	X	
Little Black Cormorant (P. sulcirostris)	X	
Pied Cormorant (P. varius)	X	
Little Pied Cormorant (P. melanoleucos)	X	
Darter (Anhinga rufa)	X	
Reef Heron (Egretta sacra)	X	
Little Egret (E. garzetta)	X	
White Egret (Egretta alba)	X	JA
White-faced Heron (A. novaehollandiae)	X	
White-necked Heron (Ardea pacifica)	X	
White Ibis (Threskiornis molucca)	X	
Straw-necked Ibis (T. spinicollis)	X	
Glossy Ibis (Plegadis falcinellus)	X	
Yellow-billed Spoonbill (Platalea flavipes)	X	
Black Swan (Cygnus atratus)	X	
Mountain Duck (Tadorna tadornoides)	X	
Black Duck (Anas superciliosa)	X	
Grey Teal (A. gibberifrons)	X	
Blue-winged Shoveller (A. rhynchotis)	X	
Pink-eared Duck (Malacorhynchus membranaceus)	X	
White-eyed Duck (Aythya australis)	X	
Musk Duck (Biziura lobata)	X	
Whistling Eagle (Haliastur sphenurus)	X	
White-breasted Sea Eagle (Haliaeetus leucogaster)	X	
Swamp Harrier (Circus approximans)	X	
Osprey (Pandion haliaetus)	X	
Swamphen (Gallinula porphyrio)	X	
Coot (Fulica atra)	X	
Pied Oystercatcher (Haematopus ostralegus)	X	
Black-fronted Dotterel (Charadrius melanops)	X	
Red-capped Dotterel (C. ruficapillus)	X	
* Mongolian Dotterel (C. mongolus)	X	JA
* Large Sand-dotterel (C. leschenaultii)	X	JA
* Grey Plover (Pluvialis squatarola)	X	JA
* Whimbrel (Numenius phaeopus)	X	JA
* Eastern Curlew (N. madagascariensis)	X	JA
* Greenshank (Tringa nebularia)	X	JA
* Common Sandpiper (T. hypoleucos)	X	JA
* Terek Sandpiper (T. cinerea)	X	JA
* Knot (Calidris canutus)	X	JA
* Great Knot (C. tenuirostris)	X	JA
* Sharp-tailed Sandpiper (C. acuminata)	X	JA
* Pectoral Sandpiper (C. melanotos)	X	JA
* Red-necked Stint (C. ruficollis)	X	JA
* Curlew Sandpiper (C. ferruginea)	X	JA
* Black-tailed Godwit (Limosa limosa)	X	JA
* Bartailed Godwit (L. lapponica)	X	JA
Pied Stilt (Himantopus himantopus)	X	
Banded Stilt (Cladorhynchus leucocephalus)	X	
Red-necked Avocet (Recurvirostra novaehollandiae)	X	
Silver Gull (Larus novaehollandiae)	X	
Caspian Tern (Sterna caspia)	X	
Crested Tern (S. bergii)	X	JA
Whiskered Tern (S. hybrida)	X	
Fairy Tern (S. nereis)	X	
Little Grassbird (Megalurus gramineus)	X	
White-fronted Chat (Epthianura albifrons)	X	
TOTAL	60	

Source: Lane, 1976

* Summer migrants from the northern hemisphere

JA Species listed in the Japan-Australia Treaty on Migratory and Endangered Birds

4.0 EXISTING NUTRIENT AND BIOLOGICAL STATUS

The Peel-Harvey Estuary is a highly stressed nutrient enriched ecosystem. This condition is largely a consequence of the agricultural activities carried out in the Murray, Serpentine and Harvey River catchment areas. The undeveloped soils in these catchments are inherently deficient in nutrients and this has led to the heavy use of fertilisers. This in turn has resulted in elevated nutrient levels (principally phosphorus and nitrogen) in the rivers discharging into the Estuary. The eutrophic condition is manifested in the Peel Inlet by an excessive growth of benthic macro-algae (Enteromorpha, Chaetomorpha and Ulva) and in the Harvey Estuary by regular 'blooms' of phytoplankton (Nodularia).

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

During the early 1970s, the dominant nuisance macro-alga was Cladophora, a filamentous species that grew as small cottonwool - like balls, and formed a carpet over the bottom. Since then, the blue-green micro-alga Nodularia, has become a problem species in the Harvey Estuary and Chaetomorpha, Ulva and Enteromorpha in the Peel Inlet.

Nodularia blooms are normally confined to spring and early summer, and have been worse and more prolonged in the Harvey Estuary. There were occassional blooms before 1980, but since then, they have been annual events. Since 1983, the area covered by the Nodularia bloom has remained relatively constant.

Data compiled by Lenanton et al. (1985) and Potter et al. (1983) indicate that the extensive growth of macro-algae and blue-green alga during the last ten years have coincided with increases in total fish abundance and catch per unit effort. This led to the conclusion that the beneficial effects of increasing entrophication on the fish fauna are greater than the detrimental consequences (Lenanton et al. 1985).

Since these results were published, the total fish catch for the Estuary has decreased from 807t in 1982/83 to 515t in 1984/85. This fall was almost entirely due to a reduction in the yellow eye mullet catch (Fisheries Department, 1986). The reason for this trend is unclear, however, it is unlikely to be due to the eutrophic condition of the Estuary (Lenanton, 1986). A possible explanation is that the increased beach fishing effort for yellow eye mullet near Mandurah may be depleting spawning stocks of this species, leading to reduced numbers of juveniles within the Estuary.

Whilst the increased eutrophication of the Estuary does not appear to have directly affected fish stocks, various studies have demonstrated that Nodularia blooms do affect the distribution of fish populations. This has meant that fishermen who normally operate in the Harvey Estuary, where the blooms are most intense, have been required to divert their activities to the Peel Inlet where conditions for fishing are more favourable during the bloom periods (Lenanton et al. 1985).

The effect of increased macro-algal and blue-green algal growths since 1970 on crustacean populations, is more difficult to assess for two reasons. The first is that very little research has been performed on the three species that form the basis of the fishery, ie. the blue manna crab, the western king prawn and the western school prawn. The second reason is that a significant proportion of the crab and prawn catch is taken by amateurs, and therefore, catch statistics are incomplete. However, EPA officers have noted that Nodularia growth seems to exclude prawns from the area (EPA, pers. comm.). The general opinion is that prawn catches in the Estuary were high in the 1960s, slightly reduced in the 1970s and somewhere in between during the 1980s (Loneragan, pers. comm.). Studies on both species of prawn are presently being carried out by the Environmental and Life Sciences group at Murdoch University. These studies may present a clearer understanding of the relationship between prawns and the eutrophic condition of the Estuary.

5.0 ESTUARINE CONDITION AT POINT GREY

The Point Grey foreshore comprises three geomorphological zones:

- The western foreshore, which represents the north eastern region of the Harvey Estuary, and consists of a relatively narrow marginal platform approximately 400m wide.

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

The geomorphology of the intertidal and shallow sub-tidal margins of Point Grey has a significant affect on the local estuarine condition because it effects fundamental habitat variables such as water circulation, substrate type, water depth and turbidity.

Algal accumulations cause most concern when they occur near or upwind from urbanised areas, such as those at Coodanup and Novara. Accumulations that occur in more remote areas, are of less concern because odours generated from decomposing algae are too distant from existing population areas to be offensive. As a result, the foreshore at Point Grey has not been regularly monitored for algal accumulations to date, so the magnitude of the algal problem at this location is largely unknown.

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

Because the algae detach and float, areas of accumulation are largely determined by growth areas, the direction of the wind, wave action and currents (both tidal and wind generated). During spring and summer, the prevailing winds are from the southeast in the morning and southwest in the afternoon (Figure 3). The strength and duration of these winds are sufficient to establish a wave set that reinforces the effect of wind on floating algae, resulting in large accumulations on the northern foreshores of Peel Inlet. The likelihood of excessive accumulations of algae occuring on either the eastern or western foreshore of Point Grey is therefore lower than could be expected for foreshore areas affected by summer wind and wave patterns. Waterways Commission officers have noted large accumulations of macro-algae in these areas in recent years, however, these have not been quantitatively measured (Waterways Commission, pers. comm.). These accumulations are likely to be the cause of potential public comment.

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

The data indicate that, for sampling stations located on the eastern foreshore of Point Grey, algal biomass levels are consistently lower than those occurring offshore from points of accumulation near Coodanup, the Inlet Channel and Falcon (Figure 4). The only exception to this generalisation is the second last sampling period, where the station in Robert Bay showed high levels of biomass.

Enrichment/sulphurization of nearshore sediments is thought to occur as a result of decomposing algae, thus providing circumstantial evidence that algae does beach along the foreshore, and is therefore likely to result in the temporary loss of amenity.

The sampling programme did not include a station near the western foreshore at Point Grey. In the deeper water at this location, Chaetomorpha is known to grow in large amounts. However, during the time when weed accumulation causes the most problems, strong sea breezes result in a northerly flow of water along this section of the foreshore and therefore, heavy accumulations are unlikely.

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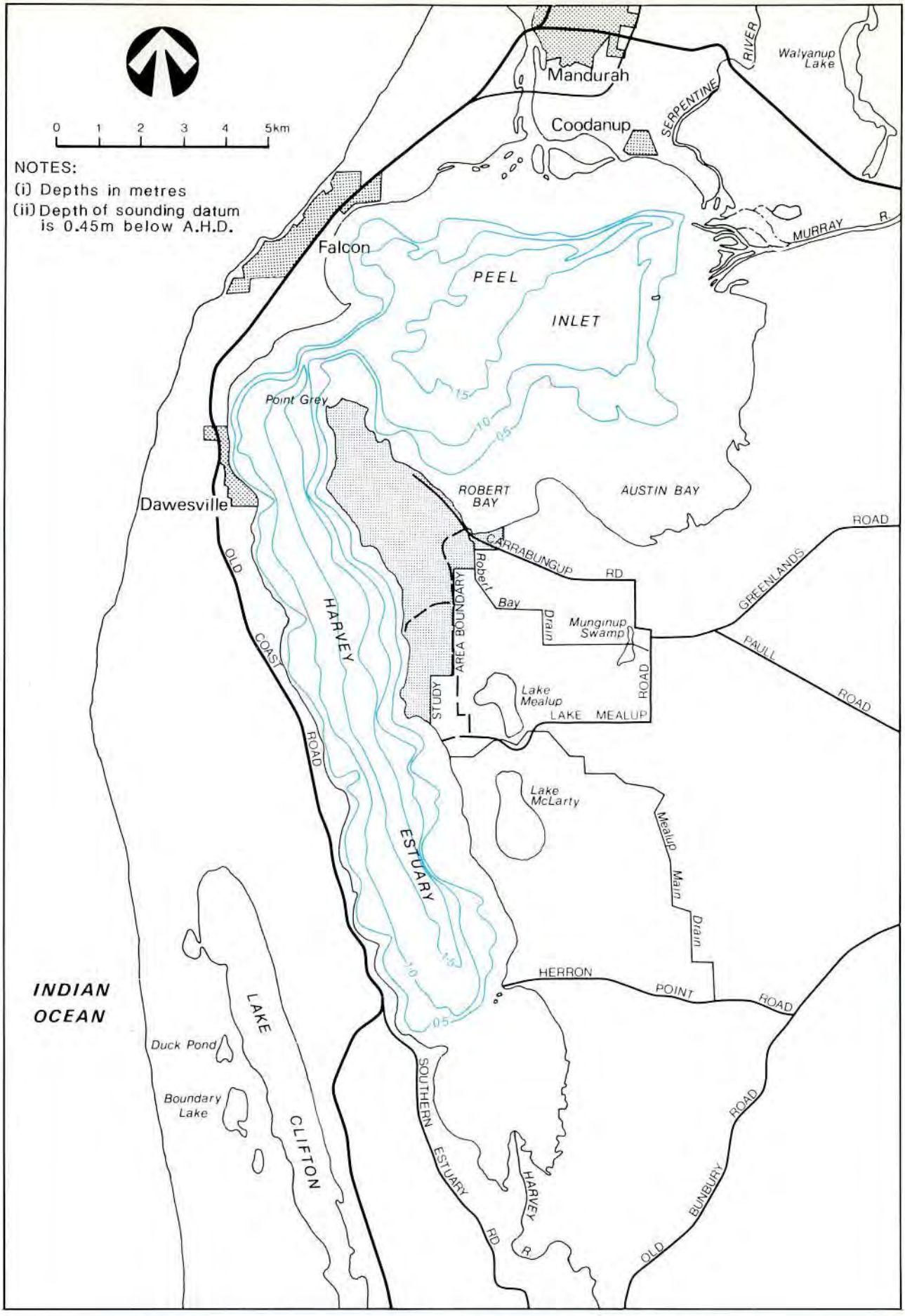
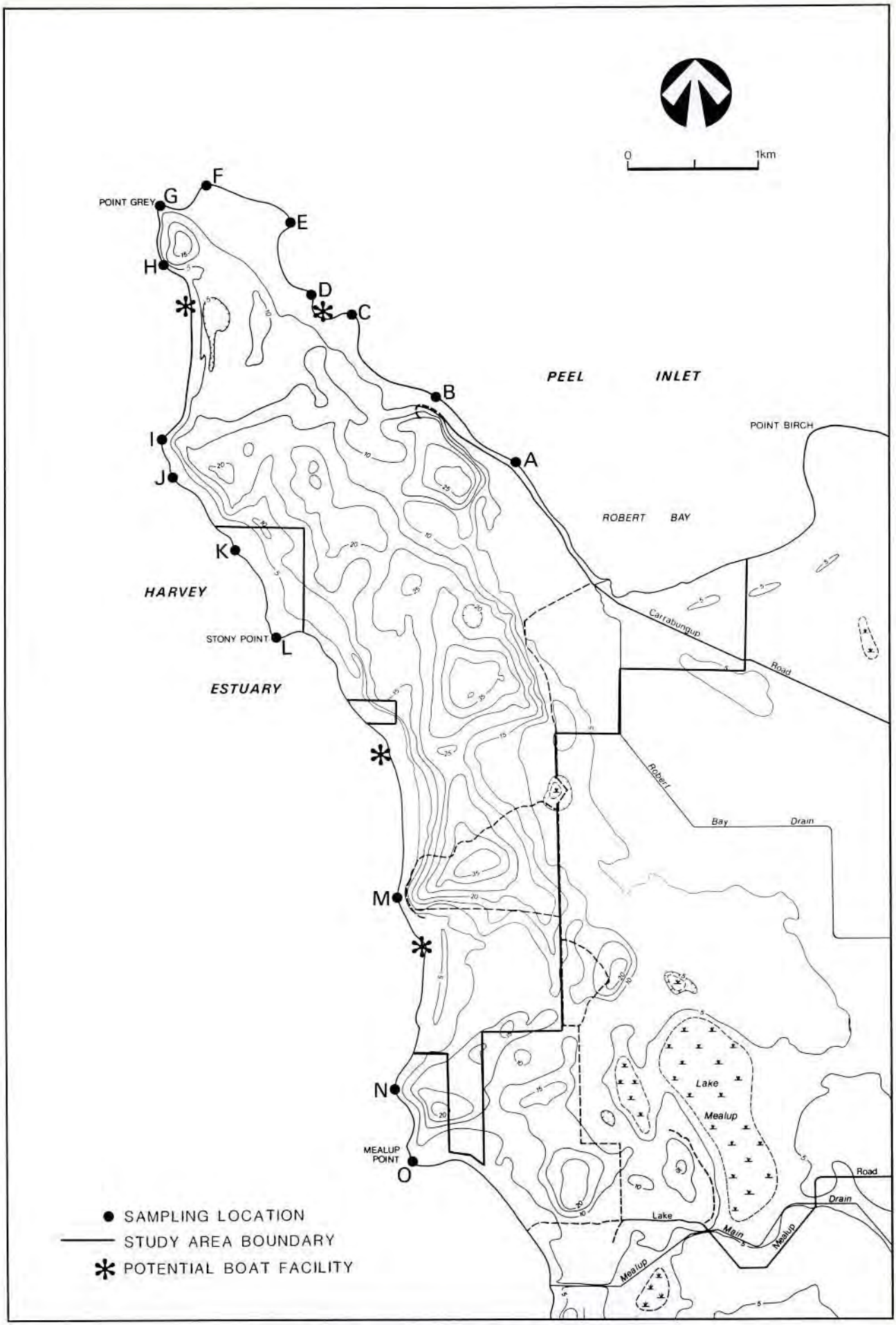
FIGURES



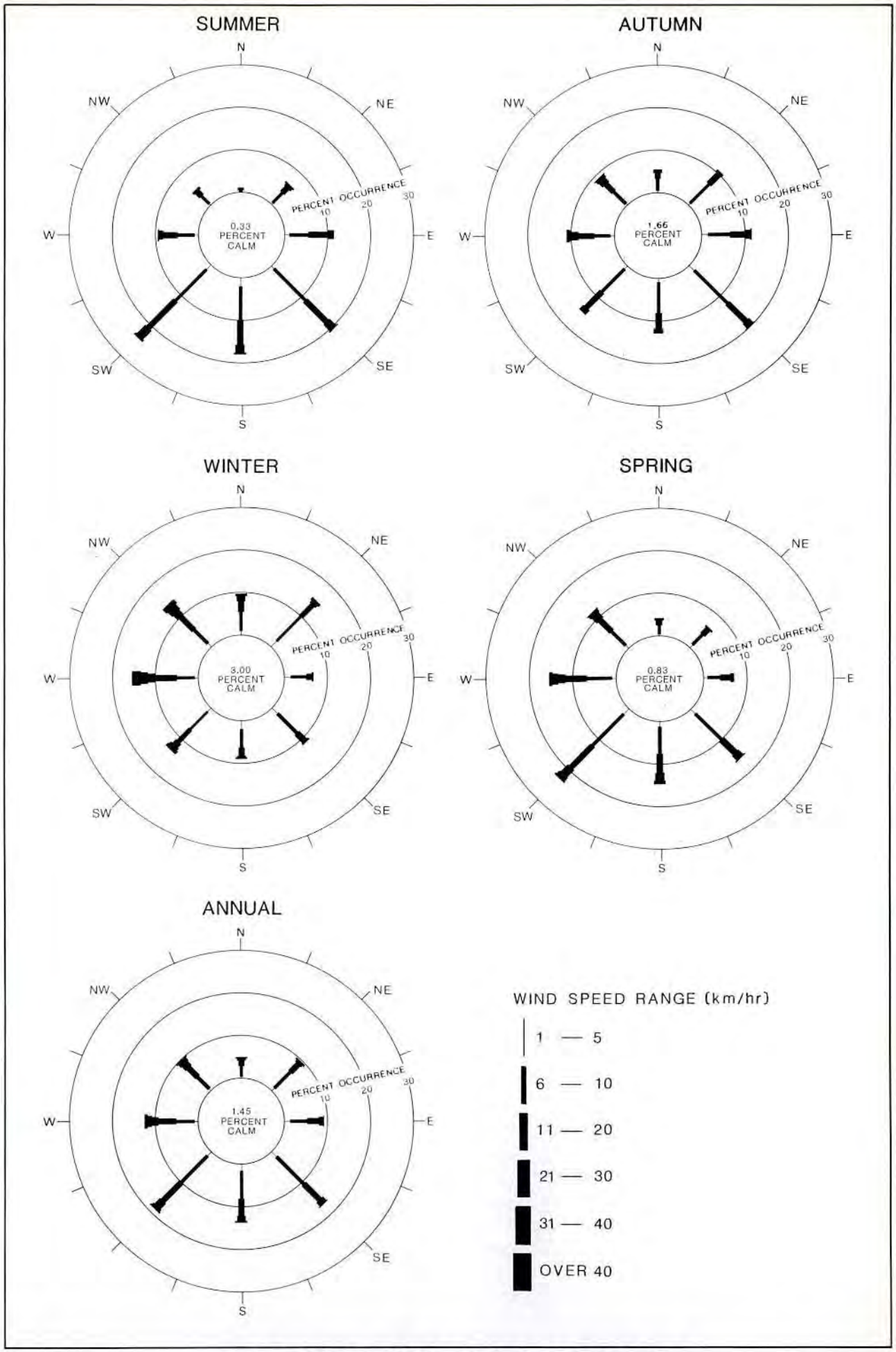
BATHYMETRY OF PEEL INLET AND HARVEY ESTUARY



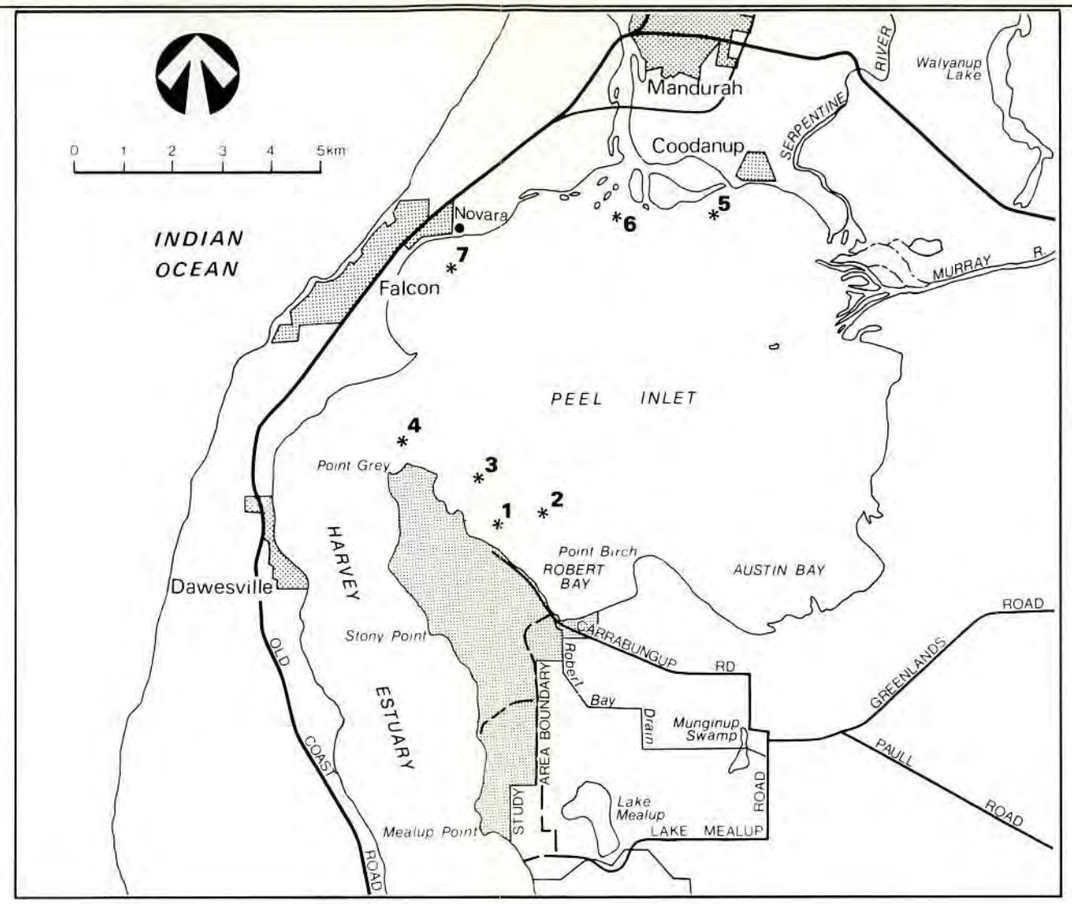
AQUATIC BIRD CENSUS LOCATIONS

Dames & Moore

Figure 2

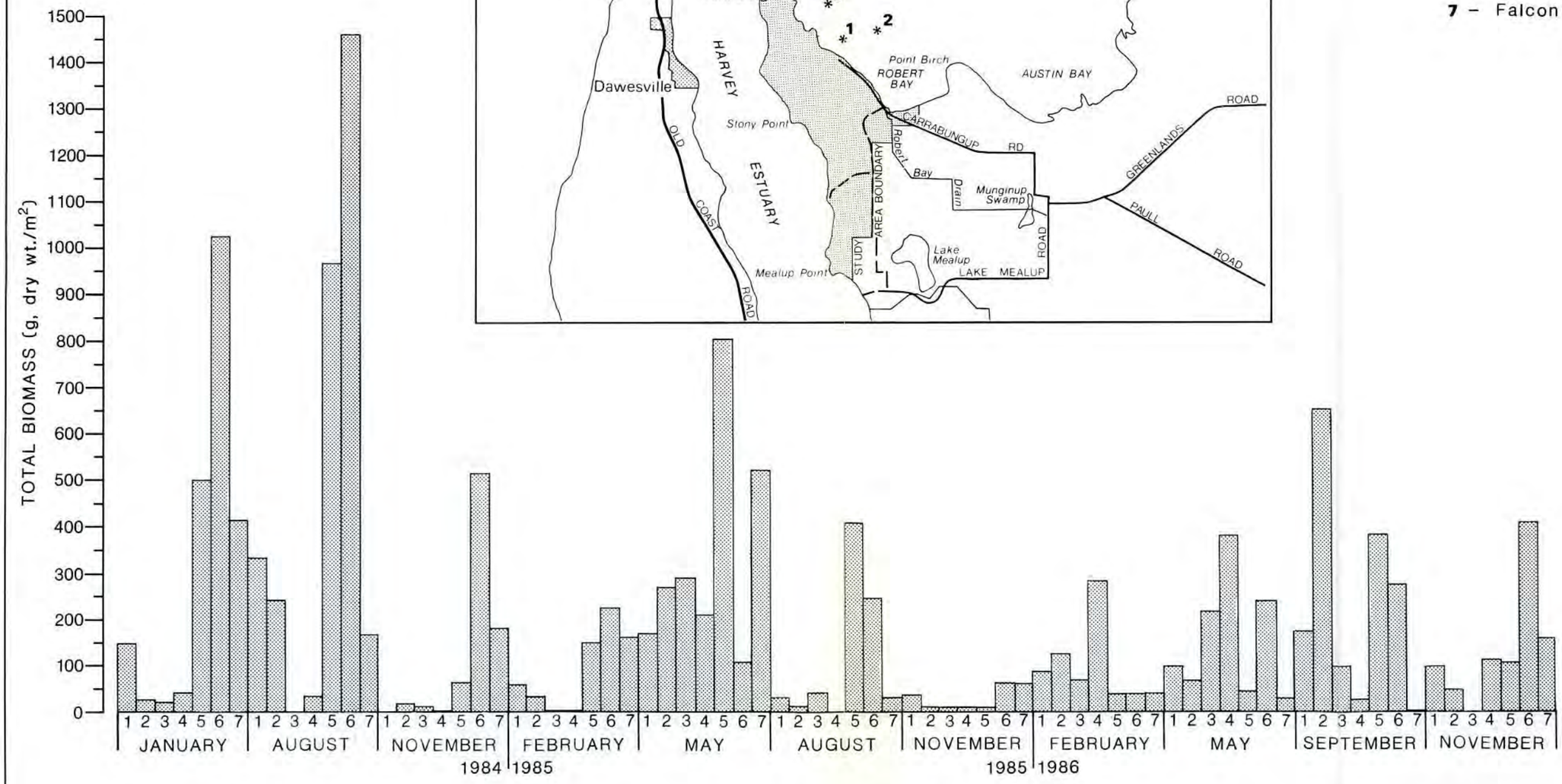


SEASONAL WIND ROSES : MANDURAH



* MACRO ALGAL SAMPLING SITES

1 – Point Grey Site
2 – Point Grey Site
3 – Point Grey Site
4 – Point Grey Site
5 – Coodanup site
6 – Channel site
7 – Falcon site



A COMPARISON OF ALGAL BIOMASS FOR SELECTED SITES NEAR POINT GREY AND PEEL INLET

Dames & Moore

Figure 4

APPENDIX E

APPENDIX E

THOMAS PEEL COLLEGE

THOMAS PEEL COLLEGE

During recent years most developing countries in the Asian and European region have shifted their focus of development activity from the building of physical infrastructure to education and training.

Although there has been a major emphasis upon the development and expansion of education facilities in these countries, the demand is still far in excess of availability which, coupled with often poor standards of tuition, has generated a sizeable flow of students to developed nations such as the United States of America, Canada, Australia, the United Kingdom and Germany - Australia being the most recent.

As has tradionally been the case, personal and family funding remains the major funding avenue for overseas students. This is reflected in the commitment and reasonably high level of achievement by the students.

Europe and North America have for many years provided a wide range of educational facilities for foreign, fee-paying students. Asian students, for example, currently occupy more than 350,000 places in the United States tertiary system alone, and at considerably higher fee and living cost structures than those currently studying in Australia.

The distances travelled to these countries, as well as their climatic inconveniences, gives Australia another distinct advantage when dealing with students of Asian origin.

Although tertiary and matriculation students have attended Australian education facilities for some time, no provision has to date been made for post secondary non-degree training in such areas as commercial and business studies, business management, secretarial, English language and basic computing. Australia is the obvious choice for the development of an International Education college concept to fill this void, aimed at high standards of tuition, personal care and security. The majority of governments in the region will encourage the support of a facility to fill this gap, which will assist in the transfer of education and knowhow.

The curriculum would also be directed towards young men and women in business who are in need of short, intensive and practical courses. The study areas previously noted are based upon research carried out to establish and verify the need and demand.

Thomas Peel College (the College) is planned to provide both academic and student residential accommodation to ensure cultural integration within the college environment, while at the same time providing a protective structure within the college campus.

THE COLLEGE CONCEPT

The concept of an international post secondary college was based on the considerable overseas experience of some of those responsible for its development. Based upon this knowledge and experience, it was conceived that such an establishment could be successfully developed in Western Australia and that the most appropriate setting for a college would be outside, but within comfortable reach of, the City of Perth.

To ensure the viability of a private international college for overseas, and specifically South East Asian students, WAITEC were commissioned to carry out an in-depth study and survey supporting the establishment of a College in Western Australia.

The study brief was to:

- Identify the legal, administrative, political and educational factors affecting the establishment of the proposed institution.
- Determine overseas demand for the proposed education facility.
- Ascertain the prospects of obtaining suitable academic staff for the institution.
- Estimate the economic viability of the project.
- Outline a programme and timetable for implementation along with a plan for its financing, managing and marketing.

The feasibility study was headed by Dr Roger C. Smith, a member of the WAITEC team. Consultants in Malaysia, Indonesia and Thailand were also utilised. A number of Commonwealth and State Government institutions provided assistance.

The results of the study confirmed that the College was a feasible proposition and would provide a service very much in demand in South East Asia. It furthermore confirmed that if the equivalent of 1000 students per year were to be considered, that such numbers could easily be sustained on a continuing basis.

Nothing was found during the study which would prevent the establishment of a private college or its accreditation as a reputable institution. The concept received positive response from all sources surveyed.

The College plans to accommodate secondary school leavers who have elected not to pursue tertiary education, but wish to arm themselves for a place in the white collar industry, or similarly companies who have valued employees they wish to upgrade in any or all of the disciplines within the College curriculum.

To enable students to choose, intermix or fit into various or singular disciplines, the College will conduct its tuition in training blocks, thus enabling them to enter on any level based on competence and/or requirements. At the same time students can be full or part-time, i.e. attend for one semester or for one or more years.

English language will play a large role in the curriculum as a student's level of competence will control his or her entry into other training blocks.

The College will be a diploma level institution and will be developed for 1000 full time students.

The College will be administered by a Board of Governors comprising eminent educators from Asia and Australia.

Approximately 80 academic and administrative staff will operate the College. Additionally there will be other functions relating to security, maintenance, medical and student care.

The College will be privately funded and be administered without Government assistance. It will ensure appropriate academic accreditation.

Some of the major advantages which the proposed College can offer are:

- Western Australia is geographically closer to the South East Asian region, even within the Australian context, than alternative education centres. This is financially advantageous to a students travel costs and those of visiting family and friends.
- The Western Australian climate is temperate which is more suitable to students from the Asian region.
- Australian education standards are perceived to be amongst the best in the world and are sought after by overseas students.
- The College will offer on-campus accommodation within a safe and secure environment.
- At this time, no other academic institution in Australia offers this type of post secondary education and training, together with course and term flexibility.
- Ease of entry into Australia for College enrollment has been confirmed.
- The concept will provide Australia with much needed foreign exchange.

APPENDIX F

APPENDIX F

ASSESSMENT OF NUTRIENT STATUS AT POINT GREY

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SUMMARY

Phosphorus application to the Point Grey site under the existing and potential agricultural use is expected to vary from a minimum of 6.3t/yr (farming the existing 720ha of cleared land and using superphosphate applications recommended by the Department of Agriculture) to more than 19 t/yr should the site be fully cleared for commercial farming using conventional rates of superphosphate application.

Development of the site in consideration of the potential nutrient pollution problems has resulted in the definition of management programmes which will reduce the total phosphorus input to the Point Grey site to an estimated maximum of 4.5t/yr. Further reductions in phosphorus addition may be realised by encouraging the use of native gardens and by implementing a soil testing programme aimed at determining the optimum level of fertiliser application.

Reducing nutrient application to the site is expected to result in a similar reduction in nutrient outflow from the site to the Estuary. In terms of total nutrient output to the Peel-Harvey Estuary, these reductions are expected to have only a negligible, if any, detrimental effect.

1.0 NUTRIENT APPLICATION FOR EXISTING FARM MANAGEMENT

1.1 POTENTIAL PHOSPHORUS APPLICATION AS SUPERPHOSPHATE

Application rates of phosphorus (as superphosphate) to farming areas within the Swan Coastal Plain have been estimated to average about 18kg/ha/yr, as elemental phosphorus (Yeates et al. 1985). The Point Grey site, if fully developed for agriculture, may have a total annual phosphorus addition of 1083ha x 18kg = 19t/yr, using conventional application rates of superphosphate. This is probably an upper estimate since it is likely that 5 to 10% of the property would remain unfertilised.

If only the 720ha of existing cleared land were commercially farmed, the phoshorus application would be 720ha x 18kg = 13t/yr.

1.2 RECOMMENDED PHOSPHORUS APPLICATION AS SUPERPHOSPHATE

A soil testing programme was undertaken by the Western Australian Department of Agriculture, Catchment Extension, Fertiliser Advisory Service. Sixteen paddocks/areas were sampled and eleven analyses were reported. Two of these soil samples were taken on undeveloped bush blocks (Figure 1).

Table 1 lists the results of the survey in terms of the Department's recommendations for fertiliser application for optimum farm production.

TABLE 1

SOIL SAMPLE ANALYSES

PADDOCK NO. (see Figure 1)	SOIL TYPE	OPTIMUM SUPERPHOSPHATE APPLICATION RATE (kg/ha)	APPLICATION RATE AS PHOSPHORUS (P) (kg/ha)
2	Coloured Sand	80	7.2
3	Joel/Deep Coolup	230	20.7
4	Coloured Sand	120	10.8
6	Coloured Sand	80	7.2
7 *	Coloured Sand	170	15.3
8 *	Coloured Sand	130	11.7
12	Good Transitional	50	4.5
13	Coloured Sand	90	8.1
14	Coloured Sand	80	7.2
15	Good Transitional	60	5.4
16	Joel/Deep Coolup	100	9.0

* Forested paddocks

Fertiliser was seen to be required for each paddock sampled. In terms of phosphorus required, the paddocks varied from 4.5kg/ha to 20.7kg/ha with the uncleared bush blocks requiring 11.7kg/ha and 15.3kg/ha (Table 1). The average phosphorus application to the site was recommended to be 8.7kg/ha (as P) to the existing farmland and 13.5kg/ha to the uncleared area should it be cleared for agricultural production. For agricultural use of the existing farmland only, the total application of phosphorus is recommended to be 720ha x 8.7kg = 6.3t/yr. The recommended total phosphorus application to the site for the full development would then be:

720ha x 8.7kg	=	6.3t/yr
363ha x 13.5kg	=	4.9t/yr
TOTAL		11.2t/yr

Although potential agriculture development may realise the input of as much as 13 to 19t/yr, the quantity of 6.3t/yr, as recommended by the Department of Agriculture, is used in this document as a baseline for comparison with phosphorus inputs from the proposed development.

2.0 SOURCES OF NUTRIENT APPLICATION TO THE DEVELOPMENT

2.1 GENERAL

The preliminary assessment of nutrient sources was undertaken to quantify the potential phosphorus loading to the site from all sources without considering the implementation of any management programmes to minimise nutrient application.

This section compares the potential application rates firstly without management, and then with the proposed management programmes, to show how reductions in nutrient input under a carefully planned and managed urban development, can be achieved.

Nutrient loading to the site under the proposed development will vary with time until full development is achieved. The sources of nitrogen and phosphorus inputs are listed as follows:

- o fertiliser application to residential and leisure lots,
- o fertiliser application to the golf course,
- o fertiliser application to public parks, gardens and college campus,
- o nutrient addition to the site from disposal of treated sewage effluent, and
- o disposal of sewage effluent on the leisure lots by septic tanks.

In addition, small quantities of fertiliser will be applied to the property during the early years of the project to support "maintenance level" agricultural production. This activity will be progressively phased out, and hence, nutrients generated from this source will have no long term consequence to the overall nutrient budget for the project.

2.2 ESTIMATES OF TYPICAL FERTILISER APPLICATION TO RESIDENTIAL AND LEISURE LOTS

It has been assumed that the area on each residential and leisure lot that is fertilised (lawn, gardens and verge) averages 450m^2. This is a conservatively high estimate as it neglects any lots that have native gardens and/or ground covers, large paved areas, swimming pools etc.

The recommended fertiliser application rate (CSBP & Famers Ltd, pers. comm.) is given as 50g/m^2/yr, giving an annual fertiliser application rate of 50g x 450m^2, or 22.5kg/yr per block.

The average phosphorus content of lawn fertiliser is assumed to be about 6% (worst case) giving an upper total phosphorus input estimate of 1.35kg/yr per block.
For full development, the maximum phosphorus loading, without any management to promote native gardens and ground covers becomes 1.35kg x (2820 + 300) or 4.2t/yr (assuming 2820 residential lots and 300 leisure living lots).

The potential annual loading to the site over the development period is calculated from the estimated number of lots sold by that year, multiplied by the above application rate (Table 2).

Nitrogen loading is calculated using the same approach and by assuming that the nitrogen content of garden fertiliser is about 12% (CSBP & Farmers, pers. comm.).

TABLE 2

TYPICAL NUTRIENT INPUTS FROM FERTILISER APPLICATION TO PRIVATE ALLOTMENTS (WITHOUT MANAGEMENT)

YEAR	PHOSPHORUS RESIDENTIAL (t/yr)	PHOSPHORUS LEISURE (t/yr)	NITROGEN RESIDENTIAL (t/yr)	NITROGEN LESIURE (t/yr)
1	0.1	0.1	0.2	0.2
5	0.7	0.4	1.4	0.8
10	1.3	0.4	2.6	0.8
15	2.0	0.4	4.0	0.8
20	2.7	0.4	5.4	0.8
30	3.4	0.4	6.8	0.8
40	3.8	0.4	7.6	0.8
50	3.8	0.4	7.6	0.8

2.3 ESTIMATES OF TYPICAL FERTILISER APPLICATION RATES TO GOLF COURSE

Nutrient application to the golf course has been calculated assuming that there are 20ha of fairways and 5ha of greens. Advice from CSBP & Farmers suggest that application rates should be four applications of 600kg/ha each year for greens, and two applications of 600kg/ha each year for fairways.

The fertiliser recommended is 2% phosphorus (as P) and 12% nitrogen (as N) by weight.

The potential total nutrient inputs without the implementation of management programmes (see Section 3.3) then become:

Greens

600kg/ha x 4 applic/yr x 0.02%P x 5ha = 0.24t/yr (phosphorus)

and 600kg/ha x 4 applic/yr x 0.12%P x 5ha = 1.44t/yr (nitrogen)

Fairways

600kg/ha x 2 applic/yr x 0.02%P x 20ha = 0.48t/yr (phosphorus)

and 600kg/ha x 2 applic/yr x 0.12%P x 10ha = 2.88t/yr (nitrogen)

Hence the maintenance inputs of nutrients are 0.72t/yr phosphorus and 4.32t/yr nitrogen.

It has been estimated that the establishment of the course will require a threefold addition of fertiliser in the first year and a twofold addition in the second year. The estimated nutrient inputs to the golf course has been summarised in Table 3.

TABLE 3

ESTIMATED NUTRIENT INPUTS TO GOLF COURSE

YEAR	PHOSPHORUS (t/yr)	NITROGEN (t/yr)
1	2.16	12.96
2	1.52	8.64
3+	0.76	4.32

2.4 ESTIMATES OF TYPICAL FERTILISER INPUTS TO COLLEGE, PUBLIC PARKS AND GARDENS

The College areas to be fertilised are one oval (assumed area of 5ha) and 5ha of lawned area. The remaining 40ha will include native vegetation and ground covers, College buildings, car parks and roads.

Calculation of the total nutrient inputs are made by assuming that:

- the oval is fertilised at the rate of two applications of 600kg/ha of fertiliser each year (2% P and 12% N), and
- the lawns are fertilised at a rate of 12kg/ha of phosphorus per year and 36kg/ha of nitrogen per year (CSBP & Farmers, pers. comm.).

Nutrient addition as fertiliser to the College campus is assumed to begin in year one of the development.

Phosphorus input is calculated as follows:

Oval

Phosphorus applied = 5ha x 600kg/ha x 2 applic/yr x 0.02% = 0.12t/yr

Nitrogen applied = 5ha x 600kg/ha x 2 applic/yr x 0.12% = 0.72t/yr

Lawn Area

Phosphorus applied = 5ha x 12kg/ha = 0.06t/yr

Nitrogen applied = 5ha x 36kg/ha = 0.18t/yr

This gives a total phosphorus application of 0.18t/yr and a total nitrogen application of 0.9t/yr.

Public parks and gardens are expected to total an area of about 45ha (10% of the total residential area) following full development. Of this 45ha, it is estimated that 20ha will be 'wet' parkland requiring fertiliser maintenance, and the remaining 25ha will be 'dry' unfertilised parkland areas.

It has been assumed that the 'wet' parkland will be initially 5ha and increased in area by 5ha every ten years over the first thirty years.

The 'wet' parkland is expected to have a phosphorus application rate of 12kg/ha of phosphorus per year and 36kg/ha of nitrogen per year.

Total application to the public parks is shown in Table 4.

TABLE 4

FERTILISER APPLICATION RATES TO PUBLIC PARKS

YEAR	AREA OF 'WET' PARKS (ha)	PHOSPHORUS APPLICATION (t/yr)	NITROGEN APPLICATION (t/yr)
1 - 9	5	0.06	0.36
10 - 19	10	0.12	0.72
20 - 29	15	0.18	1.08
30+	20	0.24	1.44

2.5 ESTIMATES OF NUTRIENT ADDITION BY DISPOSAL OF SEPTIC TANK EFFLUENT ON THE LEISURE LOTS

Disposal of sewage by means of septic tanks results in the addition of phosphorus (as phosphate) and nitrogen (as nitrates) to the soil profile where it may be leached to the groundwater table. Studies have shown that septic tank may contribute 3kg/yr of phosphorus and 18kg/yr of nitrogen to the leach drain disposal (Whelan et al. 1981). These estimates were determined for Bassendean Sands which have a much lower nutrient absorbtion capacity than the yellow sands of the Karrakatta Unit that typifies most of Point Grey. The figures will therefore be conservatively high.

Using these estimates, the use of septic tanks at the leisure lots on the development could potentially contribute 0.9t/yr of phosphorus (300 lots x 3kg/yr) and 5.4t/yr of nitrogen (300 lots x 18kg/yr) at full development. The nutrient inputs by septic tanks over the development period are given in Table 5.

TABLE 5

NUTRIENT INPUTS FROM DISPOSAL OF SEPTIC TANKS EFFLUENT ON LEISURE LOTS

YEAR	PHOSPHORUS ADDITION (t/yr)	NITROGEN ADDITION (t/yr)
1	0.06	0.36
5	0.41	2.46
10	0.74	4.44
15 +	0.90	5.40

2.6 ESTIMATES OF NUTRIENT ADDITION BY DISPOSAL OF TREATED SEWAGE EFFLUENT

Sewage effluent disposal volumes are estimated by assuming that treatment of 180L/resident per day is required (Water Authority of Western Australia, 1987). The treated effluent will have a phosphorus concentration of 2mg/L and a nitrogen concentration of 10mg/L. These concentrations will be achieved using a tertiary treatment facility.

Using these estimates, the nutrient addition to the site over the development period from treated effluent is estimated to increase to a maximum of about 1.0t/yr of phosphorus and 5.0t/yr of nitrogen (Table 6).

TABLE 6

NUTRIENT INPUTS FROM DISPOSAL OF TREATED SEWAGE EFFLUENT

YEAR	PHOSPHORUS ADDITION (t/yr)	NITROGEN ADDITION (t/yr)
1	0.14	0.7
5	0.26	1.3
10	0.36	1.8
15	0.48	2.4
20	0.58	2.9
30	0.73	3.7
40	0.86	4.3
50	1.01	5.1

2.7 TOTAL POTENTIAL NUTRIENT LOADING TO THE SITE

Without any management programme, it has been calculated that the phosphorus loading would increase from about 2.8t/yr at the start of the development to a maximum of 7.3t/yr at full development (Table 7).

This maximum load compares with recommended phosphorus application of either 6.3t/yr or 11.2t/yr for agricultural land use, depending on the level of development (i.e. 720ha or 1083ha).

Comparison of the magnitude of the various sources of phosphorus application for the proposed development show that the fertiliser applied to residential lawns and gardens amount to more than the addition of all the other phosphorus sources (Figure 2). As a consequence, management of nutrient inputs to the site are to be aimed at reducing this potential phosphorus source. These management procedures are described in the following section.

TABLE 7

POTENTIAL UNMANAGED PHOSPHORUS APPLICATION

YEAR	R. LAWN* (t/yr)	L. LAWN* (t/yr)	GOLF (t/yr)	COLLEGE (t/yr)	PARKS (t/yr)	SEPTIC (t/yr)	STP EFF* (t/yr)	TOTAL (t/yr)
1	0.1	0.1	2.16	0.18	0.06	0.06	0.14	2.8
5	0.7	0.4	1.52	0.18	0.06	0.41	0.26	3.5
10	1.3	0.4	0.76	0.18	0.12	0.74	0.36	3.9
15	2.0	0.4	0.76	0.18	0.12	0.9	0.48	4.8
20	2.7	0.4	0.76	0.18	0.18	0.9	0.58	5.7
30	3.4	0.4	0.76	0.18	0.24	0.9	0.73	6.6
40	3.8	0.4	0.76	0.18	0.24	0.9	0.86	7.1
50	3.8	0.4	0.76	0.18	0.24	0.9	1.01	7.3

*R. Lawn = Residential Lawn
L. Lawn = Leisure Lawn
STP eff. = Sewage Treatment Plant effluent

Total nitrogen input to the site at full development has been estimated to be 25t/yr. This compares to about 140t/yr calculated to be added by nitrogen fixing pasture under agricultural development (Department of Agriculture, pers. comm.). A summary of potential nitrogen loading is given in Table 8.

TABLE 8

POTENTIAL UNMANAGED NITROGEN APPLICATION

YEAR	R. LAWN (t/yr)	L. LAWN (t/yr)	GOLF (t/yr)	COLLEGE (t/yr)	PARKS (t/yr)	SEPTIC (t/yr)	STP EFF (t/yr)	TOTAL (t/yr)
1	0.2	0.2	13.0	0.9	0.4	0.4	0.7	15.8
5	1.4	0.8	8.6	0.9	0.4	2.5	1.3	14.6
10	2.6	0.8	4.3	0.9	0.7	4.4	1.8	15.5
15	4.0	0.8	4.3	0.9	0.7	4.4	2.4	17.5
20	5.4	0.8	4.3	0.9	1.1	4.4	2.9	19.8
30	6.8	0.8	4.3	0.9	1.4	4.4	3.7	22.3
40	7.6	0.8	4.3	0.9	1.4	4.4	4.3	23.7
50	7.6	0.8	4.3	0.9	1.4	4.4	5.1	24.5

3.0 EXPECTED NUTRIENT LOADINGS TO THE POINT GREY DEVELOPMENT WITH NUTRIENT MANAGEMENT

3.1 GENERAL

Although estimates of nutrient loading have been made for both phosphorus and nitrogen, the effects of phosphorus loading are considered to be a more important guide to the devlopments' nutrient impacts, as it is predicted that there will be a considerable reduction in nitrogen loading due to the eventual replacement of nitrogen fixing pasture associated with agricultural activities. Additionally, since the estuarine system is phosphorus limiting, the reduction of phosphorus inputs to the Estuary is regarded as a major objective in the DCE's preferred management strategy (DCE, 1984).

The development loading of 7.3t/yr is a upper estimate of phosphorus application, and can be significantly reduced by a nutrient management programme. This management programme, which is readily achievable, has three principal objectives, namely:

- reduction in the application of phosphorus fertilisers on private lawns and gardens,
- reduction in the amount of fertiliser applied to the golf course, and
- reduction in the phosphorus application to College and public parks and gardens.

These programmes and the expected reductions in nutrient loadings to the site, are described in the following subsections.

3.2 MANAGEMENT OF PHOSPHORUS APPLICATION TO PRIVATE ALLOTMENTS

The programme to reduce phosphorus application to private allotments can be achieved in three ways:

- reduction in the area of lawns and gardens to be fertilised,
- reduction in total phosphorus application to lawns and gardens, and
- encourage the use of native plant species.

In order to achieve these objectives, the following management techniques are to be used by the Proponent:

- o display homes will have native gardens, and areas of lawn will be limited,
- o lot purchasers will be provided with an incentive to purchase native shrubs, trees and ground covers,
- o promotion will be undertaken to demonstrate the advantages of native gardens in terms of maintenance, water and fertiliser costs,
- o a nursery will be established at Point Grey that will supply low phosphate fertilisers and a variety of local plant species suitable for local conditions, and
- o the use of household bores will be prohibited because of potential saline intrusion into the shallow aquifer; this action is expected to discourage home owners from growing conventional lawns and exotic gardens, because it will limit the availability of an inexpensive water supply.

With these measures, it is anticipated that the area of lawns and gardens that require fertiliser can be reduced by at least 25%, consequently reducing the phosphorus application to 75% of that value calculated in Section 2.2. At full development (2820 residential lots), the phosphorus application can therefore be reduced as follows:

$$1.35\text{kg P} \times 2820 \times 0.75 = 2.9\text{t/yr (P)}$$

For the leisure lots, it is expected that the area of lawns and gardens could be reduced by at least 50%, giving at full development:

$$1.35\text{kg P} \times 300 \times 0.5 = 0.2\text{t/yr (P)}$$

Further reduction in phosphorus application to private allotments can also be achieved by using low phosphorus fertiliser. Lawn and garden fertilisers containing only 2% phosphorus and 12% nitrogen are available (e.g. Growing Power, CSBP & Farmers, pers. comm.), and as part of the nutrient management programme the Proponent will undertake to:

- o promote the use of low phosphorus fertilisers, and
- o ensure that retail outlets at Point Grey stock low phosphorus fertilisers.

With these measures it is anticipated that at least 50% of private lot owners will use the low phosphorus fertilisers. Phosphorus application can then be estimated to be 0.45kg P/yr/lot compared to 1.35kg P/yr/lot using conventional fertilisers with 6% phosphorus.

Hence, at full development, and given the implementation of environmental management policies, phosphorus application to the residential lots is calculated as follows:

Residential		
Normal fertiliser	1.35kg P x 1410 lots x 0.75% =	1.45t/yr
Low P fertiliser	+ 0.45kg P x 1410 lots x 0.75% =	0.48t/yr
	TOTAL	1.93t/yr

Leisure Lots		
Normal fertiliser	1.35kg P x 150 lots x 0.5% =	0.1t/yr
Low P fertiliser	+ 0.45kg P x 150 lots x 0.5% =	0.3t/yr
	TOTAL	0.13t/yr

This gives a total phosphorus application on private lawn and garden fertiliser as 2.1t/yr compared with the potential of 4.2t/yr for an unmanaged urban development applying high phosphorus fertiliser.

3.3 MANAGEMENT OF PHOSPHORUS APPLICATION TO THE GOLF COURSE

The Proponent intends to undertake routine soil sampling on the golf course to determine recommended phosphorus application rates. In this way it is expected that phosphorus application to the grounds will be reduced as follows:

- 1 year at the rate of 0.72t/yr as described in Section 2.3.
- 2 years at a rate of 0.44t/yr (same application to greens but reduction in phosphorus application to fairways to 10kg/ha/yr).

This gives an annual average phosphorus load of 0.53t/yr.

The golf course will experience a further reduction in imported phosphorus application as it is to be watered by effluent from the sewage treatment plant.

At full development, the effluent will provide about 1.0t/yr of elemental phosphorus, which is more than the total golf course requirement. Therefore, the actual application of phosphorus as lawn fertiliser to the grounds may be reduced to nil in the long term, depending on the results of the soil testing programme.

Table 9 shows potential replacement of golf course fertiliser with treatment plant effluent over the development period.

TABLE 9

POTENTIAL REPLACEMENT OF GOLF COURSE FERTILISER WITH TREATED EFFLUENT

YEAR	GOLF COURSE REQUIREMENT (P)	STP (P) EFFLUENT*	STP EFFLUENT (P) TO GOLF COURSE	IMPORTED (P) TO GOLF COURSE
1	2.16	0.14	0.14	2.02
5	1.52	0.26	0.26	1.26
10	0.76	0.36	0.36	0.4
15	0.53	0.48	0.48	0.05
20	0.53	0.58	0.58	0
30	0.53	0.73	0.73	0
40	0.53	0.86	0.86	0
50	0.53	1.01	1.01	0

* STP Sewage Treatment Plant

3.4 MANAGEMENT OF PHOSPHORUS ADDITION TO THE COLLEGE CAMPUS, PUBLIC PARKS AND GARDENS

The Proponent will undertake annual soil sampling on the public parks and College area. As with the golf course, it is expected that these areas will be reduced in phosphorus application by following the recommended fertiliser application rates. These rates are expected to be about two thirds that estimated for typical inputs to College parks and gardens (Section 2.4). The expected inputs are given in Table 10.

TABLE 10

ESTIMATED NUTRIENT INPUTS TO COLLEGE, PUBLIC PARKS AND GARDENS

YEAR	PHOSPHORUS APPLICATION (t/yr)	NITROGEN APPLICATION (t/yr)
1 - 9	0.12	0.84
10 - 19	0.24	1.08
20 - 29	0.36	1.08
30+	0.48	1.56

3.5 SIGNIFICANCE OF THE PROPOSED NUTRIENT MANAGEMENT PROGRAMME

Significant reductions in potential phosphorus loading of the Point Grey site can be made by management programmes aimed at reducing lawn fertiliser application and by utilising the sewage treatment plant effluent as a water and fertiliser source for the golf course.

A breakdown of nutrient loading (as phosphorus) for all sources over the development period is given in Table 11.

Figures 3 and 4 shows the percentage breakdown of phosphorus loadings from all sources by managing nutrient loading to the development.

A comparison of phosphorus loading to the site is given in Table 12 for:

- the recommended farm management fertiliser programme,
- the proposed Point Grey urban development without any nutrient management, and
- the proposed development with the nutrient management programme.

For development with proposed management programmes, phosphorus application to the site has been predicted to be 4.5t/yr compared with 6.3t/yr recommended by the Department of Agriculture for continued agricultural production.

TABLE 11

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

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

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

TABLE 12

COMPARISON OF PHOSPHORUS LOADING FOR FARMING AND DEVELOPMENT WITH AND WITHOUT PROPOSED NUTRIENT MANAGEMENT PROGRAMME

YEAR	FARMING (Recommended P application)* 720ha (t/yr)	FARMING (Recommended P application)* 1083ha (t/yr)	DEVELOPMENT WITHOUT NUTRIENT MANAGEMENT (t/yr)	DEVELOPMENT **WITH NUTRIENT MANAGEMENT (t/yr)**
1	6.3	11.2	2.8	**2.7**
5	6.3	11.2	3.5	**2.7**
10	6.3	11.2	3.9	**2.7**
15	6.3	11.2	4.8	**2.9**
20	6.3	11.2	5.7	**3.4**
30	6.3	11.2	6.6	**4.2**
40	6.3	11.2	7.1	**4.4**
50	6.3	11.2	7.3	**4.5**

* Department of Agriculture estimates

4.0 NUTRIENT OUTPUTS FROM THE SITE TO THE ESTUARY

The movement of nutrients from the land surface through the soil to the shallow groundwater and horizontally in the shallow groundwater body to the Estuary system, is very difficult to describe quantitatively.

Phosphorus applied as fertiliser to the ground surface will be dissolved by rainfall and will leach into the shallow soils where it may be taken up by plant roots, adsorbed onto the soil or transported to the shallow groundwater body. The amount reaching the groundwater will be determined by the season, the adsorbtion - desorbtion properties of the soil, as well as many other physical, chemical and biological considerations. Phosphorus taken up by plants is subsequently ingested by stock, and some will be recycled to the soil store in more soluble form. The remaining phosphorus may be exported as produce.

Once the phosphorus is in the permanent shallow aquifer, it may react chemically or physically with the soil particles. Alternatively, it may be transported by groundwater flow to surface discharge, or in the case at Point Grey, to the surface sediments of the estuarine basin.

A simplified way of estimating potential groundwater transport of nutrients from the Point Grey site is to assume that shallow groundwater system is in steady state. That is, that groundwater recharge is balanced by groundwater outflow (no annual change in groundwater storage) and that annual phosphorus addition to the shallow groundwater is balanced by annual phosphorus losses by groundwater outflow from the site (no annual change in groundwater phosphorus storage).

The total annual phosphorus outflow can then be estimated as the product of the aquifer phosphorus concentration and throughflow (assumed to be equal to the recharge).

The phosphorus outflow from Point Grey is calculated to be:

Phosphorus outflow		=	Q x C
		=	0.044 t/yr
where	Q	=	area of farmland x recharge (10% of annual rainfall)
		=	$720 \times 10^4 m \times 0.88m \times 0.10$
		=	$0.63 \times 10^6 m^3/yr$
	C	=	average phosphorus concentration in shallow groundwater (0.07mg/L, Dames & Moore, 1986)

If it is assumed that the historical superphosphate application rate for farming the 720ha has been about 10kg/ha, then the outflow is only 0.4% of the assumed application rate.

Increases in phosphorus outflow from the site may occur if there is an increase in phosphorus concentration of the groundwater outflow, however, such an increase is not expected to occur following the proposed development of Point Grey for the following reasons:

- approximately 70% of the maximum amount of added phosphorus will be applied as fertiliser in a similar form and method as agricultural superphosphate, but will be spread on a larger area than the existing farmland, and
- septic tank effluent is restricted to leisure living lots which are to remain heavily forested, thereby giving rise to nutrient uptake by native vegetation.

An increase in annual groundwater outflow from the area may occur as a direct result of importing additional water to the development.

The increase in recharge due to imported water is estimated as follows:

- o recharge of sewage treatment plant effluent during winter months ($0.2 \times 10^6 m^3/yr$)
- o recharge of water imported to the leisure living lots during the winter months ($0.02 \times 10^6 m^3/yr$).

It has been assumed that during the summer months increased recharge due to imported water will result in an increase in evapotranspiration losses from the soil and shallow groundwater water stores.

On the area of the development (1083ha), it is assumed that 10% of rainfall (88mm/yr) is lost as groundwater throughflow. This is equivalent to $0.95 \times 10^6 m^3$ of water per annum. This, when added to the recharge of imported water, will increase to about $1.2 \times 10^6 m^3/yr$ following complete development of the site.

The steady state loss of phosphorus following development can be calculated by assuming that it is 0.4% (as calculated above) of the site load of 4.5t/yr, that is, about 0.02t/yr compared with 0.04t/yr predicted to be lost from the existing farming practices.

A nitrogen balance may be determined in the same way.

It has been estimated that agricultural use of the area may produce about 5tN/ha per annum of dry plant matter which contains about 5% by weight of nitrogen (Department of Agriculture, pers. comm.). This could result in a potential nitrogen loading to the site (if all plant matter were grazed and the nitrogen recycled to the soil) of 200kg/ha per annum. On the 720ha cleared area, this gives a total potential loading of 144t/yr. There is no nitrogen addition to the site by agricultural fertilisers (e.g. superphosphate).

The average aquifer concentration is estimated to be 5.9mg/L, as elemental nitrogen (Dames & Moore, 1986).

Using the estimated steady throughflow of 0.63 x $10^6 m^3/yr$, this would result in a total nitrogen outflow from the site of 3.7t/yr, or about 2.6% of the estimated loading under agriculture.

For the proposed development, it is estimated that as much as 80% of the existing farmland will not be fixing atmospheric nitrogen, but nitrogen will be added as fertiliser and sewage treatment plant effluent.

The maximum nitrogen addition as fertiliser, sewage treatment plant effluent and septic tank effluent is estimated to be 25t/yr. Assuming 20% of the total area is capable of fixing atmospheric nitrogen at rates similar to farming, the potential nitrogen loading to site becomes:

Imported nitrogen		25t/yr
Fixed Atmospheric nitrogen	+ 1083ha x 20% x 0.2t/yr	= 43t/yr
	TOTAL	= 68t/yr

Thus it can be estimated that there will be about a 50% reduction in potential nitrogen loading to the site for the development as compared with farming with a similar percentage of potential reduction in nitrogen outflow to the Estuary.

5.0 REFERENCES

Dames & Moore (1986), Water Supply and Environmental Investigations for the proposed Point Grey development Pinjarra W.A., Report prepared for Feilman Planning Consultants.

Water Authority of Western Australia (1987), Sewage Manual Volume 1.

Whelan, B.R., Barrow, N.J. and Carbon, B.A. (1981), Movement of phosphate and nitrogen from septic tank effluent in sandy soils near Perth, Western Australia,in C.R. Lawerance and R.J. Hughes (eds.),'Proceedings Groundwater Conference', Aust. Water Resour. Counc. Conf. Ser. No.1, AGPS, Canberra.

Yeates, J.S., Arkell, P.T., Russell, W.K., Deeley, D.M., Peek, C. and Allen, D. (1985), Management of Agriculture Phosphorus Losses from the soils of the Peel Harvey Catchment, in D.C.E Bulletin No. 195.

FIGURES

INDIAN OCEAN

PEEL INLET

HARVEY ESTUARY

LAKE CLIFTON

INDIAN OCEAN

Pinjarra Road

PINJARRA

Old Bunbury Road

South Western Highway

STUDY AREA BOUNDARY

A
B

B´

C

C´

A´

HS 55 MI2

MI0

MII

HS 56

HS 57

HS 58

HS 59

PG1

HS 53

HS 54

HS 60

HS 61

HS 49

HS 50

HS 51

HS 52

PJ1

HS 48

PG2

HS 47

HS 41

HS 42

HS 43

HS 44

HS 45

HS 46

HS 36

HS 37

HS 38

HS 39

HS 40

HS 62

HS 31

HS 32

HS 33

HS 34

HS 35

- Leederville production bore
- Leederville observation bore
- Abandoned exploratory oil well
- Surficial observation bore
- Property Location
- A-A´ Cross Section

0 1 2 3 4 5km

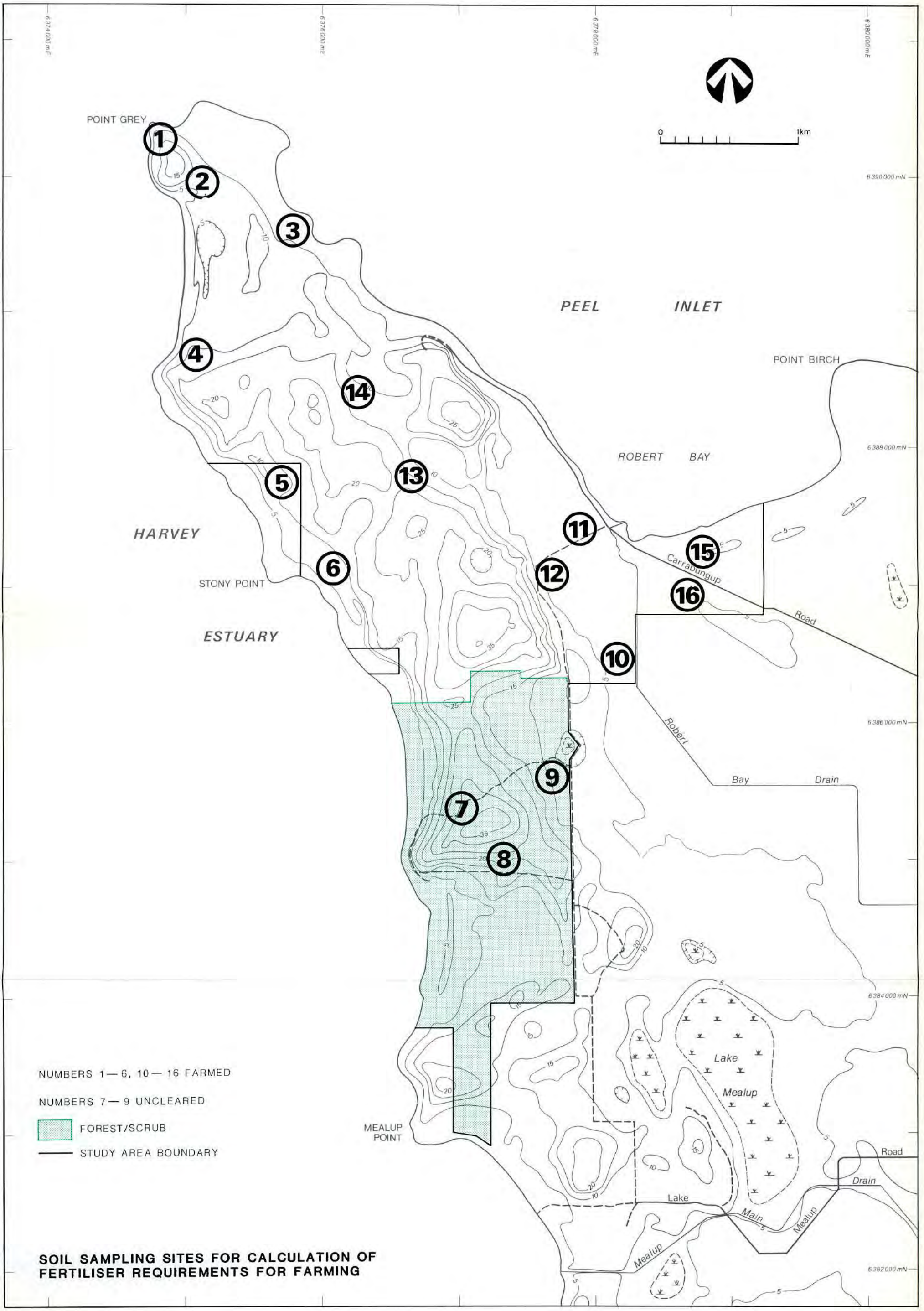
LOCATION PLAN

Figure 1

Dames & Moore

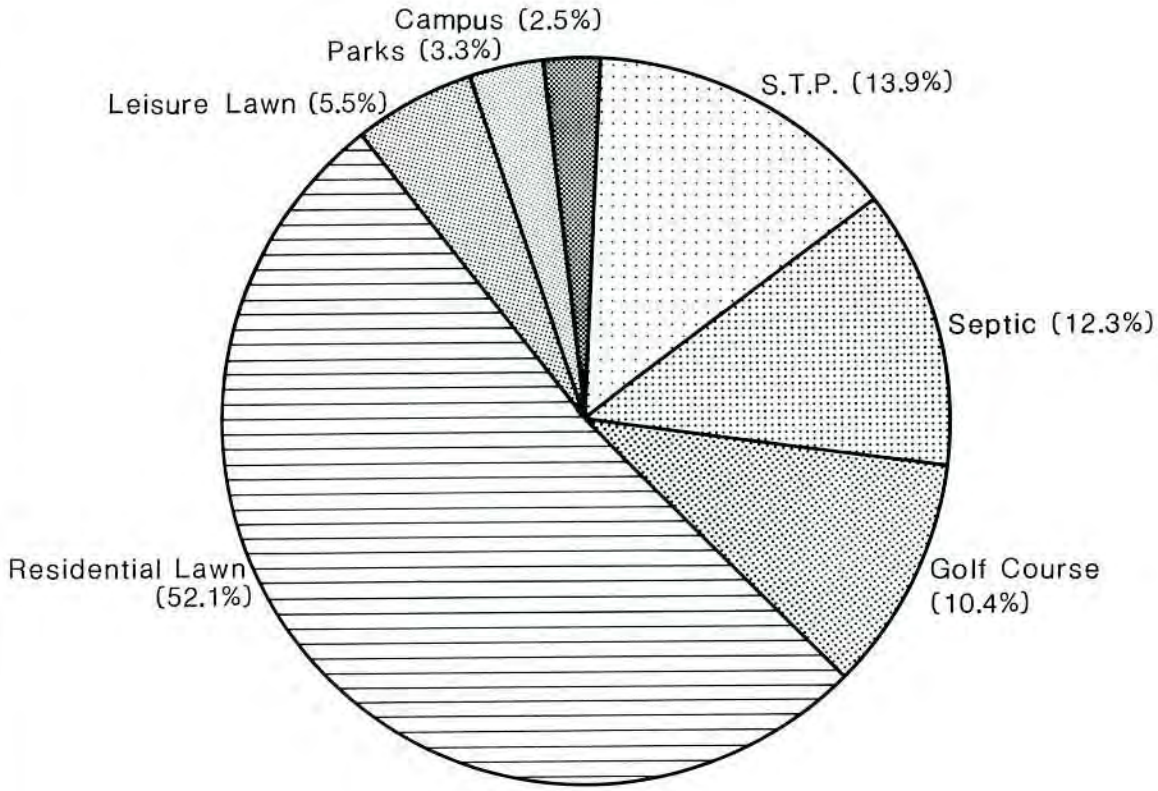
SOURCE: Groundwater Resource Consultants

Dames & Moore



SOIL SAMPLING SITES FOR CALCULATION OF FERTILISER REQUIREMENTS FOR FARMING

Figure 1

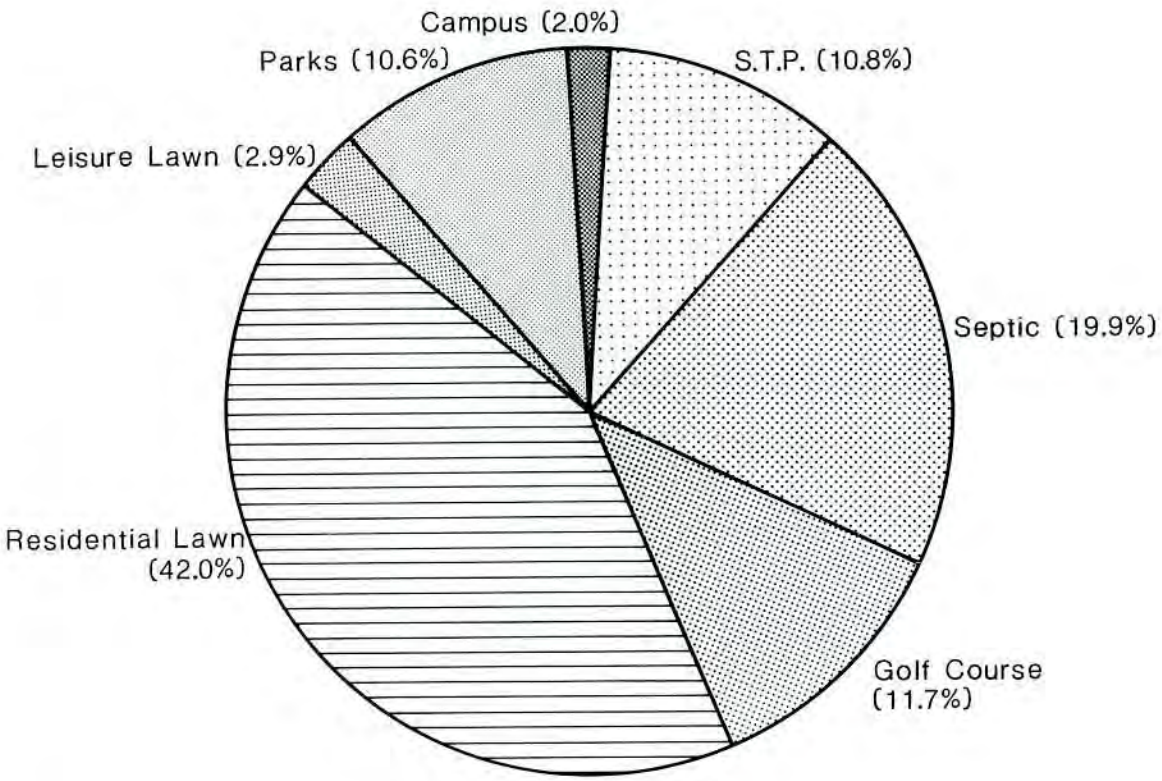


S.T.P. —— SEWAGE TREATMENT PLANT EFFLUENT
SEPTIC —— SEPTIC TANK EFFLUENT
GOLF —— FERTILISER APPLIED TO GOLF COURSE
R.LAWN —— FERTILISER APPLIED TO RESIDENTIAL LAWNS
L.LAWN —— FERTILISER APPLIED TO LEISURE LOT LAWNS
PARKS —— FERTILISER APPLIED TO PUBLIC PARKS & GARDENS
CAMPUS —— FERTILISER APPLIED TO COLLEGE CAMPUS

PHOSPHORUS LOAD - YEAR 50
POTENTIAL UNMANAGED LOAD
(Maximum load 7.3 t/yr P)

Dames & Moore

Figure 2



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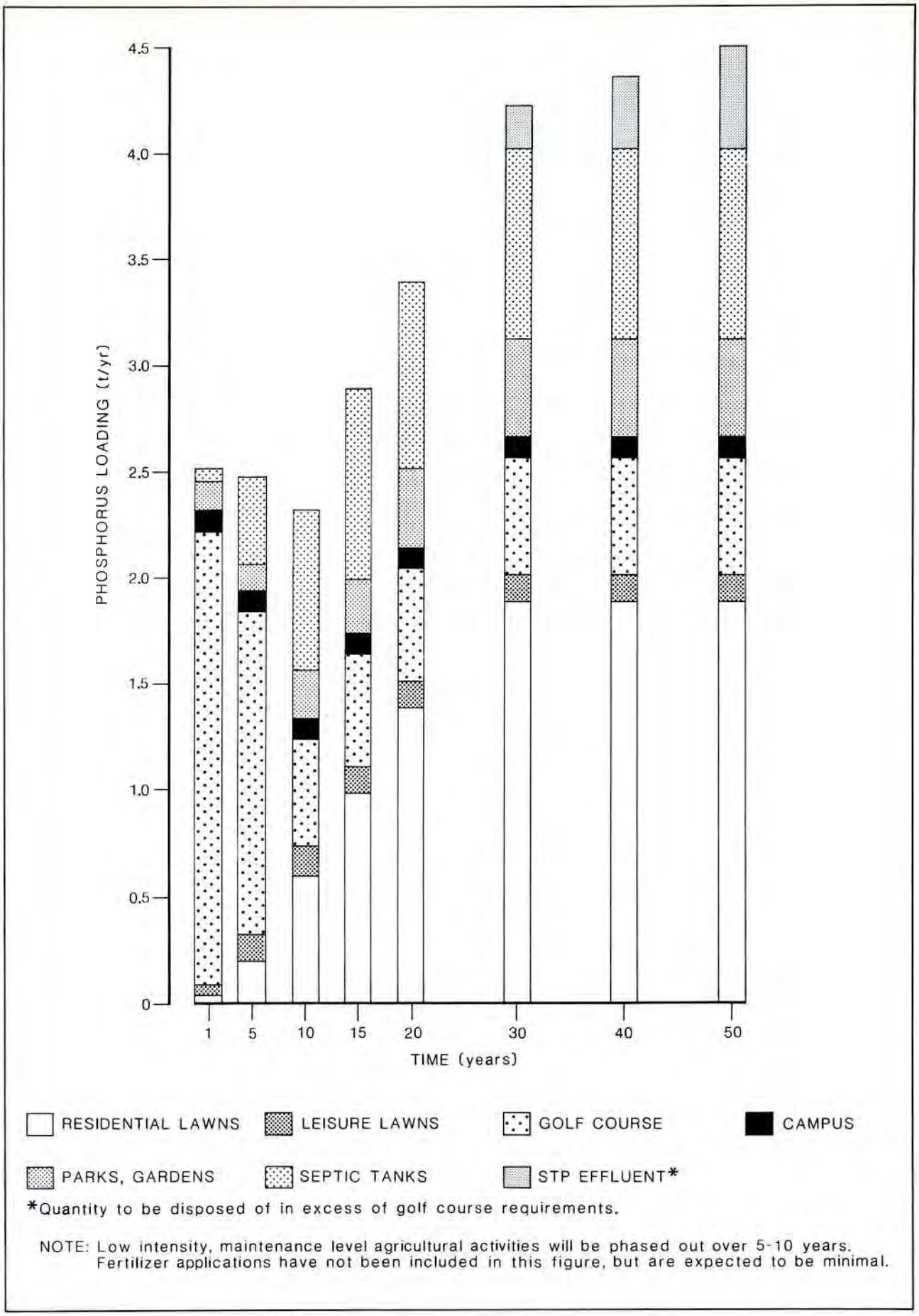
PARKS —— FERTILISER APPLIED TO PUBLIC PARKS & GARDENS
CAMPUS —— FERTILISER APPLIED TO COLLEGE CAMPUS

PHOSPHORUS LOAD - YEAR 50
WITH MANAGEMENT
(Maximum load of 4.5 t/yr P)



PREDICTED PHOSPHORUS LOADING FROM THE DEVELOPMENT OVER TIME

APPENDIX G

APPENDIX G

GROUNDWATER SUPPLY INVESTIGATION

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ADDENDUM G-III	Completion Reports, Leederille Formation Exploratory Bores PG1 and PG2

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8	Leederville Formation; Salinity Contours
9	Leederville Formation, Potentiometric Head
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11	Schematic Layout of Shallow Groundwater Supply Simulations
12	Predicted Drawdown for Low Recharge Year

1.0 INTRODUCTION

At the request of Mallina Holdings Ltd, a preliminary investigation has been made of potential sources of groundwater supply for the proposed Point Grey development, incorporating the Thomas Peel College, with associated residential and leisure living lots and tourist holiday accommodation.

The initial scout drilling investigation and site hydrogeology has been reported previously (Dames & Moore, 1986).

Two potential aquifers have been identified in the surficial and Leederville Formations, and the following work completed.

- Drilling and logging of 30 exploratory holes in the surficial formation within the Point Grey site, primarily to investigate nutrient levels in the water table aquifer but also to test the thickness of the freshwater lens on the development site.
- Pump testing of a Water Authority of Western Australia (Water Authority) test bore on the Point Grey site, which was drilled in 1981, to evaluate potential groundwater supplies for Miami. This bore was screened at a depth of 72 to 80m in the upper part of the Leederville Formation.
- Construction of two exploratory bores south and east of the Point Grey site to evaluate regional groundwater salinity in the Leederville Formation aquifer.
- Review of the unpublished results of an extensive investigation of the surficial aquifer, which extends eastwards from the Peel Inlet and Harvey Estuary.
- Regional correlation of results of groundwater exploration and testing of the Leederville Formation as part of the Miami and Mandurah groundwater investigations, deep oil exploration drilling and the Park Ridge (west of Harvey Estuary) groundwater supply development.
- Assessment of the environmental impact of development of the surficial aquifer, east of the site.

The location of the site and of all relevant groundwater investigation and supply bores are shown on Figure 1.

2.0 WATER SUPPLY REQUIREMENT

The proposed development schedule has been used to estimate water supply demand for domestic purposes and irrigation of parks, gardens and the golf course. Only the domestic supply would need treatment to Water Authority standard, and a major part of the irrigation demand could be met from use of untreated Leederville groundwater and recycled effluent from the sewage treatment plant.

Projected demands are as follows.

TABLE 1

PROJECTED WATER DEMAND

YEAR	DOMESTIC SUPPLY (treated ML/yr)	IRRIGATION SUPPLY (untreated ML/yr) College	Golf Course	Parks & Gardens	TOTAL IRRIGATION
1	254	150	304	75	529
5	515	150	256	75	481
10	752	150	207	150	507
15	989	150	157	150	457
20	1172	150	107	225	482
50	1518	150	0	300	450

(Effluent availability from sewage treatment plant increases from 71ML/yr at year 1 to 508ML/yr at year 50. Total golf course requirement is 375ML/yr)

3.0 HYDROGEOLOGY

The hydrogeology of the area as it relates to this study is described by reference to the surficial formation on the Point Grey site, the surficial formation eastward of the site (Waroona Mound) and the Leederville Formation. A generalised hydrogeological section (Figure 2) shows the relationship between these formations.

3.1 SURFICIAL FORMATION

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

3.1.1 Point Grey Site

At an early stage of the investigation, a total of 30 scout holes were drilled on-site to determine the salinity and nutrient levels in the surficial formation groundwaters (Dames & Moore, 1986). It was recognised that at the Point Grey site itself, the potential for other than limited abstraction from this source was not a viable option, but the role of the aquifer in discharging nutrients to the Estuary was seen to be a critical environmental consideration.

The locations of the scout holes and Sections 1-1' to 7-7' (Addendum G-I) based on the scout drilling results, are attached to this report together with completion reports for each hole (Addendum GII).

The sections indicate that on the project site, the water table elevation is between 0 and 0.5m AHD. Groundwater quality is generally very poor with high salinities (20,000 to 30,000mg/L). Because of infiltrating rainwater, a small freshwater lens has been established on top of this very saline water and its lateral extent and thickness are shown on cross-sections 3-3' and 4-4'. The salt water interface is a sharp boundary, occupying a vertical interface of only 1.0 to 2.0m.

The analyses of shallow groundwater samples taken during the drilling programme show that the level of nitrates in the upper zone of saturation is generally high under the farmland and can be above the allowable limit of 45mg/L for potable groundwater. In addition it is only the freshwater lens which contains high nitrates and this suggests that the source of the nitrate is derived from agricultural practices as the concentrations were noticeably lower under the forested site.

Phosphate levels in the shallow groundwater are generally quite low under both the farmland and forested area, and only one exploration bore (PG5) intersected groundwater with a phosphate content greater than 0.2mg/L. Unlike the nitrate, the larger concentrations of the phosphate occur both in the freshwater lens and the more saline water. The source of the phosphate could be from both the ground surface and the water of Peel Inlet.

3.1.2 Eastward of Point Grey Site (Waroona Mound)

The Harvey Shallow Groundwater Investigation, conducted by the Geological Survey of Western Australia, involved the construction and testing of a large number of groundwater bores (designated as HS) located both on the Point Grey site and regionally over a wide area to the east and south (Figure 1). Summary results from the investigation are presented in the following series of figures:

- Groundwater salinity at the water table (Figure 3),
- Groundwater salinity at the base of the surficial aquifer (Figure 4), and
- Water table contours (Figure 5).

The contact between Guildford sands (on the west) and Guildford clays (on the east) is shown on the groundwater salinity figures.

Evidence for significant recharge to the surficial formation on a regional scale is given by the low salinities at the water table over much of the area. Recharge may be as much as 20 to 30% of rainfall where the ground has been cleared for pasture. The influence of the saline waters of Peel Inlet and Harvey Estuary is also evident, with groundwater salinities in excess of 1000mg/L forming a wedge at the base of the aquifer extending about 10km southeast of the centre of the Point Grey site.

This accounts for the limited availability of potable groundwater at the Point Grey site and the far greater potential of the surficial aquifer to the east. The results of test pumping of two of the bores, HS32 and HS48 are given in Table 2. HS32 is located in the area near the proposed wellfield in the surficial aquifer.

TABLE 2

TEST PUMPING RESULTS
HARVEY SHALLOW GROUNDWATER BORES

NO.	DISCHARGE RATE (m^3/d)	AQUIFER	TRANSMISSIVITY (m^2/d)	HYDRAULIC CONDUCTIVITY (m/d)
HS32	194	Jandakot Beds	23	3
HS48	1168	Jandakot Beds	409	16

Chemical analyses of the groundwaters from these two bores, taken at the base of the surficial aquifer, are given below, expressed in mg/L unless otherwise stated:

	HS32	HS48
Electrical Conductivity mS/m at 25°C	93.5	228
Total Dissolved Salts	495	1220
pH	7.6	7.4
Colour (Alpha Units)	100	15
Total Hardness (as $CaCO_3$)	220	410
Total Alkalinity (as $CaCO_3$)	185	230
Calcium	66	106
Magnesium	13	35
Sodium	101	299
Potassium	4	5
Bicarbonate	226	281
Chloride	169	582
Sulphate	15	39
Nitrate	<1	<1
Silica	14	17
Boron	0.07	
Fluoride	<0.1	0.1
Iron	6.8	2.3
Nitrate (as N)	<0.02	<0.02
Ammonium (as N)	0.14	0.24
Phosphorus (as P)	0.07	0.07

3.2 LEEDERVILLE FORMATION

The Leederville Formation is a multi-layered aquifer fully saturated with groundwater. It has been explored by a number of exploratory and production bores in the Mandurah/Pinjarra region. Locations of bores for which useful information is available are shown on Figure 1.

Specifically, the data used have been derived from water supply investigation bores drilled for Mandurah (M), Miami (Mi), Park Ridge (PR), Point Grey (PG) together with the Harvey Shallow Groundwater Investigation bores (HS) and the deep Pinjarra No. 1 exploratory oil well (PJ1). Completion reports for the Point Grey exploratory bores (PG1 and PG2) are attached in Addendum G-III.

The Leederville Formation gives a characteristic response on down-hole gamma ray and resistivity logs enabling lithological correlations to be made with a high degree of confidence. These correlations are supported by lithological descriptions which confirm the continuity of horizons such as the 'green clay marker'. A typical correlation is shown on Figure 2 (Section A-A').

Groundwater salinities can be deduced from the resistivity logs and checked against chemical analyses of groundwater samples collected from the completed monitor bores.

The aquifer of interest to this study is the Upper Leederville Formation, ie. that part of the Leederville Formation lying above the 'green clay marker'. It subcrops beneath clays and sands of the Guildford Formation/Jandakot Beds to the east of the Peel-Harvey Estuary, and dips westwards beneath the Estuary and Ocean. Recharge in the area under review is by downward leakage of groundwater from the surficial formations.

At Point Grey ,where the PG2 exploratory bore was drilled to a depth of 149m, the Upper Leederville Formation aquifer is at a depth of 80m to an estimated 200m below AHD. It contains low salinity groundwater (less than 1000mg/L TDS) through the total depth drilled. This low salinity zone is also present to the west of the Estuary in the Park Ridge (135 to 190m+ depth) bore. In the northern part of the area, the aquifer extends from 25m to an estimated 140m depth, with potable groundwater between 65 and 105m depth. In Miami 1/80 exploratory bore, the aquifer extends from about 50m to 230m depth and contains mainly brackish groundwater with only a thin layer of low salinity groundwater near 80m depth.

The results from these bores are summarised on the two east-west sections presented on Figure 6.

Structure contours on the 'green clay marker' shown on Figure 7 confirm the westerly dip of the Upper Leederville aquifer and show it to subcrop beneath the surficial formation some 12km east of Point Grey.

Approximate groundwater salinities (Figure 8) and potentiometric heads (Figure 9) indicate a westerly flow with salinities strongly influenced by the saline waters of the surficial formation close to Peel Inlet.

Groundwater quality from the low salinity groundwaters in the aquifer are expected to be comparable to that derived from samples collected by the former Public Works Department during the pumping test at Miami 1/80. Because PG1 and PG2 were completed as piezometers, only limited airlifting was possible, and the collected samples were simply analysed for pH and electrical conductivity. These analyses confirmed the salinity interpreted from the downhole resistivity logs and indicate it to be similar to that from the Miami 1/80 bore.

TABLE 3

MIAMI 1/80 BORE
SAMPLE AFTER 8hrs PUMP TESTING

PARAMETER	VALUE
Conductivity (mS/m)	141
	milligrams per litre
Total Dissolved Salts	800
Chloride	315
Total hardness (as $CaCO_3$)	255
Total alkalinity (as $CaCO_3$)	203
Calcium	51
Magnesium	31
Sodium	161
Iron (soluble)	0.4
Manganese (soluble)	0.05
Fluoride	0.1
Nitrate	<1

4.0 GROUNDWATER AVAILABILITY

The Water Authority of Western Australia require that before they will take over a water supply scheme, the safe renewable yield of the source has been proved to their satisfaction. This is a very difficult, if not impossible task, and generally a valued judgement must be made by developers and Water Authority officers.

In this instance, the most economical source of supply for the Point Grey development is the Upper Leederville aquifer. The work completed to date indicates that the aquifer has the capacity to meet the project requirement for at least 5 years, but that additional drilling and testing is required to upgrade the estimates of throughflow and recharge, and to assess whether it can support the total development. Because of the time and cost associated with these investigations, it has been decided to seek approval for the project on the basis of a surficial supply to the east, known as the Waroona Mound. This groundwater source has been investigated by the Geological Survey, and their unpublished results indicate the existance of suitable supplies of potable water, capable of meeting the total project demand. If approval is granted, further investigations on the Leederville Formation will proceed.

4.1 SURFICIAL AQUIFER - WAROONA MOUND

The Geological Survey have delineated several groundwater flow system within the surficial formation on the coastal plain, as a result of the Harvey Shallow Groundwater Investigation. Further, the throughflow within each flow section has been estimated. This is done by use of water table contours, water table gradients and aquifer permeability, to estimate the groundwater discharge across a particular water table contour.

In the Waroona flow system, here called the Waroona Mound, the aquifer recharge zone for the Leederville Formation shown on Figure 10, equates to one of the flow sections evaluated by the Geological Survey. This flow section (Waroona No. 3) discharges across the 1m water table contour to the Harvey Estuary at a rate of 4130m^3/d (1500ML/yr), equivalent to 1.7% of average annual rainfall.

Rainfall recharge at a higher elevation on the groundwater mound, between the 5m and 10m water table contour, is considered to be much greater at 10 to 20% of rainfall, and it is appropriate to estimate a water balance for the surficial aquifer in this more elevated area where a production wellfield is planned to be sited, supplemented as required by the Leederville aquifer groundwater resources.

The total area of aquifer which has low salinity groundwater through its full saturated thickness to the base of the surficial aquifer (see Figure 5) is about 120km^2. Much of this area is underlain by clays of the Guildford Formation, and although this clay base area constitutes a significant resource, the water balance of the area of Guildford Sands recharging the Upper Leederville aquifer has been examined, as it directly relates to calculations of recharge to the Upper Leederville aquifer.

This area, as shown in Figure 10, covers 41.5km^2. Groundwater inflow to the area is calculated by use of hydraulic conductivities, flow lines and water table gradients determined by the Geological Survey. Rainfall is assumed to average 960mm/yr. Groundwater outflow is determined on the downflow side of the recharge area. Drainage and runoff is estimated using coefficients determined by the Department of Conservation and Environment during the Peel Inlet nutrient study (18% of rainfall). Evapotranspiration has been conservatively calculated as 80% of rainfall (Water Authority, pers. comm.).

The estimated figures are as follows:

Groundwater inflow, Gi	=	350(T) x 0.001(i) x 7000(l)
	=	2800m^3/day
Rainfall, R	=	0.96m/yr x 41.5km^2
	=	110,000m^3/day
Groundwater outflow, Go	=	300(T) x 0.001(i) x 8000(l)
	=	2400m^3/day
Drainage and runoff, Dr	=	19,800m^3/day
Evapotranspiration, Et	=	88,000m^3/day
Leakage, L	=	to be calculated

The water balance then becomes:

R + Gi	=	Et + Dr + Go + Leakage
∴ 110,000 + 2800	=	88,000 + 19,800 + 2400 + L
∴ L	=	2600m^3/day
	=	950ML/yr

By these estimates, recharge to the surficial aquifer is equivalent to (R-Et)/R or 20% of rainfall. Although a small change in the evapotranspiration estimate could radically affect the above conclusion, it is clear that there is a substantial reserve of groundwater in the surficial aquifer in this area, with recharge of some 8000ML/yr. A proportion of this recharge enters the Upper Leederville aquifer and the conclusion can be drawn that the surficial aquifer in its own right could meet the total project demand. Economically, however, it would be advisable to utilise the Upper Leederville aquifer to meet part or all of the project demand, at least in the first five to ten years of development.

4.2 LEEDERVILLE AQUIFER

According to the calculations in the preceding section, at least 950ML/yr of groundwater is available from the Upper Leederville aquifer as a long term sustainable yield. Development of this source would lead to a marginal reduction in water table levels over the whole recharge area thereby reducing evapotranspiration and drainage losses, and increasing recharge. From this assessment it is expected that the total project requirement of 2130ML/yr could possibly be met from the Leederville aquifer.

Present throughflow in the Upper Leederville aquifer can be estimated, using a transmissivity of 550m^2/day, hydraulic gradient of 0.0005 and section length of 7000m.

$\therefore$ Throughflow = 550 x 0.0005 x 7000
= 1925kL/day
= 700ML/yr

This calculation, for the undisturbed aquifer system, is close to the leakage figure calculated for the surficial aquifer. As discussed however, this is a conservative figure when the current drainage and evapotranspiration losses which will be partly recoverable in the future, are taken into account.

4.3 ESTIMATION OF GROUNDWATER SUPPLY IMPACTS

4.3.1 Water Supply Impacts of Pumping from the Surficial Aquifer

It is proposed that the water developments' supply requirements be based on the surficial aquifer about 15km to the southeast of Point Grey. This may be supplemented by supplies from the Leederville aquifer.

The economic disadvantages of using the surficial supply, in comparison to the Leederville supply, are the distance away from the site and the thinness of the aquifer (approximately 20m compared to 50 to 100m in the Leederville) which will result in the requirement to have more, lower yielding bores.

A hypothetical abstraction borefield in the unconfined aquifer has been simulated using the USGS groundwater flow model (MODFLOW).

This simulation was carried out to predict the dewatering effects of abstraction from the borefield over a twelve month drought period.

Aquifer parameters were assumed to be:

- hydraulic conductivity 15m/d
- storage coefficient 0.1
- initial flow depth 20m

Rainfall data for the lowest recorded rainfall year, recorded for Perth between 1877 and 1986 (1940) was used to determine groundwater recharge. Recharge was assumed to be 10% of this rainfall. Recharge and pumping were distributed over five 73 day periods and Table 4 lists these data.

TABLE 4

RECHARGE AND PUMPING RATES FOR WAROONA MOUND
(assumes 1940 Perth rainfall data)

TIME PERIOD (days)	MONTHLY DATA USED	ASSUMED RAINFALL (mm)	ASSUMED RECHARGE RATE (mm/d)	ASSUMED PUMPING RATE (kL/d)
0-73	O*, N, D	46	0.06	4160
73-146	J, F, M	22	0.03	8320
146-219	A, M, J*	136	0.19	4160
219-292	J*, J, A*	175	0.24	2080
292-365	A*, S, O*	130	0.18	2080
TOTAL		509	51	1520ML

* - HALF MONTHLY RAINFALL

Simulation of abstraction from a right angled borefield (expected to be located along road reserves) extending 2.0km on each arm, enabled the prediction of localised drawdowns and extent of drawdown influence. Figure 11 shows a schematic layout of the borefield and simulation scheme. The simulation was carried out six times, in three 2 month steps of no recharge followed by three 2 month steps of recharge at a rate of 10% of annual rainfall.

Results are summarised in Table 5.

TABLE 5

TRANSIENT RESPONSE OF SHALLOW BOREFIELD AQUIFER WITH SEASONAL RECHARGE

	SIMULATION TIME	AVERAGE DRAWDOWN IN BOREFIELD	RADIAL INFLUENCE
End of Summer	146	1.3	1.5
End of Winter	365	0.4	0.6

At the end of the summer period, the drawdowns were predicted to be in the order of only a few metres in the vicinity of the borefield, and the extent of drawdown influences was predicted to occur to a maximum distance of about 1.5km from the borefield.

Following recharge over the winter period, the drawdowns near the borefield were predicted to be less than about one metre and the drawdown influence reduced to about 0.6km from the borefield (Figure 12).

The impacts of these drawdowns are expected only to have a localised, if any, affect on surface water hydrology. Within the area of the low salinity shallow groundwater where the borefield would be located, there are no wetlands of any significance.

This area is primarily used for agricultural activities and is extensively drained to reduce water logging. Any impacts would lead to reduced (but probably immeasurable) drainage outflow from the area centred about the borefield.

4.3.2 Leederville Aquifer

Unmanaged abstraction of water from the Leederville aquifer could cause impacts to the supply, if the induced drawdown levels lead to intrusion of saline water from other areas. The sources of saline water near Point Grey are expected to be to the northwest, underlying the Estuary, and in various aquifer sequences above or below the producing aquifer.

Conventional water resource planning generally requires that the total pumpage from an aquifer should be less than the throughflow at the site, to avoid mining the resource. Calculation of this throughflow rate is very difficult to achieve, complications being the determination of the aquifer properties which may vary greatly over small areas and changes to the recharge/discharge pattern caused by the abstraction operations.

Impacts related to saline intrusion can be readily predicted, given abstraction scenarios and can be monitored during the supply period and managed by optimal location of borefields and control of pumping. Impacts of pumping from the Leederville aquifer on the overlying surficial aquifer and wetlands, are expected to be contained within the area of Leederville subcrop, some 12 to 15km southeast of the site. Near the site, the surface hydrology is independent of the Leederville aquifer, being separated from it by up to 50m of a sequence of low permeability claystones interbedded with sandstones.

As a consequence, there will be no water supply impacts on wetlands such as Lake Mealup, due to pumping from the Leederville aquifer at, or near to Point Grey.

5.0 CONCLUSIONS

The total Point Grey project can be supplied from the extensive low salinity groundwater source in the Waroona Mound, a surficial aquifer southeast of the Point Grey site. The closest wellfield would be located 12 to 15km southeast of the site. Recharge to this aquifer is sufficient to provide the total water supply requirement to full project development at year 50.

The water would require treatment for iron and coloration. Computer modelling indicates that water table drawdown levels can be managed to avoid undue impact on wetlands in the area. Further investigation would be required to determine the number, siting and optimum yield of production bores in the proposed wellfield.

During the early stages of the development (eg. the construction phase of the College) it is proposed to utilise the Upper Leederville aquifer for part or all of the initial water requirements. The calculation given in this report suggest that the sustainable yield of the Upper Leederville aquifer is capable of meeting the initial 5 year project demand with the potential to meet the total project requirement if the wellfield is sited to ensure maximum leakage from the surficial aquifer southeast of Point Grey.

6.0 RECOMMENDATIONS

The surficial aquifer has sufficient sustainable resources to meet the long term total project requirement. This proposal is based on the utilisation of the surficial aquifer as the source for water.

It is recommended that further studies be undertaken at an early stage to upgrade the potential of the Upper Leederville aquifer with a view to its development as the Point Grey water supply source.

Subject to liaison and discussion with the Water Authority, it is proposed that the following action be taken to further investigate the potential of the Leederville Formation.

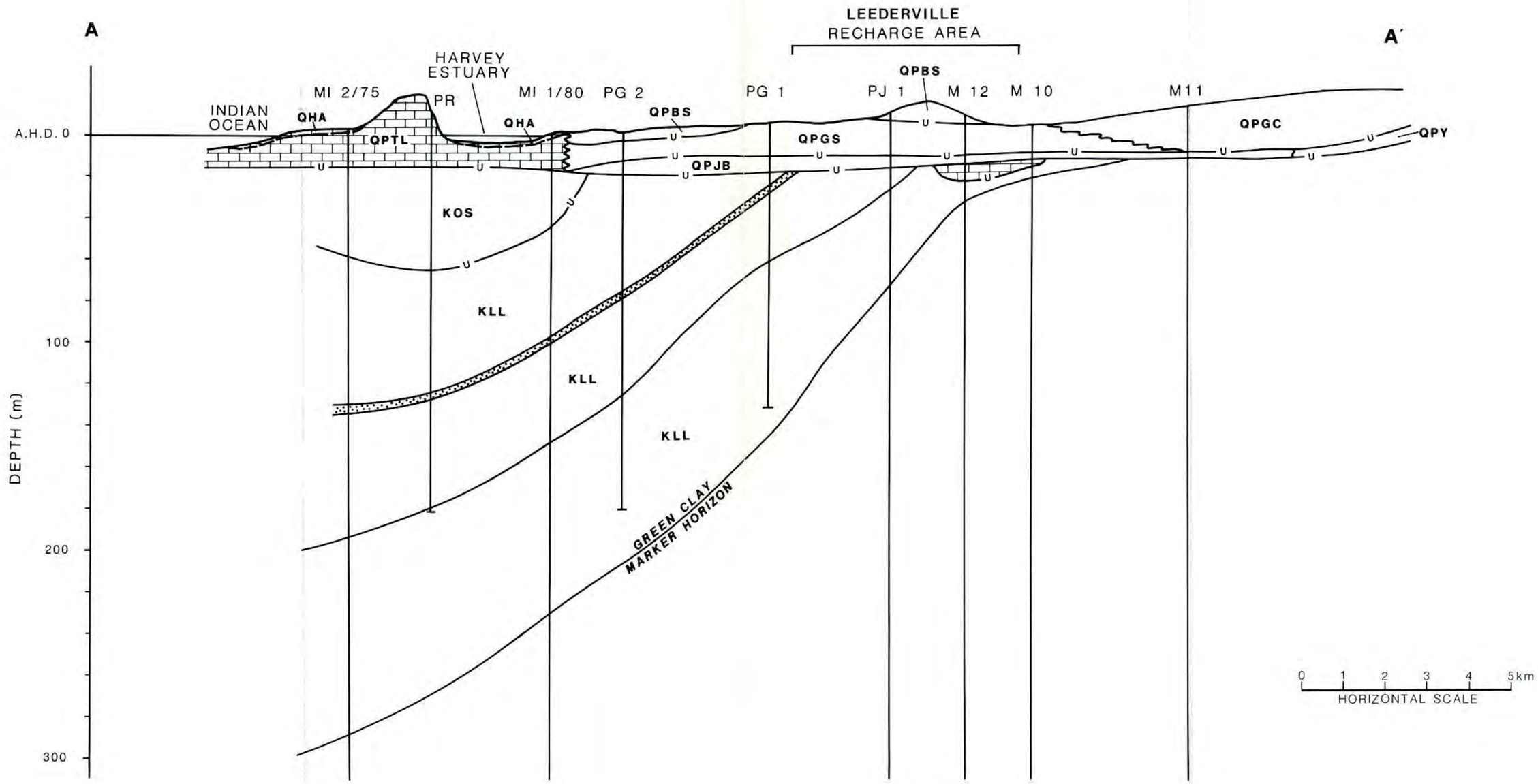
- Utilisation of Miami 1/80 as a construction water supply source and longer term irrigation source for Thomas Peel College, with appropriate monitoring of salinity, drawdown and pumpage.
- Exploration and development of water supply wells in the Leederville Formation both within the Point Grey site and southeastwards toward the main recharge area. Determination of aquifer coefficients, salinity distribution, head differences between the surficial and Leederville aquifers, and leakage coefficients.
- Computer modelling to determine appropriate aquifer management strategies for control of salt water interface migration and aquifer drawdown levels.

7.0 REFERENCE

Dames & Moore (1986), Water Supply and Environmental Investigations for the proposed Point Grey development Pinjarra, W.A., Report prepared for Feilman Planning Consultants.

FIGURES

SECTION A-A'



Quaternary
- QHA Alluvium
- QPBS Bassendean Sand
- QPTL Tamala Limestone
- QPGS Guildford Sand
- QPGC Guildford Clay
- QPJB Jandakot Beds
- QPY Yoganup Formation

Cretaceous
- KOS Osborne Formation
- KLL Leederville Formation (Sand Layer)

REGIONAL HYDROGEOLOGICAL SECTION

Dames & Moore

SOURCE: Groundwater Resource Consultants

Figure 2

INDIAN OCEAN

PEEL INLET

HARVEY ESTUARY

LAKE CLIFTON

INDIAN OCEAN

STUDY AREA BOUNDARY

GUILDFORD SAND

GUILDFORD CLAY

PINJARRA

Pinjarra Road

Old Bunbury Road

South Western Highway

M12 2/75 · M11/80 · M12 · M10 · M11 · PG1 · PG2 · PJ1 · PR

HS 58 · HS 59 · HS 53 · HS 54 · HS 56 · HS 57 · HS 60 · HS 61 · HS 50 · HS 49 · HS 48 · HS 47 · HS 51 · HS 52 · HS 46 · HS 44 · HS 45 · HS 41 · HS 42 · HS 43 · HS 36 · HS 37 · HS 38 · HS 39 · HS 40 · HS 62 · HS 31 · HS 32 · HS 33 · HS 34 · HS 35

4000 · 2000 · 1000 · 500

- Leederville production bore
- ⊙ Leederville observation bore
- ⌀ Abandoned exploratory oil well
- • Surficial observation bore
- —500— Salinity contour (mg/L TDS)
- ━━ Contact between sand and clay of Guildford formation

0 1 2 3 4 5km

SURFICIAL FORMATIONS
SALINITY CONTOURS AT WATER TABLE

Figure 3

Dames & Moore

SOURCE: Groundwater Resource Consultants

INDIAN OCEAN

PEEL INLET

HARVEY ESTUARY

LAKE CLIFTON

INDIAN OCEAN

M22/75

M11/80

HS58

HS59

HS53

HS55

M12

M10

PG1

STUDY AREA BOUNDARY

PR

PG2

HS47

HS49

PJ1

HS48

GUILDFORD SAND

HS41

HS42

HS43

HS36

HS37

HS62

HS31

HS32

HS33

HS34

HS35

2000

1000

500

Old Bunbury Road

Pinjarra Road

HS56

HS57

PINJARRA

HS54

M11

HS60

HS61

HS50

HS51

HS52

GUILDFORD CLAY

HS44

HS45

HS46

HS38

HS39

HS40

South Western Highway

- Leederville production bore
- Leederville observation bore
- Abandoned exploratory oil well
- Surficial observation bore
- — 500 — Salinity contour (mg/L TDS)
- Contact between sand and clay of Guildford formation

0 1 2 3 4 5km

SURFICIAL FORMATIONS
SALINITY CONTOURS
BASE OF AQUIFER

Dames & Moore

SOURCE: Groundwater Resource Consultants

Figure 4

INDIAN OCEAN

PEEL INLET

HARVEY ESTUARY

LAKE CLIFTON

INDIAN OCEAN

M12/75

M11/80

HS58

HS59

PG1

STUDY AREA BOUNDARY

PR

PG2

HS47

HS41

HS62

HS55

M12

M10

HS56

HS57

Pinjarra Road

PINJARRA

HS53

HS54

M11

HS60

HS61

5

10

PJ1

HS49

HS50

HS51

HS52

HS48

HS46

HS42

HS43

HS44

HS45

Old Bunbury Road

HS36

HS37

HS38

HS39

HS40

South Western Highway

HS32

HS31

HS33

HS34

HS35

5

10

- Leederville production bore
- Leederville observation bore
- Abandoned exploratory oil well
- Surficial observation bore
- 10 Water table contour (m AHD)

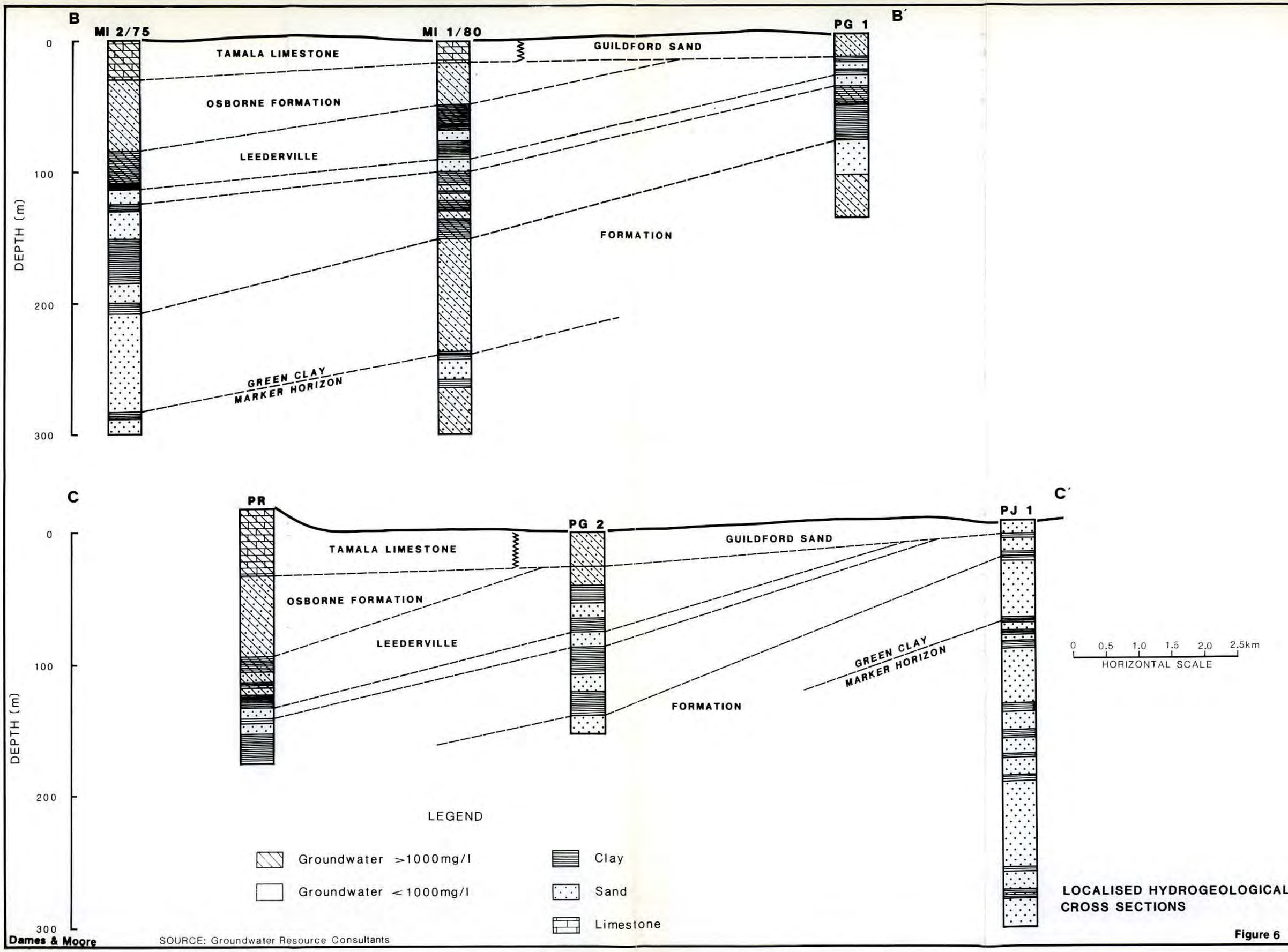
0 1 2 3 4 5km

SURFICIAL FORMATIONS WATER TABLE CONTOURS

Figure 5

Dames & Moore

SOURCE: Groundwater Resource Consultants



LOCALISED HYDROGEOLOGICAL CROSS SECTIONS

Figure 6

Dames & Moore

SOURCE: Groundwater Resource Consultants

INDIAN OCEAN

PEEL INLET

HARVEY ESTUARY

LAKE CLIFTON

INDIAN OCEAN

STUDY AREA BOUNDARY

Pinjarra Road

Old Bunbury Road

South Western Highway

PINJARRA

HS 55 MI2

MI 1/80

MI 2/75

MI0

HS 58

HS 59

HS 53

PG1

MII

HS 54

HS 60

HS 61

HS 56

HS 57

PR

PJ 1

HS 49

HS 48

PG 2

HS 47

HS 50

HS 51

HS 52

HS 46

HS 41

HS 42

HS 43

HS 44

HS 45

HS 36

HS 37

HS 38

HS 39

HS 40

HS 62

HS 31

HS 32

HS 33

HS 34

HS 35

260 220 180 140 100 60 20 0

- ● Leederville production bore
- ⊙ Leederville observation bore
- ⌀ Abandoned exploratory oil well
- • Surficial observation bore
- 20 Structure contour, green clay marker, metres below base of Surficials

0 1 2 3 4 5km

LEEDERVILLE FORMATION
STRUCTURE CONTOURS
GREEN CLAY MARKERS

Figure 7

Dames & Moore

SOURCE: Groundwater Resource Consultants

INDIAN OCEAN

PEEL INLET

HARVEY ESTUARY

LAKE CLIFTON

INDIAN OCEAN

Pinjarra Road

Old Bunbury Road

South Western Highway

PINJARRA

STUDY AREA BOUNDARY

2000

1000

500

HS 55 M12

M10

M11

M11/80

M2 2/75

HS 58

HS 59

HS 53

HS 54

HS 56

HS 57

HS 60

HS 61

PG1

PR

PJ1

HS 49

HS 50

HS 51

HS 52

HS 48

PG2

HS 47

HS 41

HS 42

HS 43

HS 44

HS 45

HS 46

HS 36

HS 37

HS 38

HS 39

HS 40

HS 62

HS 31

HS 32

HS 33

HS 34

HS 35

- Leederville production bore
- Leederville observation bore
- Abandoned exploratory oil well
- Surficial observation bore
- 500 — Approximate salinity (mg/L TDS) Leederville Formation above green clay marker

0 1 2 3 4 5km

LEEDERVILLE FORMATION SALINITY CONTOURS

Dames & Moore

SOURCE: Groundwater Resource Consultants

Figure 8

INDIAN OCEAN

PEEL INLET

HARVEY ESTUARY

LAKE CLIFTON

INDIAN OCEAN

M2 2/75

M1 1/80

HS 58

HS 59

PG 1

STUDY AREA BOUNDARY

PR

PG 2

HS 47

HS 48

PJ 1

HS 49

HS 41

HS 42

HS 43

HS 62

HS 31

HS 32

HS 36

HS 37

HS 38

HS 39

HS 40

HS 44

HS 45

HS 46

HS 33

HS 34

HS 35

HS 50

HS 51

HS 52

HS 54

M11

HS 60

HS 61

HS 56

HS 57

M10

HS 55

M12

HS 53

3

5

10

Pinjarra Road

PINJARRA

Old Bunbury Road

South Western Highway

● Leederville production bore

⊙ Leederville observation bore

⌀ Abandoned exploratory oil well

• Surficial observation bore

10 Potentiometric contour (m AHD)

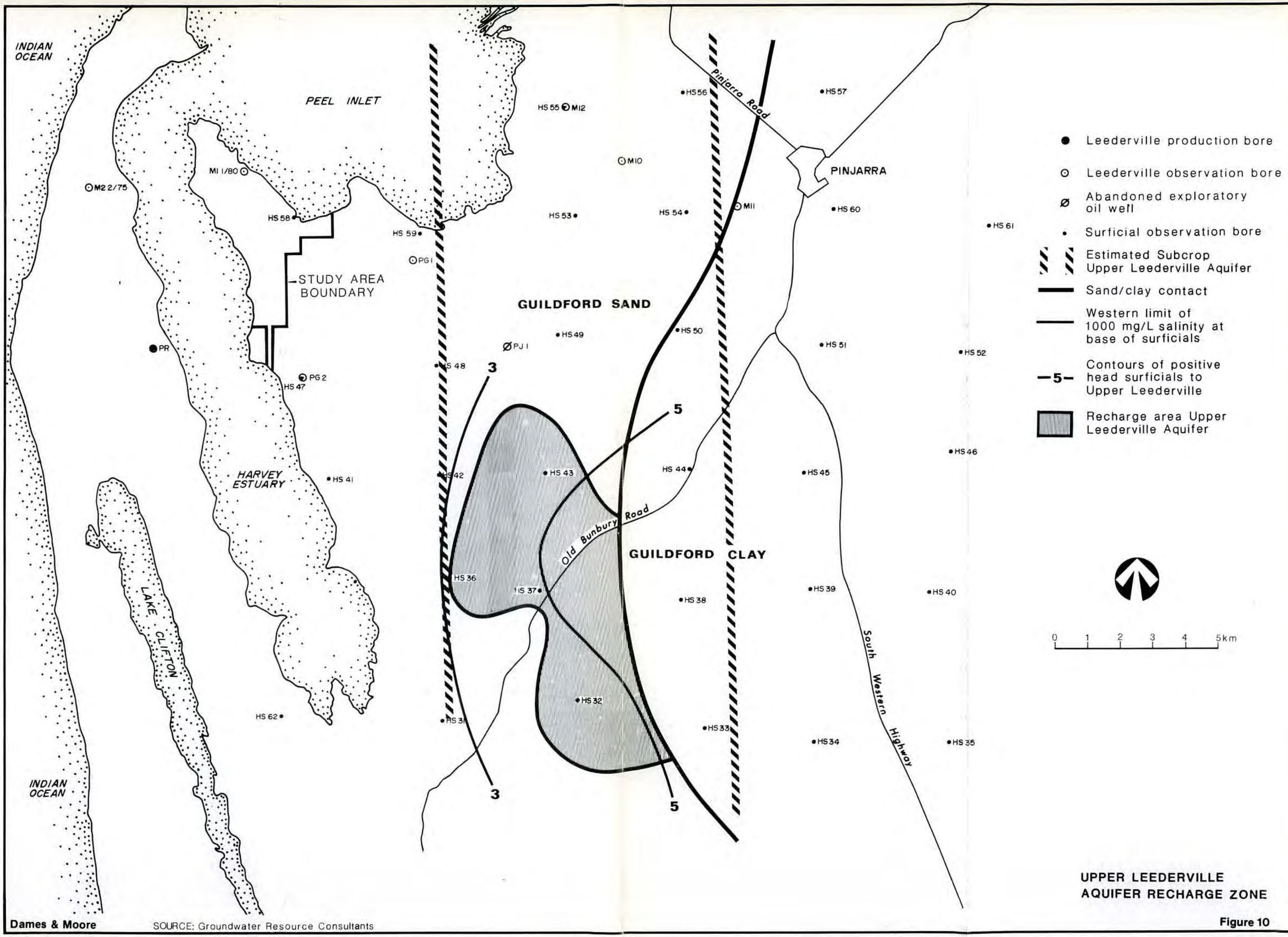
0 1 2 3 4 5 km

LEEDERVILLE FORMATION
POTENTIOMETRIC HEAD

Figure 9

Dames & Moore

SOURCE: Groundwater Resource Consultants

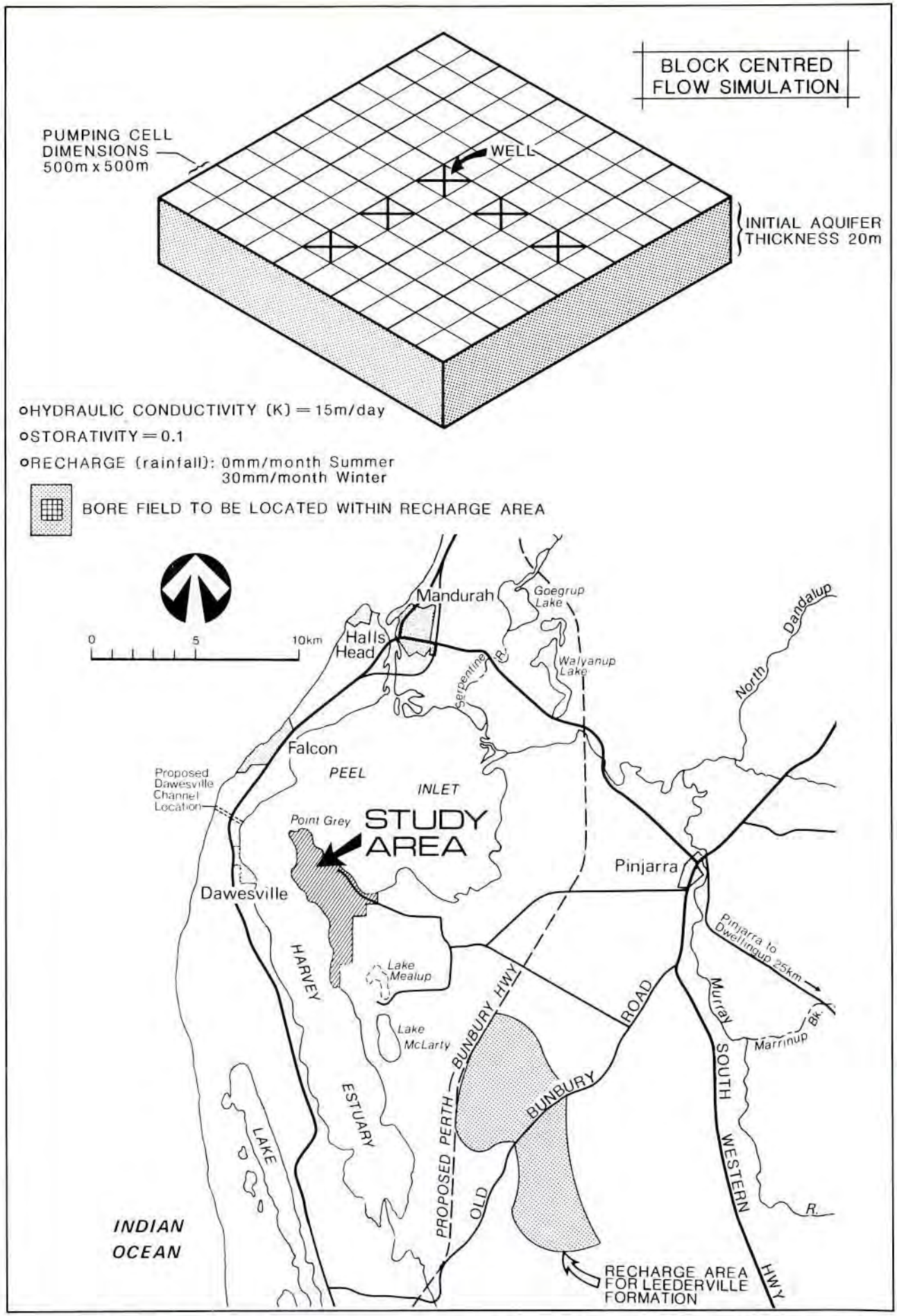


UPPER LEEDERVILLE AQUIFER RECHARGE ZONE

Dames & Moore

SOURCE: Groundwater Resource Consultants

Figure 10



SCHEMATIC LAYOUT OF SHALLOW GROUNDWATER SUPPLY SIMULATION

INDIAN OCEAN

PEEL INLET

HARVEY ESTUARY

LAKE CLIFTON

STUDY AREA BOUNDARY

PINJARRA ROAD

PINJARRA

BUNBURY ROAD

SOUTH WESTERN HIGHWAY

OLD BUNBURY ROAD

Nine Mile Lake

NINE MILE LAKE, WETLAND AREA

BOUNDARY OF LOW SALINITY SHALLOW GROUNDWATER, WAROONA MOUND

5

10

15

15

20

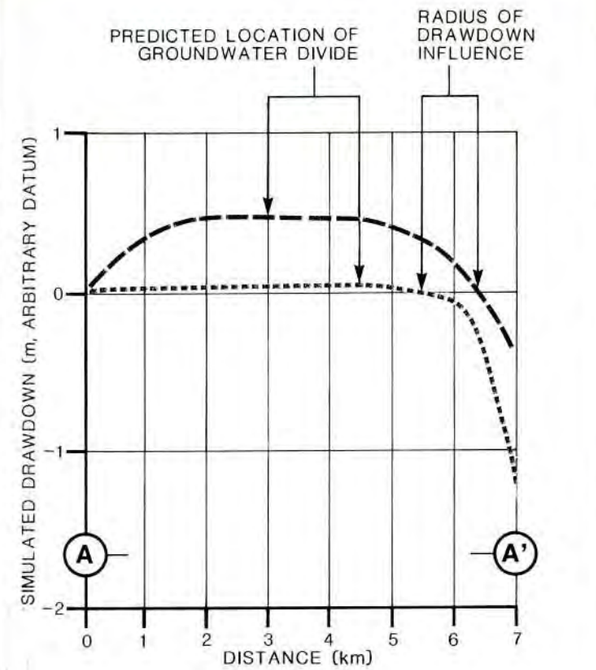
A

A'

0 1 2 3 4 5km

—10— GROUNDWATER EQUIPOTENTIAL (m, A.H.D.)ii

PREDICTED DRAWDOWN FOR LOW RECHARGE YEAR



PERMEABILITY ——— 15m/day
STORATIVITY ——— 0.10
INITIAL FLOW DEPTH ——— 20m
TOTAL ANNUAL RECHARGE (10% of 1940 RAINFALL) i ——— 51mm

CROSS SECTION A–A' SIMULATED GROUNDWATER LEVELS

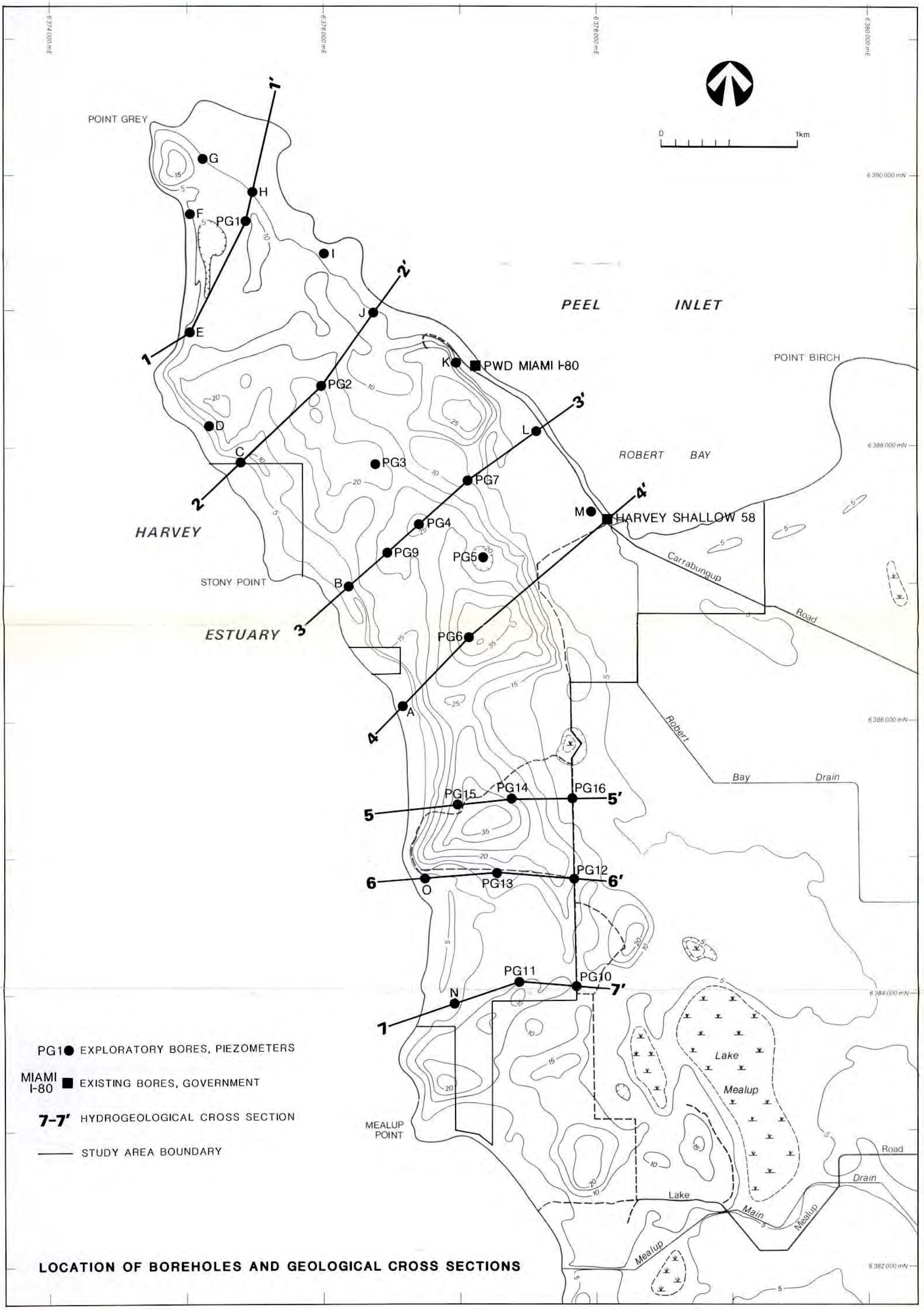
SOURCES: i/ 1940 PERTH RAINFALL METEOROLOGY DATA
ii/ GEOLOGICAL SURVEY OF W.A. (unpublished data)

Dames & Moore

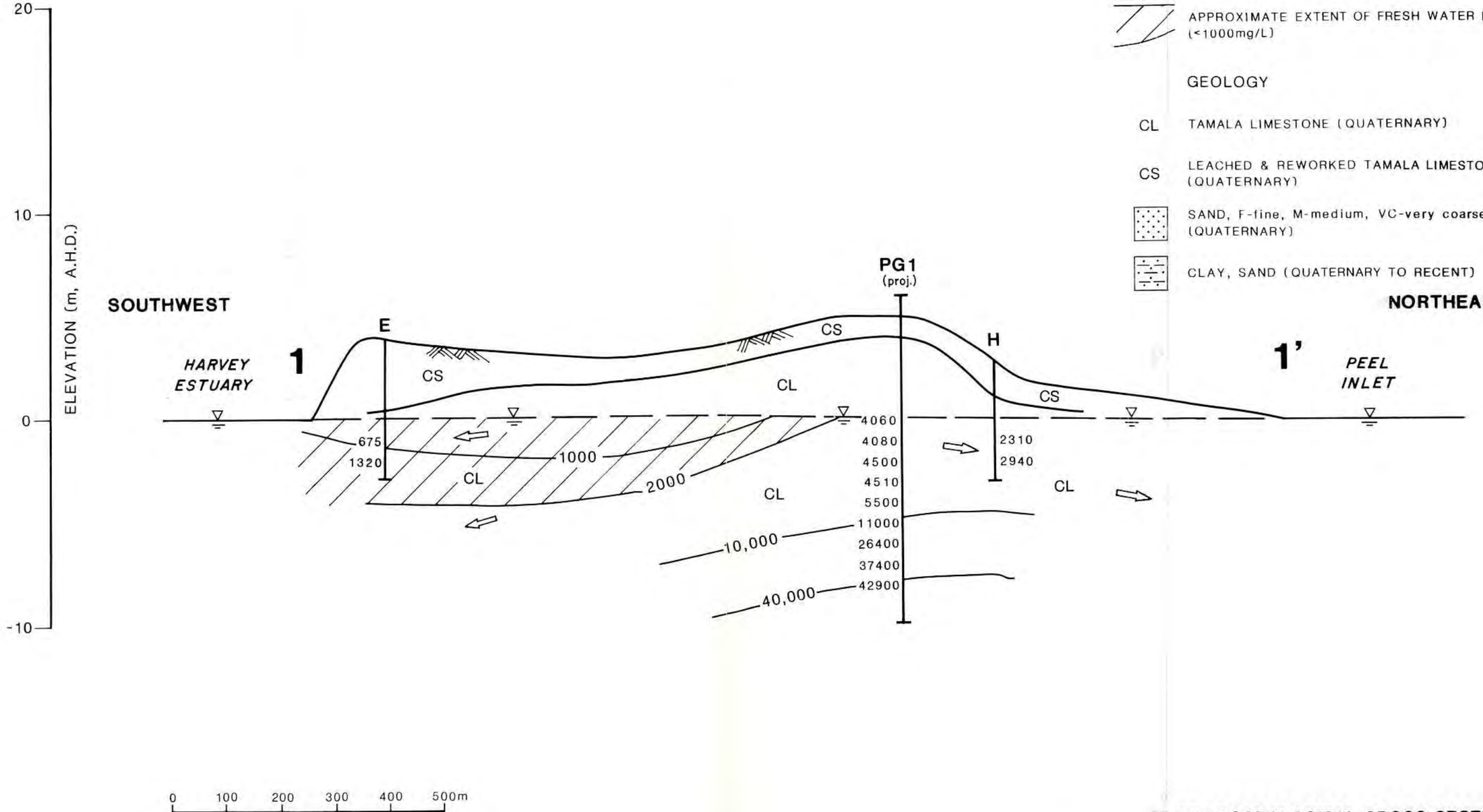
Figure 12

ADDENDUM G-I

LOCATION PLAN AND HYDROGEOLOGICAL
CROSS-SECTIONS FOR SCOUT DRILLING AT
POINT GREY

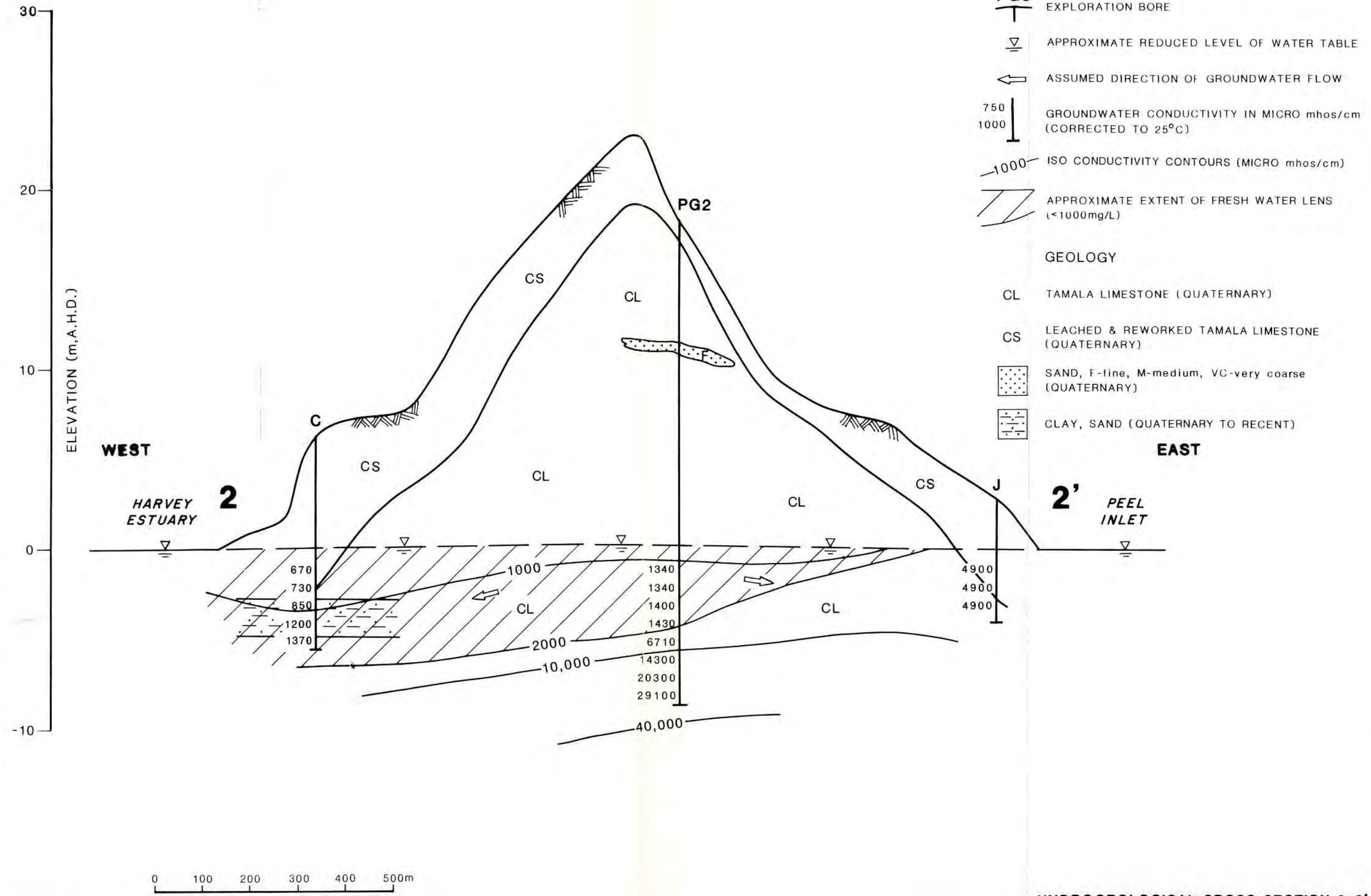


LOCATION OF BOREHOLES AND GEOLOGICAL CROSS SECTIONS



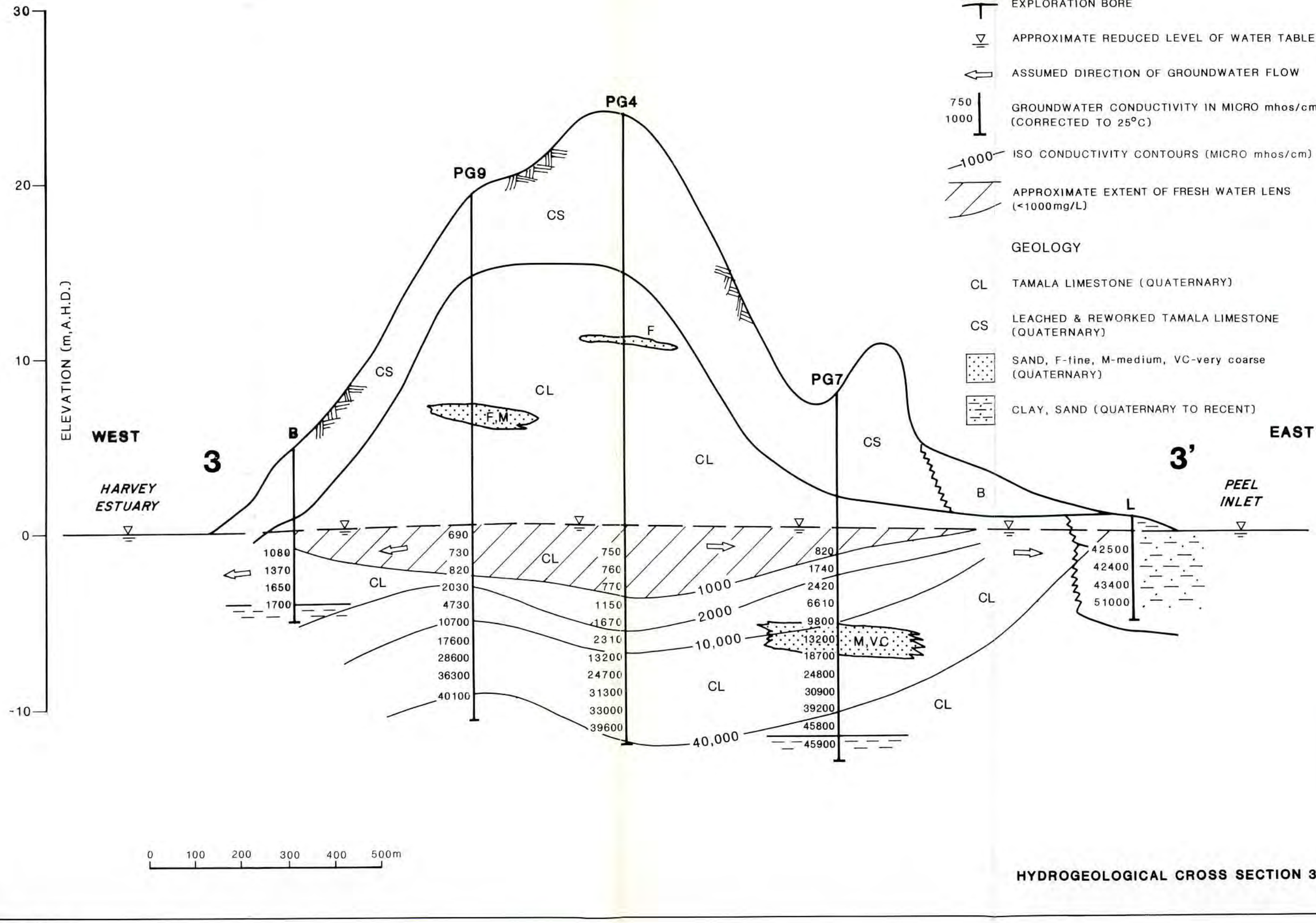
HYDROGEOLOGICAL CROSS SECTION 1-1'

Dames & Moore



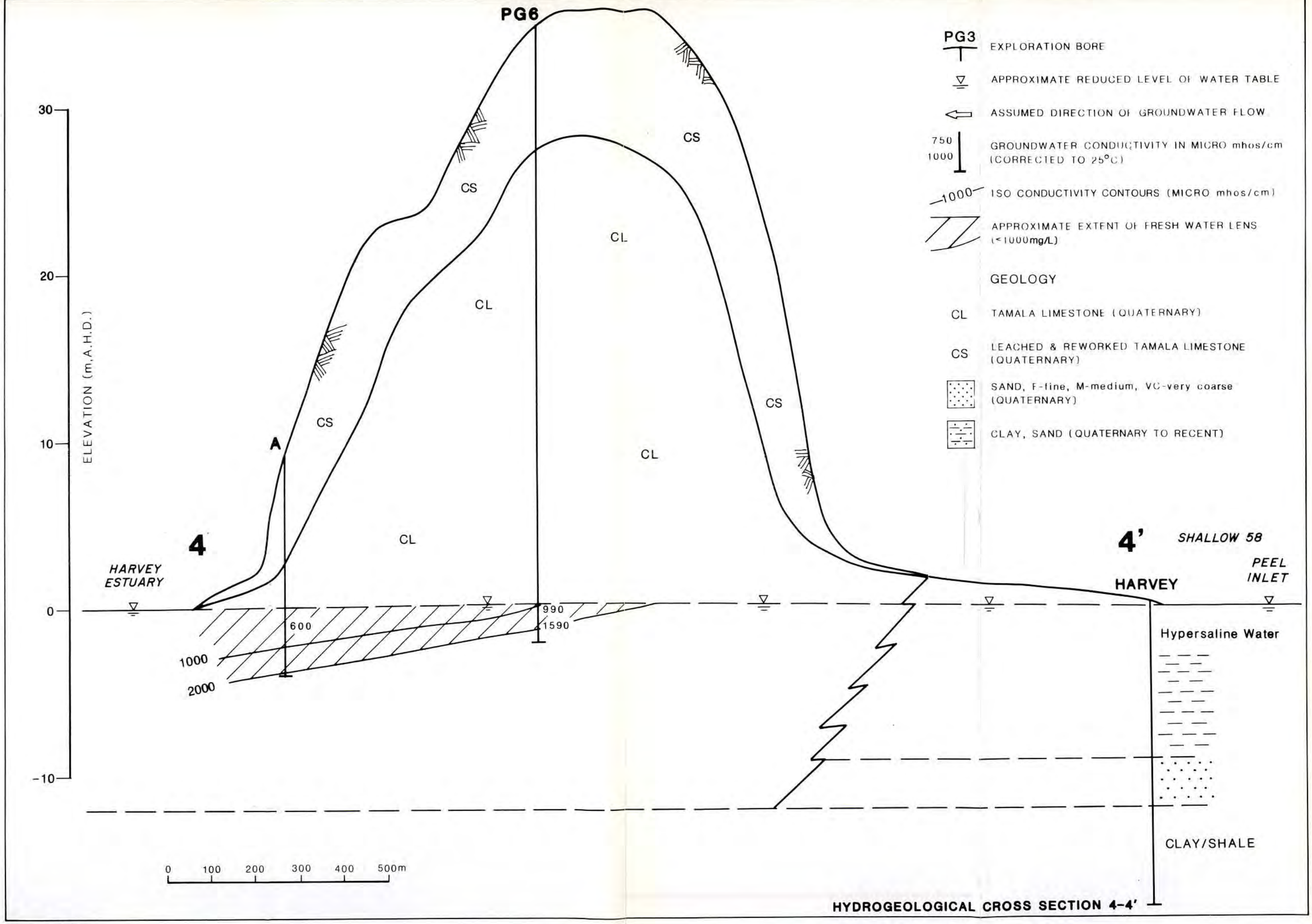
HYDROGEOLOGICAL CROSS SECTION 2-2'

Dames & Moore



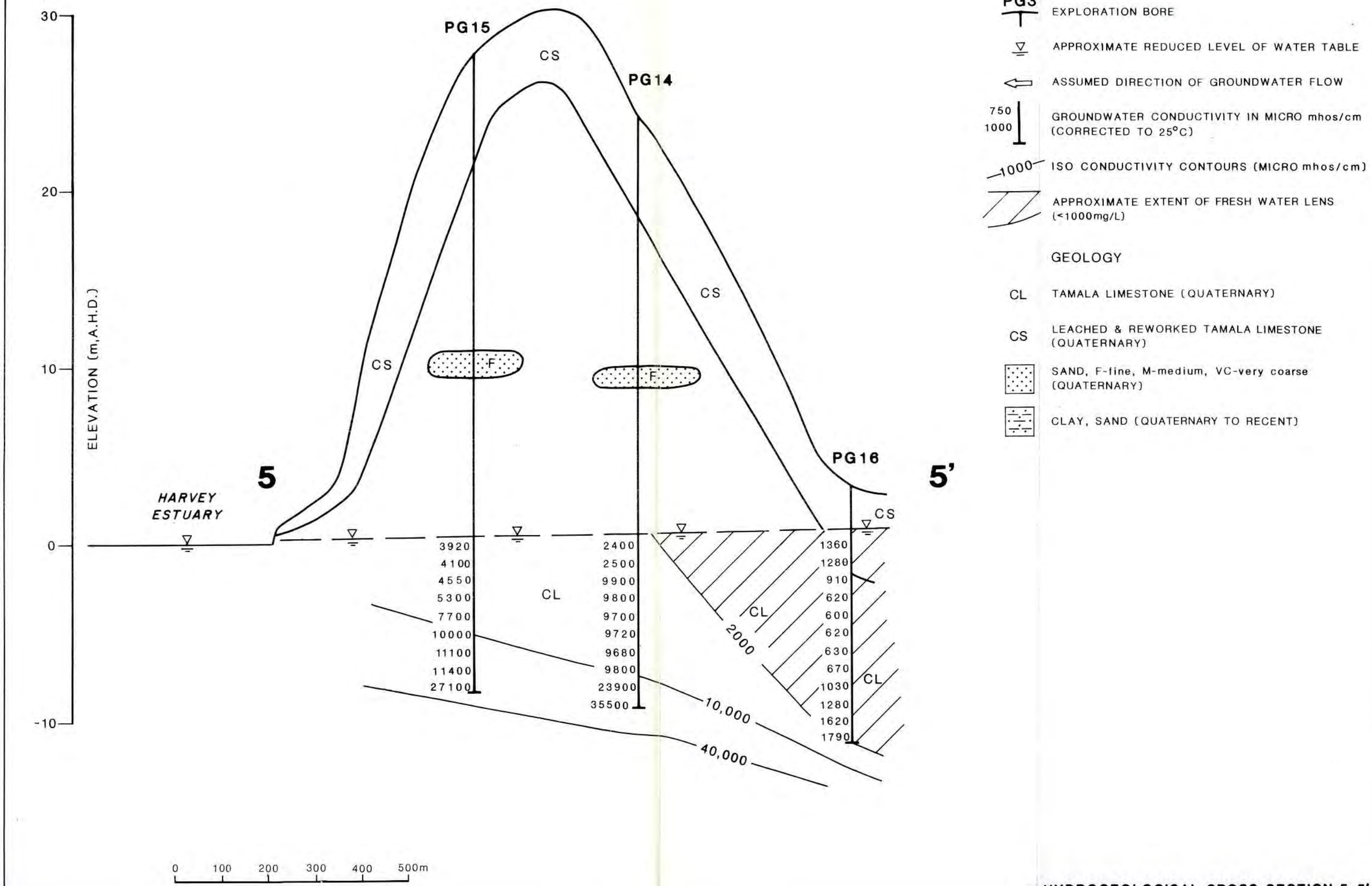
HYDROGEOLOGICAL CROSS SECTION 3-3'

Dames & Moore



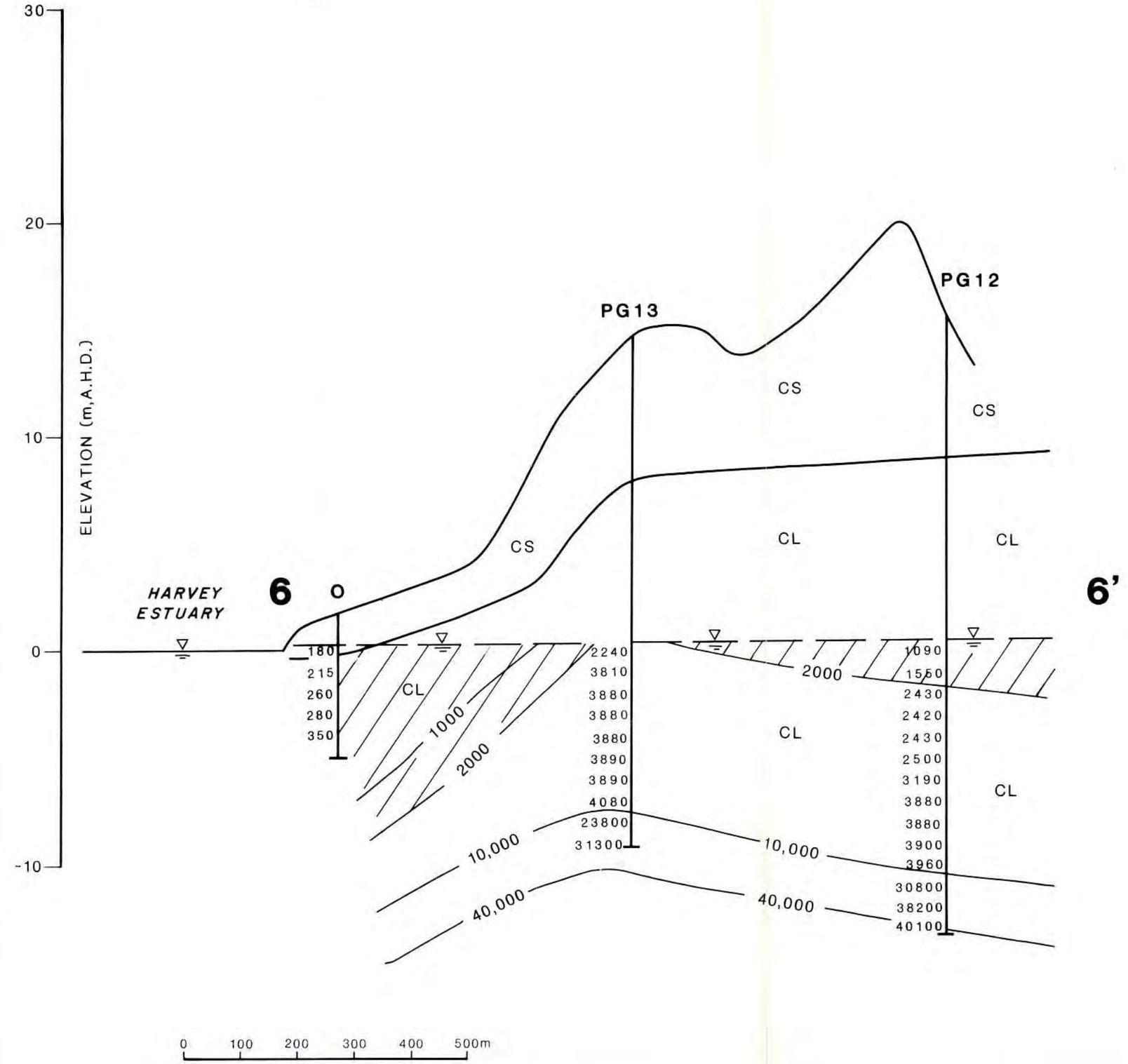
HYDROGEOLOGICAL CROSS SECTION 4-4'

Dames & Moore



HYDROGEOLOGICAL CROSS SECTION 5-5'

Dames & Moore



PG3 EXPLORATION BORE

APPROXIMATE REDUCED LEVEL OF WATER TABLE

ASSUMED DIRECTION OF GROUNDWATER FLOW

750
1000
GROUNDWATER CONDUCTIVITY IN MICRO mhos/cm (CORRECTED TO 25°C)

1000 ISO CONDUCTIVITY CONTOURS (MICROmhos/cm)

APPROXIMATE EXTENT OF FRESH WATER LENS (<1000mg/L)

GEOLOGY

CL TAMALA LIMESTONE (QUATERNARY)

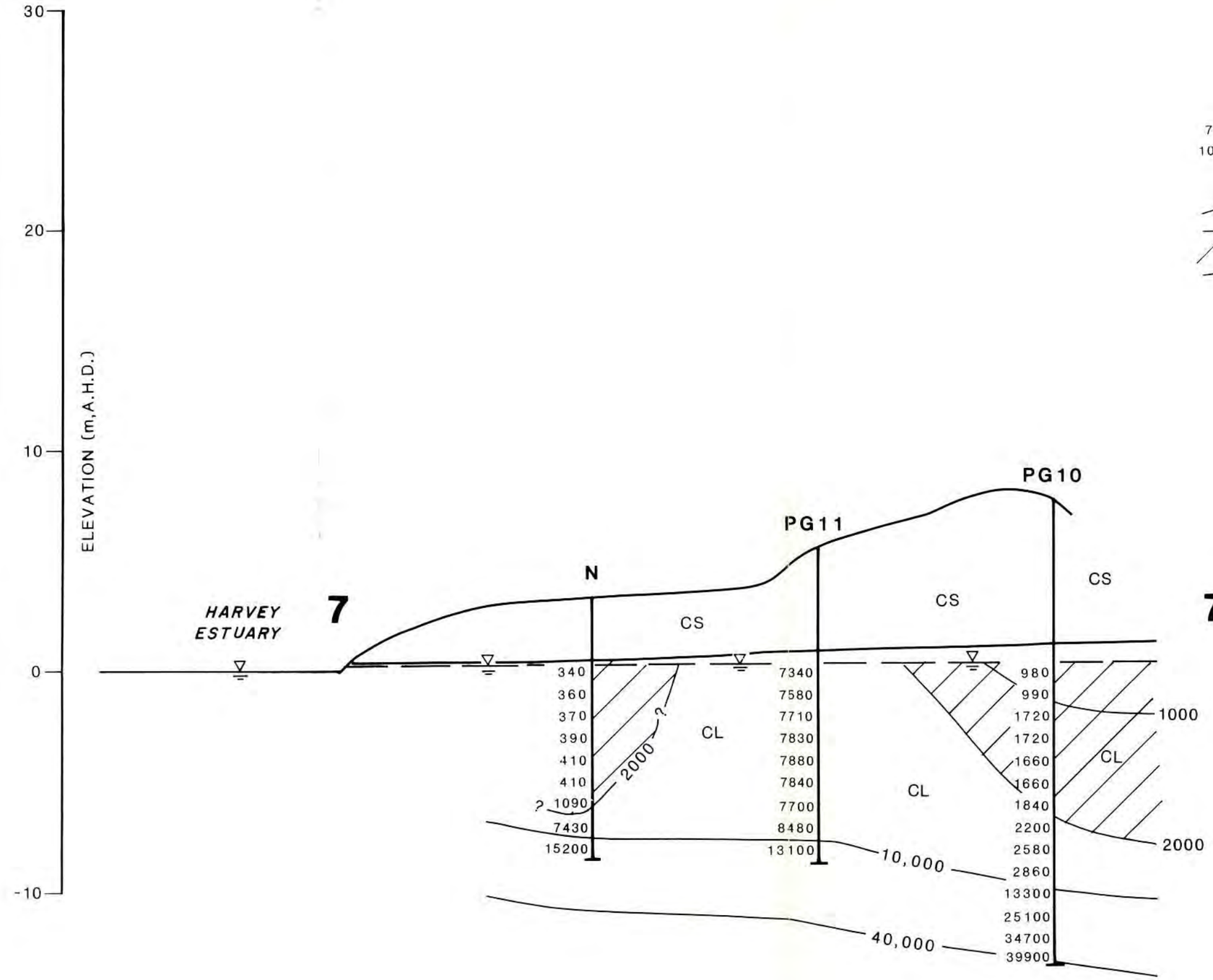
CS LEACHED & REWORKED TAMALA LIMESTONE (QUATERNARY)

SAND, F-fine, M-medium, VC-very coarse (QUATERNARY)

CLAY, SAND (QUATERNARY TO RECENT)

HYDROGEOLOGICAL CROSS SECTION 6-6'

Dames & Moore



PG3 EXPLORATION BORE

APPROXIMATE REDUCED LEVEL OF WATER TABLE

ASSUMED DIRECTION OF GROUNDWATER FLOW

750
1000
GROUNDWATER CONDUCTIVITY IN MICRO mhos/cm (CORRECTED TO 25°C)

1000 ISO CONDUCTIVITY CONTOURS (MICRO mhos/cm)

APPROXIMATE EXTENT OF FRESH WATER LENS (<1000mg/L)

GEOLOGY

CL TAMALA LIMESTONE (QUATERNARY)

CS LEACHED & REWORKED TAMALA LIMESTONE (QUATERNARY)

SAND, F-fine, M-medium, VC-very coarse (QUATERNARY)

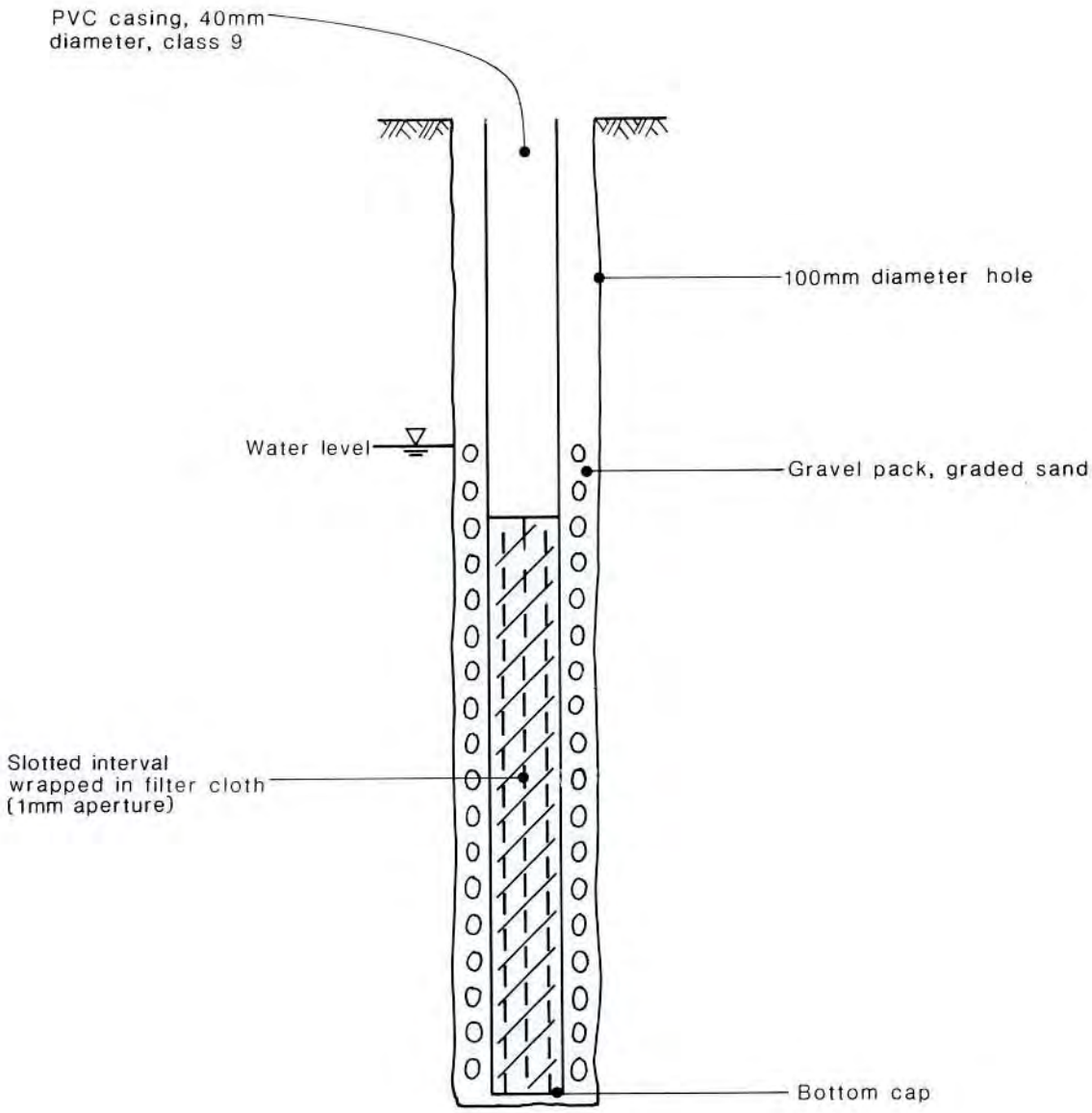
CLAY, SAND (QUATERNARY TO RECENT)

HYDROGEOLOGICAL CROSS SECTION 7-7'

Dames & Moore

ADDENDUM G-II

COMPLETION REPORTS FOR
SCOUT DRILLING AT
POINT GREY

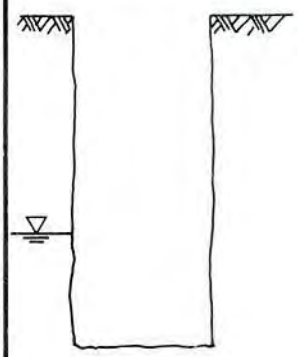


LEGEND - TYPICAL PIEZOMETER CONSTRUCTION

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE Nº: A

DRILLER: WALLIS DRILLING
REDUCED LEVEL DATUM: ≈9m
DATE DRILLED: 20 APRIL 1986
CO-ORDINATES:
TOTAL DEPTH 13m
DEPTH TO WATER: 8.85m
BORE DIAMETER: 100mm

DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		SAND, light brown to orange brown, medium to coarse grained		
5				
10		CALCARENITE, off white to pale yellow, medium to coarse grained, can be clayey	600	20.2
15		TOTAL DEPTH: 13m		
20				
25				
30				
35				
40				
45				
50				
55				

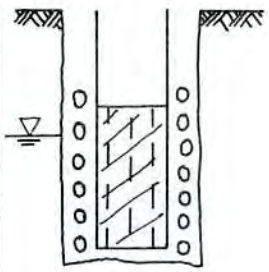
COMMENTS:

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE NO: B

DRILLER: WALLIS DRILLING
DATE DRILLED: 21 APRIL 1986
TOTAL DEPTH: 10m
REDUCED LEVEL DATUM: ≈ 5m
CO-ORDINATES:
DEPTH TO WATER: 5.09m
BORE DIAMETER: 100mm

DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		SAND, light brown to black, medium to coarse grained		
5		CALCARENITE, off white, well cemented, medium to coarse grained	1080 1250 1500	20.1
10		CLAY, grey to brown, stiff to soft	1550	19.8
		TOTAL DEPTH: 10m		
15				
20				
25				
30				
35				
40				
45				
50				
55				

COMMENTS: CASING STICKUP 0.1m

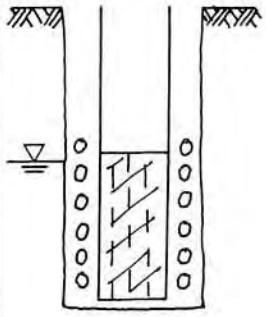
Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE NO: C

DRILLER: WALLIS DRILLING
DATE DRILLED: 21 APRIL 1986
TOTAL DEPTH 12m

REDUCED LEVEL DATUM: ≈ 6m
CO-ORDINATES:
DEPTH TO WATER: 6.52m
BORE DIAMETER: 100mm



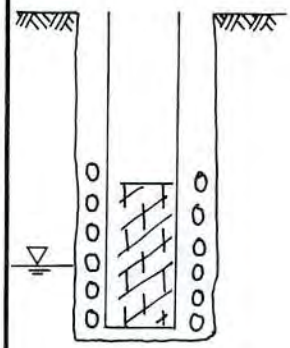
DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0	SAND, pale yellow to dark brown, fine to coarse grained		
5		620	20.8
		680	
	CALCARENITE, brown	780	
10	SANDY CLAY, brown, soft	1100	20.4
	CALCARENITE, cream, medium to very coarse grained	1250	20.2
	TOTAL DEPTH: 12m		
15			
20			
25			
30			
35			
40			
45			
50			
55			

COMMENTS: CASING STICK UP 0.35m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT BORE Nº: D

DRILLER: WALLIS DRILLING
DATE DRILLED: 21 APRIL 1986
TOTAL DEPTH: 13m
REDUCED LEVEL DATUM: ≈ 10
CO-ORDINATES:
DEPTH TO WATER: 10.27m
BORE DIAMETER: 100mm

DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		SAND, yellow to dark brown		
5		CALCARENITE, white to light brown		
		SAND, orange, fine to coarse grained		
10		CALCARENITE, off white to light brown, can be clayey	630 700	19.6 19.7
		TOTAL DEPTH: 13m		
15				
20				
25				
30				
35				
40				
45				
50				
55				

COMMENTS: CASING STICK UP 0.25m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE Nº: E

DRILLER: WALLIS DRILLING

DATE DRILLED: 21 APRIL 1986

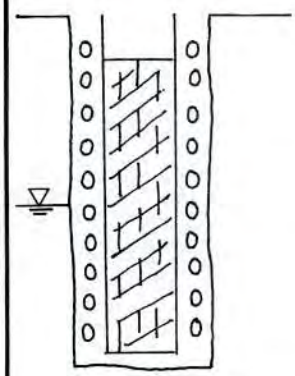
TOTAL DEPTH: 7m

REDUCED LEVEL DATUM: ≈4m

CO-ORDINATES:

DEPTH TO WATER: 3.92m

BORE DIAMETER: 100mm

DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp
0		SAND, yellow to dark brown, fine to coarse grained		
5		CALCARENITE, cream, coarse to very coarse, can be clayey	630 1240	21.4
		TOTAL DEPTH: 7m		
10				
15				
20				
25				

COMMENTS: CASING STICK UP 0.35m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE NO: F

DRILLER: WALLIS DRILLING

DATE DRILLED: 21 APRIL 1986

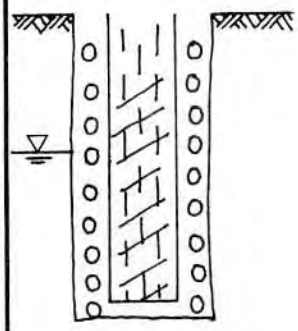
TOTAL DEPTH: 6m

REDUCED LEVEL DATUM: ≈ 3m

CO-ORDINATES:

DEPTH TO WATER: 2.79m

BORE DIAMETER: 100mm

DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		SAND, light yellow to light brown, fine to coarse grained		
5			420 480	20.8 21.0
		TOTAL DEPTH: 6m		
10				
15				
20				
25				

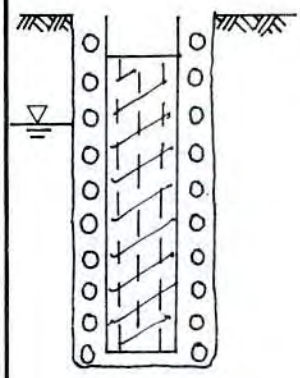
COMMENTS: CASING STICK UP 0.55m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE Nº: G

DRILLER: WALLIS DRILLING
DATE DRILLED: 21 APRIL 1986
TOTAL DEPTH: 7m
REDUCED LEVEL DATUM: ≈2m
CO-ORDINATES:
DEPTH TO WATER: 2.36m
BORE DIAMETER: 100mm

DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		SAND, brown, fine to coarse grained		
		CALCARENITE, cream to pale brown, can be clayey	4500	20.0
			6500	
			6800	
5			6900	20.5
		TOTAL DEPTH: 7m		
10				
15				
20				
25				

COMMENTS: CASING STICK UP 0.4m

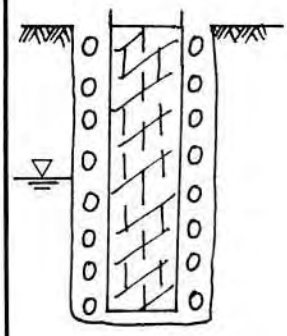
Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE NO: H

DRILLER: WALLIS DRILLING
DATE DRILLED: 21 APRIL 1986
TOTAL DEPTH: 6m

REDUCED LEVEL DATUM: ≈ 3m
CO-ORDINATES:
DEPTH TO WATER: 3.18m
BORE DIAMETER: 100mm

DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		SAND, yellow to brown, fine to coarse grained		
5		CALCARENITE, cream, coarse to very coarse grained	2120 2700	20.3 20.4
10		TOTAL DEPTH: 6m		
15				
20				
25				

COMMENTS: CASING STICK UP 0.5m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE Nº: 1

DRILLER: WALLIS DRILLING

DATE DRILLED: 21 APRIL 1986

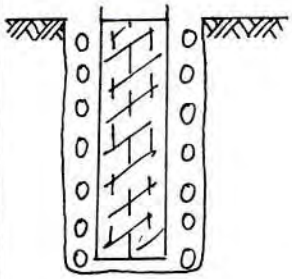
TOTAL DEPTH: 6m

REDUCED LEVEL DATUM: ≈ 3m

CO-ORDINATES:

DEPTH TO WATER: 2.58m

BORE DIAMETER: 100mm

DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		SAND, grey, fine to coarse grained		
		CALCARENITE, cream to grey, coarse to very coarse grained, some clay	700 690 700	21.0 21.2
5		TOTAL DEPTH: 5m		
10				
15				
20				
25				

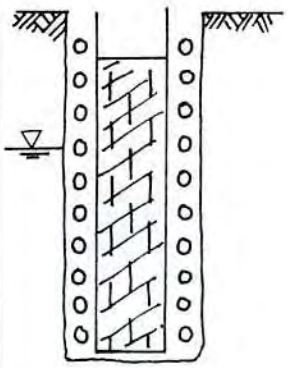
COMMENTS: CASING STICK UP 0.7m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE Nº: J

DRILLER: WALLIS DRILLING
REDUCED LEVEL DATUM: ≈ 3m
DATE DRILLED: 21 APRIL 1986
CO-ORDINATES:
TOTAL DEPTH 7m
DEPTH TO WATER: 2.89m
BORE DIAMETER: 100mm

DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		SAND, yellow brown to green grey, fine to medium grained	4500 4500 4500	20.5 20.5
5		TOTAL DEPTH: 7m		
10				
15				
20				
25				

COMMENTS: CASING DEPTH STICK UP 0.25m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE NO: K

DRILLER: WALLIS DRILLING

DATE DRILLED: 21 APRIL 1986

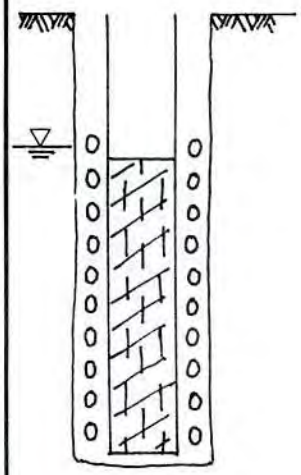
TOTAL DEPTH: 9m

REDUCED LEVEL DATUM: ≈ 3m

CO-ORDINATES:

DEPTH TO WATER: 2.66m

BORE DIAMETER: 100mm

DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		SAND, light grey, coarse grained	550	20.0
			770	
			1050	20.4
		CALCARENITE, off white, broken	1250	
			1300	
5			3500	20.0
		SAND, light grey, coarse grained		
		CALCARENITE, off yellow, hard bands, porous		
		TOTAL DEPTH: 9m		
10				
15				
20				
25				

COMMENTS: CASING STICK UP 0.25m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE NO: L

DRILLER: WALLIS DRILLING

DATE DRILLED: 21 APRIL 1986

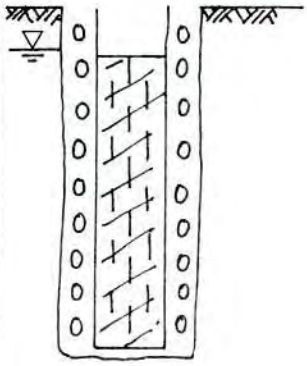
TOTAL DEPTH: 7m

REDUCED LEVEL DATUM: ≈ 1m

CO-ORDINATES:

DEPTH TO WATER: 0.93m

BORE DIAMETER: 100mm

DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		CLAY, blue grey, sticky		
5		SANDY CLAY, light brown-grey, plastic	39000 39200 40500 47500	20.5 21.3
10		TOTAL DEPTH: 7m		
15				
20				
25				

COMMENTS: CASING STICK UP 0.45m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE NO: M

DRILLER: WALLIS DRILLING

DATE DRILLED: 21 APRIL 1986

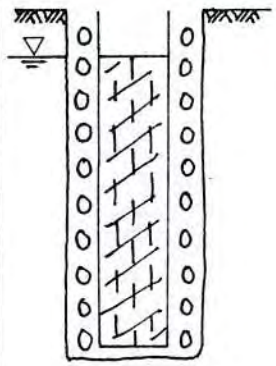
TOTAL DEPTH: 7m

REDUCED LEVEL DATUM: ≈ 1m

CO-ORDINATES:

DEPTH TO WATER: 1.00m

BORE DIAMETER: 100mm

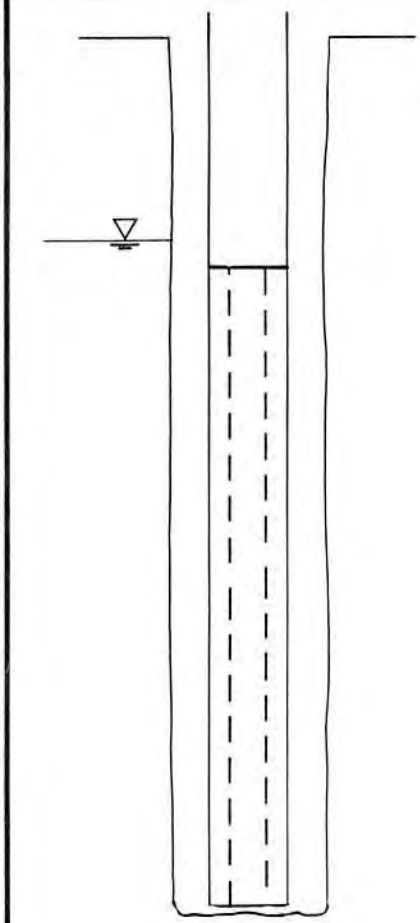
DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		SAND with CLAY, dark brown and grey, plastic		
5		CLAY, bluish grey, silty	26000 41000 50000	21.0 22.0
10		TOTAL DEPTH: 7m		
15				
20				
25				

COMMENTS: CASING STICK UP 0.3m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT **BORE NO: N**

DRILLER: WALLIS DRILLING
REDUCED LEVEL DATUM: ~3m
DATE DRILLED: 16/7/86
CO-ORDINATES:
TOTAL DEPTH: 12m
DEPTH TO WATER: 2.61m (23/7/86)
BORE DIAMETER: 100mm



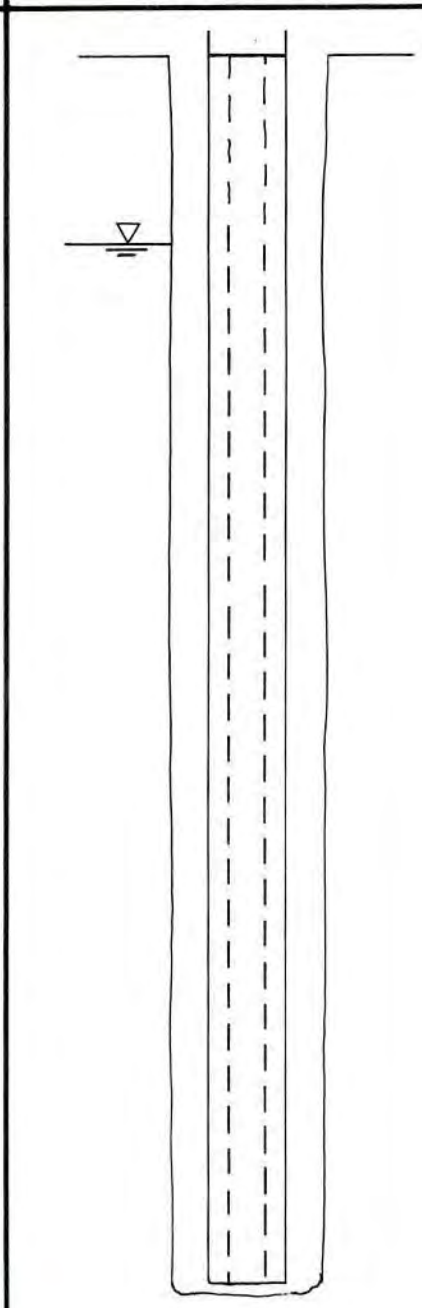
DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0–3	SAND: light yellow-brown to light grey-brown, medium to coarse grained, becoming fine to medium downhole, subangular, occasionally subrounded, poor to moderate sorting, quartz arenite with some Fe-staining and rare argillaceous matrix.	340	18.0
3–4		350	
4–5	CLAY: grey-brown, grading to sandy clay downhole	370	19.0
5–6	CLAYEY SAND: light brown-grey, fine to medium grained, occasional coarse quartz grains, subangular, moderately well sorted, moderate to abundant clay matrix (calcareous in part)	390	
6–7		410	
7–8	CALCARENITE: as above	410	20.0
8–9	CLAYEY SAND: as above	1090	
9–11	CALCARENITE: white to buff, fine to medium grained, occasional rounded coarse quartz grains, occasional yellow-brown Fe-staining and ironstone, subrounded, poor to moderate sorting, rare fossil shell fragments, occasional secondary calcification and vuggy porosity, abundant white-light grey calcareous matrix	7430	20.2
11–12		15200	20.4

COMMENTS: Casing Stickup 0.20m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT **BORE Nº: O**

DRILLER: WALLIS DRILLING
DATE DRILLED: 17/7/86
TOTAL DEPTH: 6m
REDUCED LEVEL DATUM: ~1m
CO-ORDINATES:
DEPTH TO WATER: 0.91m (23/7/86)
BORE DIAMETER: 100mm



DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0–1	SAND: medium grey to medium brown-grey medium to coarse grained, subrounded to rounded, poor to moderate sorting, quartz arenite with trace to occasional clay matrix, occasional Fe-stained clasts	180	15.0
1–2			
2–3	CLAYEY SAND: medium to dark grey-brown, fine to medium grained, abundant clay/ calcareous matrix, subangular to sub-rounded, moderately well sorted, grades to clayey calcarenite at base	215	
3–4	CALCARENITE: light to medium grey, fine to medium grained at top, grading to coarse at base, clayey at top, sub-rounded, poor to moderate sorting, abundant calcareous matrix, slightly decalcified near top, clayey at base, unconsolidated	260	
4–5		280	
5–6		350	15.5
6–7	CLAYEY SAND: medium yellow-brown medium to coarse grained, sub-rounded to rounded, poorly sorted, abundant slightly calcareous clayey matrix, Fe-stained clasts in part		

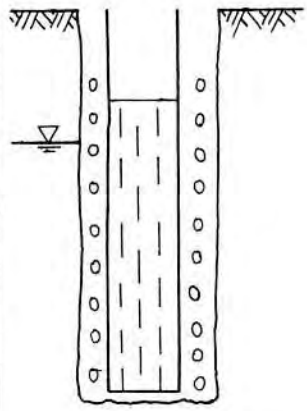
COMMENTS: Casing Stickup 0.55m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE Nº: **PG1**

DRILLER: WALLIS DRILLING
DATE DRILLED: 19 APRIL 1986
TOTAL DEPTH: 16m
REDUCED LEVEL DATUM: ~6m
CO-ORDINATES:
DEPTH TO WATER: 5.53m bgs
BORE DIAMETER: 100mm

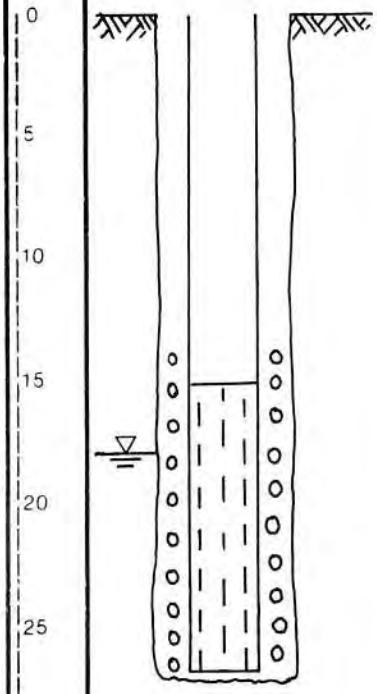
DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0		SAND, light brown fine to coarse grained		
5		CALCARENITE, white to pale yellow, hard, fine to coarse grained	3700	20.1
			3720	
			4100	
			4100	
10			5000	20.0
			10000	
			24000	
			34000	
15			39000	19.9
		TOTAL DEPTH: 16m		
20				
25				
30				
35				
40				
45				
50				
55				

COMMENTS: CASING STICK UP .35m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT BORE Nº: **PG2**

DRILLER: WALLIS DRILLING
DATE DRILLED: 19 APRIL 1986
TOTAL DEPTH: 27m
REDUCED LEVEL DATUM: ≈18m
CO-ORDINATES:
DEPTH TO WATER: 17.89m
BORE DIAMETER: 100mm



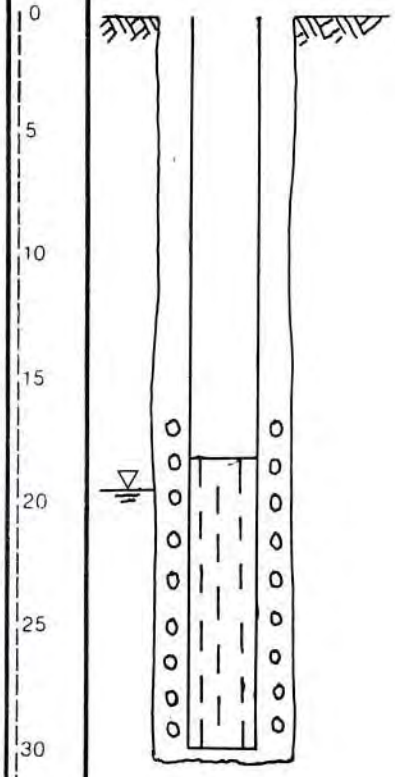
LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
SAND, brown fine to medium grained		
CALCARENITE, white to pale yellow, fine to very fine grained		
SAND, yellow fine grained		
CALCARENITE, white, medium to coarse grained		
	1220	19.8
	1220	
	1270	
	1300	
	6100	20.0
	13000	
	18500	
	26500	20.0
TOTAL DEPTH: 27m		

COMMENTS: CASING STICK UP .55m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT **BORE Nº: PG3**

DRILLER: WALLIS DRILLING
DATE DRILLED: 19 APRIL 1986
TOTAL DEPTH: 30m
REDUCED LEVEL DATUM: ≈20m
CO-ORDINATES:
DEPTH TO WATER: 19.22m
BORE DIAMETER: 100mm



DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0 – 5	SAND, light brown to pale yellow, fine to medium grained		
5 – 30	CALCARENITE, white to pale yellow, hard, fine to coarse grained	600	20.0
		600	
		610	
		800	
		950	
		1500	20.2
		15500	
		23000	
		27500	
		33000	20.2
30	TOTAL DEPTH: 30m		

COMMENTS: CASING STICK UP .45m

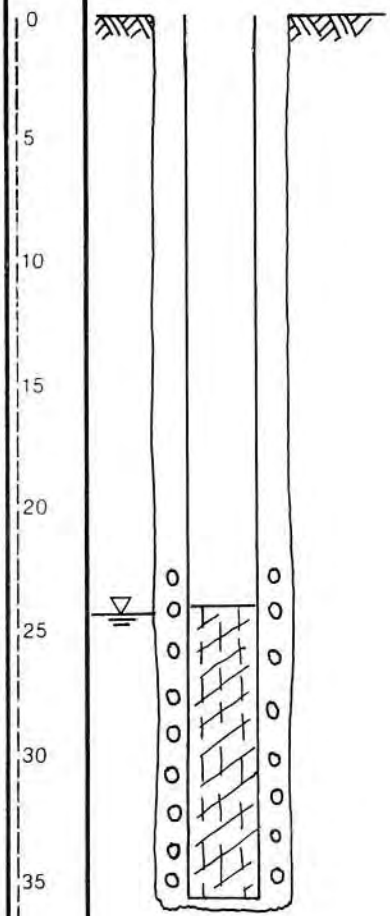
Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE NO: PG4

DRILLER: WALLIS DRILLING
DATE DRILLED: 19 APRIL 1986
TOTAL DEPTH: 36m

REDUCED LEVEL DATUM: ≈24m
CO-ORDINATES:
DEPTH TO WATER: 24.39m
BORE DIAMETER: 100mm



LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
SAND, yellow to yellow brown, fine to coarse grained		
CALCARENITE, off white to pale yellow, fine to coarse grained, some loose sand		
	680	19.6
	690	
	700	
	1050	
	1520	
	2100	20.0
	12000	
	22500	
	28500	
	30000	
	36000	20.0
TOTAL DEPTH: 36m		

COMMENTS: CASING STICK UP .4m

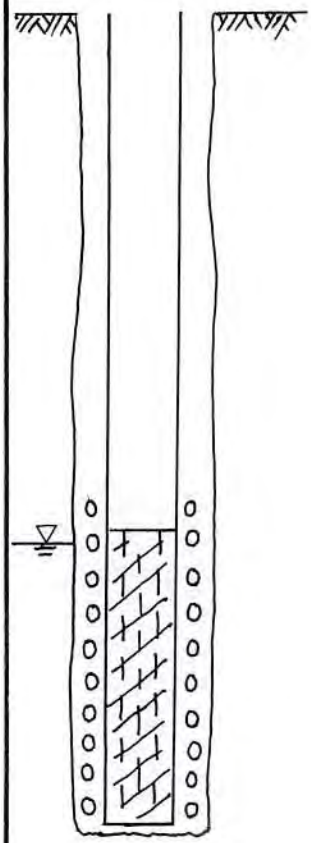
Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE Nº: PG5

DRILLER: WALLIS DRILLING
DATE DRILLED: 20 APRIL 1986
TOTAL DEPTH: 33m

REDUCED LEVEL DATUM: ≈21m
CO-ORDINATES:
DEPTH TO WATER: 21.6m
BORE DIAMETER: 100mm



DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0	SAND, brown to orange-yellow, fine to coarse grained		
5			
10	CALCARENITE, off white to light brown, fine to coarse grained, can be hard, some loose sand		
15			
20		600	20.0
		600	
		1110	
		2750	
25		5000	
		7800	20.2
		11000	
		17500	
30		25000	
		29000	
		33500	20.1
	TOTAL DEPTH: 33m		
35			
40			
45			
50			
55			

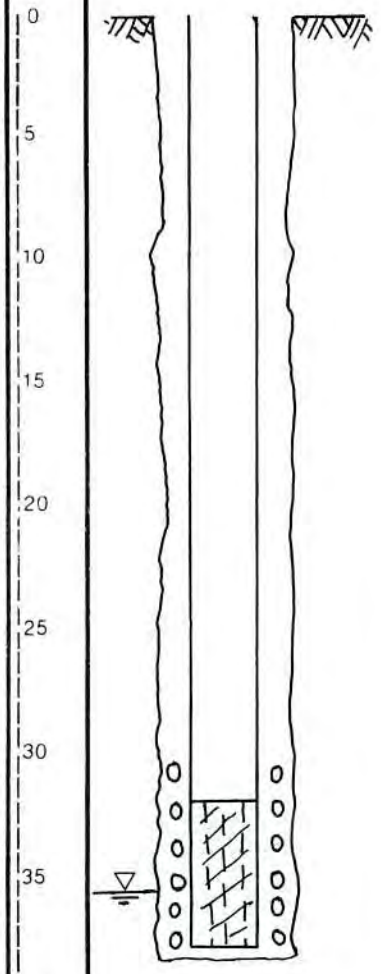
COMMENTS: CASING STICK UP 0.5m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE NO: PG6

DRILLER: WALLIS DRILLING
DATE DRILLED: 20 APRIL 1986
TOTAL DEPTH: 38m
REDUCED LEVEL DATUM: ≈35m
CO-ORDINATES:
DEPTH TO WATER: 35.83m
BORE DIAMETER: 100mm



DEPTH m	BORE CONSTRUCTION	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0 – 5		SAND, light brown to yellow, fine to coarse grained		
5 – 35		CALCARENITE, off white to light brown, hard layers, fine to coarse grained	900 1450	20.0 20.0
35 – 38		TOTAL DEPTH: 38m		

COMMENTS: CASING STICK UP .45m

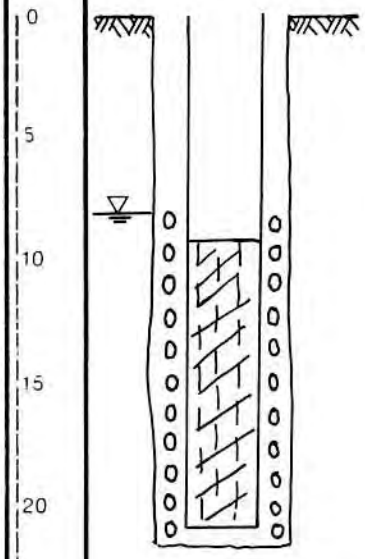
Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE NO: PG7

DRILLER: WALLIS DRILLING
DATE DRILLED: 20 APRIL 1986
TOTAL DEPTH 21m

REDUCED LEVEL DATUM: ≈8m
CO-ORDINATES:
DEPTH TO WATER: 8.00m
BORE DIAMETER: 100mm



LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
SAND, brown to yellow, fine to medium grained		
CALCARENITE, off white to light brown, can be clayey	750	19.9
	1580	
	2200	
	6000	
SAND, light brown-grey, coarse to very coarse	8900	
	12000	19.9
	17000	
CALCARENITE, off white to light brown, medium to coarse grained	22500	
	28000	19.8
	35500	
	41500	
CLAY, brown to black, micaceous	41500	19.6
TOTAL DEPTH: 21m		

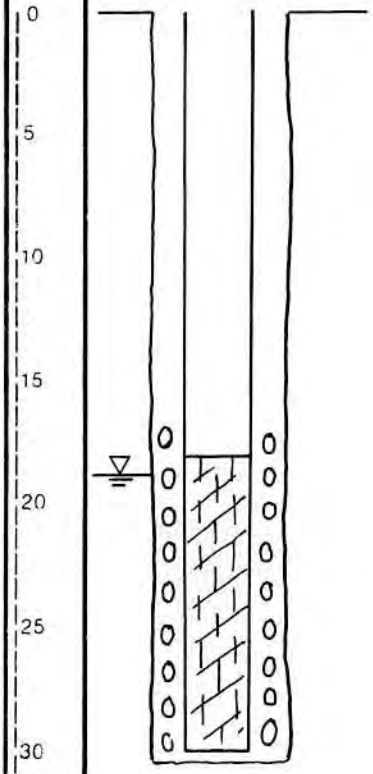
COMMENTS: CASING STICK UP .45m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE NO: PG9

DRILLER: WALLIS DRILLING
DATE DRILLED: 20 APRIL 1986
TOTAL DEPTH: 30m
REDUCED LEVEL DATUM: ≈19m
CO-ORDINATES:
DEPTH TO WATER: 18.86m
BORE DIAMETER: 100mm



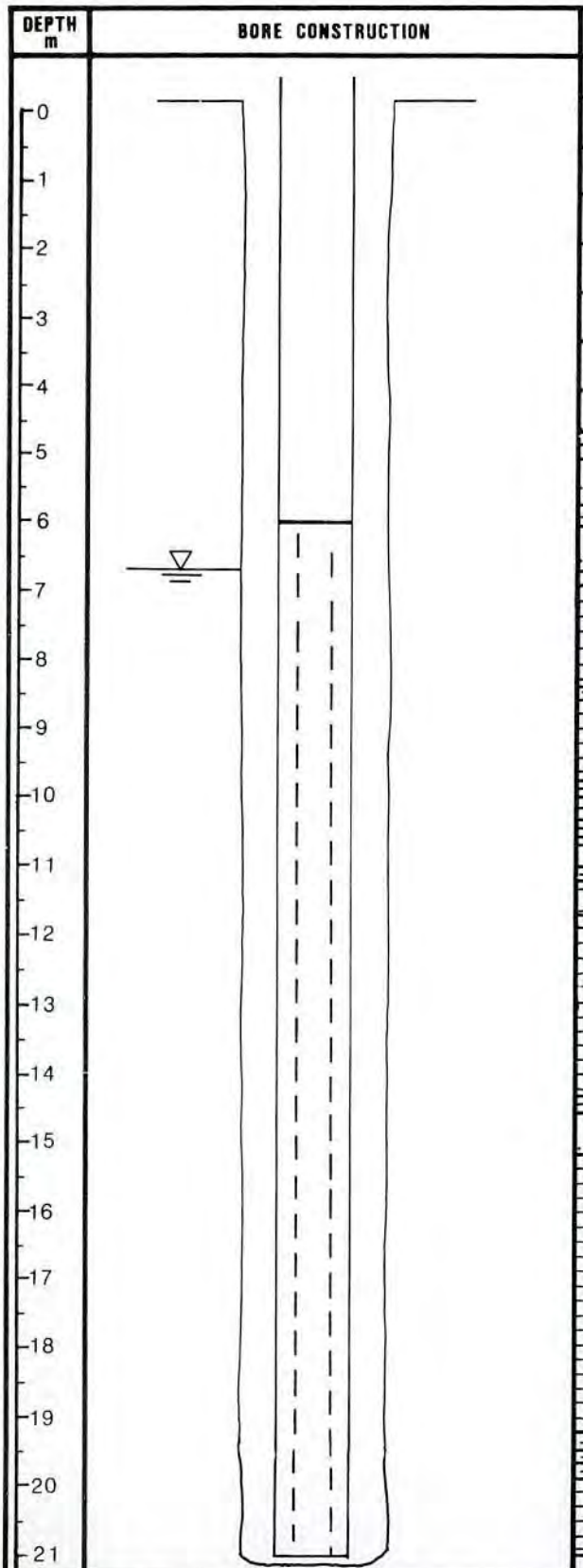
DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0	SAND, brown to yellow, fine to coarse grained		
5	CALCARENITE, off white, medium to coarse grained		
10			
15	SAND, orange-yellow, fine to medium grained		
	CALCARENITE, off white to light brown, some soft sand sections	530	20.0
20		670	
		750	
		1850	
		4300	
25		9800	20.0
		16000	
		25000	
		33000	
30		36500	20.0
	TOTAL DEPTH: 30m		
35			
40			
45			
50			
55			

COMMENTS: CASING STICK UP 0.5m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT **BORE NO: PG10**

DRILLER: WALLIS DRILLING
REDUCED LEVEL DATUM: ~7m
DATE DRILLED: 16/7/86
CO-ORDINATES:
TOTAL DEPTH: 21m
DEPTH TO WATER: 6.72m (23/7/86)
BORE DIAMETER: 100mm



DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0–6	SAND: light brown to yellow, fine to medium grained, subangular to subrounded, moderately to well sorted, quartz grains with occasional clayey matrix		
5	CALCARENITE: white to coarse, fine to medium		
5–6	SAND: as above		
6	CLAYEY SAND: medium brown, fine to medium		
6–7	SAND: as above		
7–8	CALCARENITE: white, cream, light brown grey, medium to coarse grained, sub-angular to subrounded, poor to moderate sorting quartz grains with white calcareous/clayey matrix	980	20.2
8	CLAY: as above	990	
9–10	CALCARENITE: as above but predominantly coarse grained, poorly sorted	1720	
11		1720	
11–12	CLAY: grey-brown, with occasional carbonaceous material	1660	
13		1660	20.2
13–14	CALCARENITE: White to light grey, occasionally light yellow-brown, fine to medium grained, occasionally coarse, subrounded to rounded, poor to moderate sorting, occasional to moderately abundant white to cream calcareous matrix	1840	
14–15	SAND: as above	2200	
15–16		2580	
16–17	CALCARENITE: as above but predominantly medium grained, normally graded in part, predominantly well rounded, bivalve fossil fragments and echinoid spines	2860	
18		13300	20.0
18–19		25100	
19–20	CLAY: buff to light brown	34700	
20–21	CALCARENITE: as above medium to coarse grained	39900	21.0

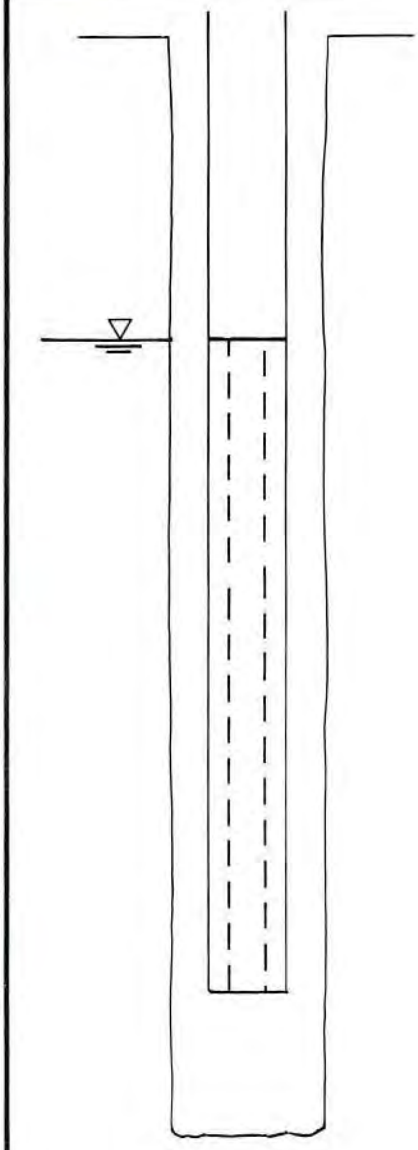
COMMENTS: Casing Stickup 0.40m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE Nº: PG11

DRILLER: WALLIS DRILLING
DATE DRILLED: 16/7/86
TOTAL DEPTH: 15m
REDUCED LEVEL DATUM: ~5m
CO-ORDINATES:
DEPTH TO WATER: 4.01m (23/7/86)
BORE DIAMETER: 100mm



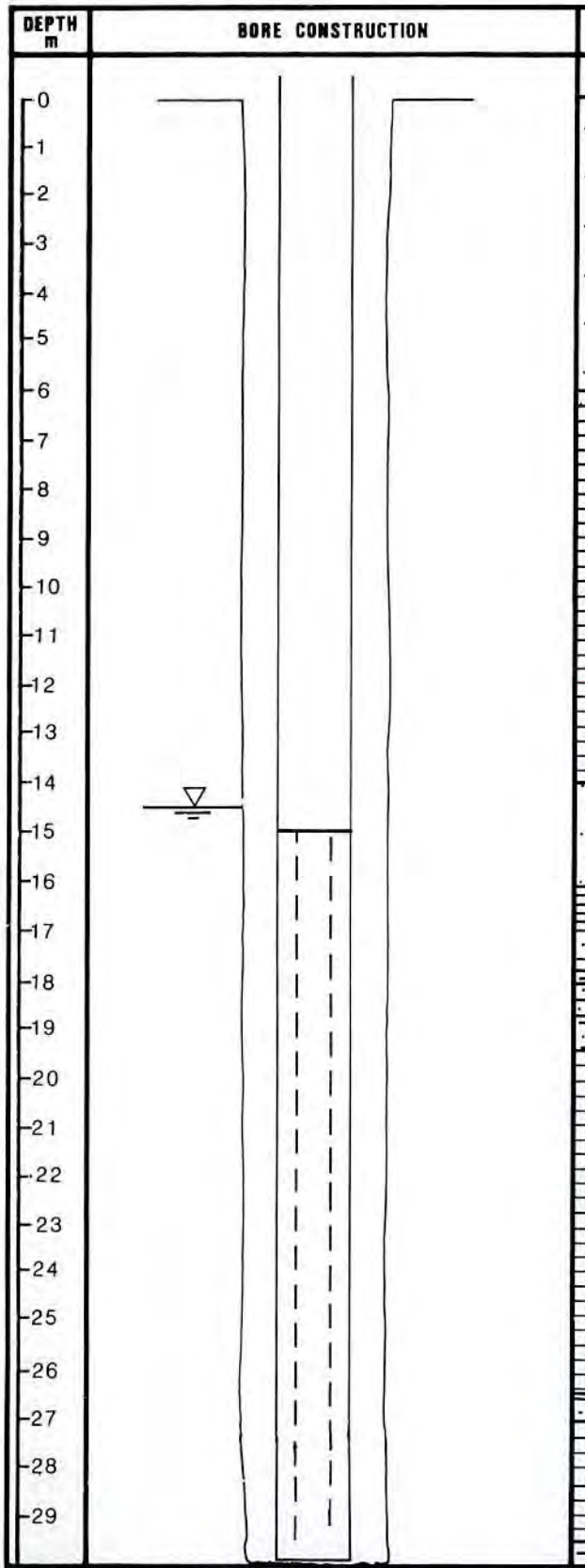
DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0–4	SAND: orange-brown to light grey-brown, fine to medium grained, occasionally coarse, moderately to well sorted, subangular to subrounded, predominantly quartz grains with trace of clay matrix in places	7340	18.5
5–6	CLAY: light grey-brown, with occasional arenaceous grains	7580	
6–7	CALCARENITE: cream to yellow-brown, fine to medium grained, quartz grains with moderate to abundant white calcareous matrix, well sorted, subangular to subrounded, lithified	7710	
7–8		7830	18.2
8–9	CLAYEY SAND: yellow brown to brown, medium to coarse grained, subrounded to rounded, poor to moderate sorting, quartz arenite with yellow-brown argillaceous matrix, grades to sandy clay in part	7780	
9–10		7840	
10–11	CALCARENITE: as above	7770	
11–12	SAND: light brown, yellow- brown, medium to coarse, abundant Fe-staining and "ironstone" clasts.	8480	19.9
12–13	CLAYEY SAND: as above	13100	20.2
13–14	CALCARENITE: white to buff, but predominantly medium to coarse grained, occasionally fine, subangular to sub-rounded, poor to moderate sorting, abundant white calcareous matrix, fossil shell fragments; becoming clayey towards bottom		
14–15	CLAYEY SAND: as above		

COMMENTS: Casing Stickup 0.50m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT **BORE Nº: PG12**

DRILLER: WALLIS DRILLING
REDUCED LEVEL DATUM: ~15m
DATE DRILLED: 16/7/86
CO-ORDINATES:
TOTAL DEPTH: 30m
DEPTH TO WATER: 14.49m (23/7/86)
BORE DIAMETER: 100mm



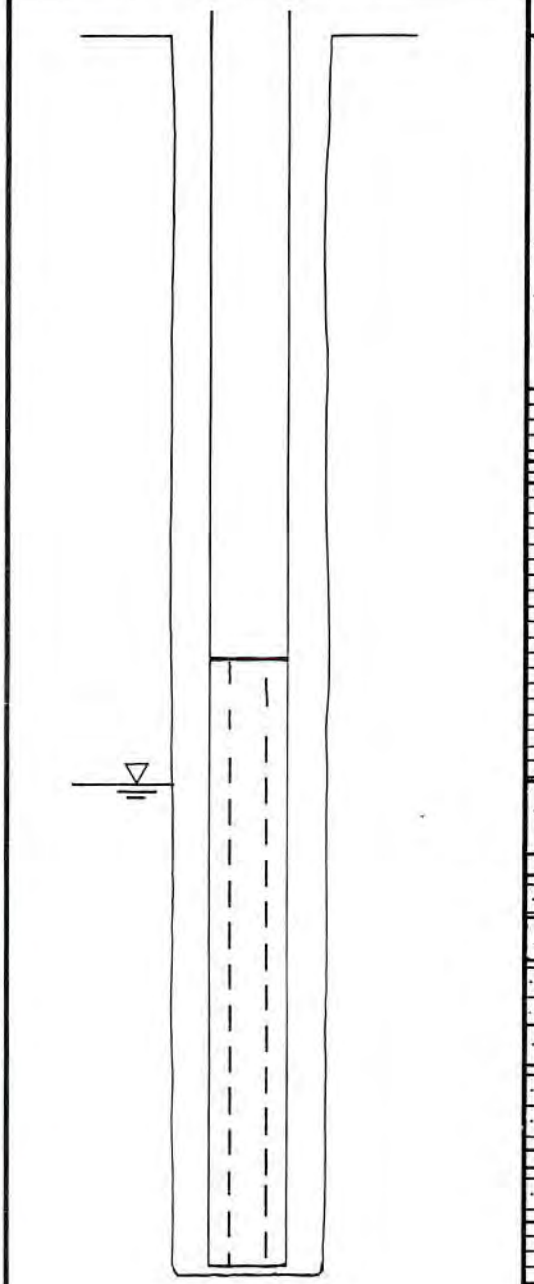
DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0–6	SAND: orange-brown, predominantly fine grained, occasionally medium, sub-rounded, some subangular grains, well sorted, quartz arenite with occasional argillaceous matrix and Fe-staining		
6–14	CALCARENITE: cream to buff, light grey, occasionally light brown, fine to medium grained, occasional coarse aggregates and argillaceous areas, subangular, becoming subrounded to rounded near base, some Fe-staining, moderately to well sorted, some secondary calcification and vuggy porosity near base, overall normally graded; fossil fragments		
14–15	SAND: yellow-brown to orange-brown, medium to coarse grained, occasionally fine, predominantly subangular, poor to moderate sorting, quartz arenite with Fe-staining and trace of argillaceous matrix	1090	19.0
15–16		1550	
16–17	CLAY: buff to light brown, with ironstone	2430	
17–19	CLAYEY SAND: medium brown, medium to coarse grained, predominantly well rounded, occasionally subrounded, occasional ironstone and calcarenite laminae, quartz arenite with some lithoclasts and abundant orange-brown argillaceous matrix	2420	20.0
19–20		2430	
20–21		2500	
21–22		3190	20.0
22–23		3850	
23–24	CALCARENITE: white to buff, light brown, medium to coarse grained, subrounded to rounded, occasionally subangular, moderate sorting, trace Fe-staining, abundant calcareous matrix occasional interbeds of clayey sand, some vuggy porosity, bivalve fossil fragments	3880	
24–25		3880	
25–26		3880	
26–27		3900	
27–28		3960	20.8
28–29		30800	
29	CLAY: dark grey to black, very carbon-aceous, silty, grades to light grey clay at bottom	38200	
		40100	20.8

COMMENTS: Casing Stickup 0.50m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT **BORE Nº: PG13**

DRILLER: WALLIS DRILLING
DATE DRILLED: 17/7/86
TOTAL DEPTH: 24m
REDUCED LEVEL DATUM: ~15m
CO-ORDINATES:
DEPTH TO WATER: 14.31m (23/7/86)
BORE DIAMETER: 100mm



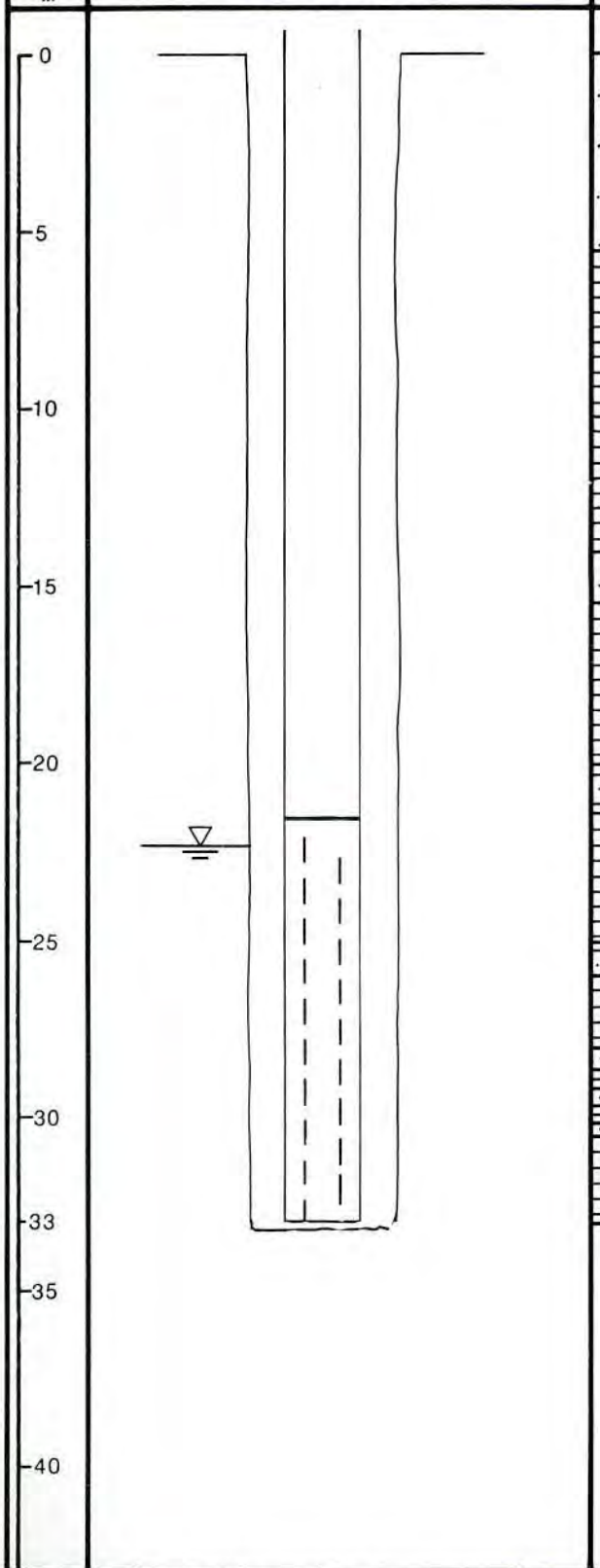
DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0–14	SAND: light yellow-brown, fine to medium grained, moderately well sorted, sub-angular to subrounded, quartz arenite with some Fe-staining and becoming slightly clayey near base		
7–14	CALCARENITE: buff to light grey, fine to medium grained, occasionally coarse, poorly sorted, subangular to sub-rounded, abundant matrix, with rare interbeds of light brown clayey sand with Fe-staining, abundant solution features and vuggy porosity near base, grades to decalcified calcarenite at base		
14–15		2240	19.0
15–16	SAND: buff to light brown, medium grained, slightly calcareous, occasional matrix decalcified calcarenite, excellent porosity, becomes clayey at base	3810	
16–17		3880	
17–18	CLAYEY SAND: buff to light brown, medium grained, subangular to subrounded, moderate sorting, moderately abundant light brown argillaceous (and slightly calcareous) matrix, trace Fe-staining, occasional ironstone clasts, inter-bedded with calcarenite	3880	
18–19		3880	20.0
19–20		3890	
20–21		3890	
21–22		4080	
22–24	CALCARENITE: white to light grey-brown medium to coarse grained, subrounded to rounded, poor to moderate sorting, matrix decalcified in places, varying porosity, fossil shell fragments	23800	
23–24		31300	21.0

COMMENTS: Casing Stickup 0.35m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT **BORE Nº: PG14**

DRILLER: WALLIS DRILLING
DATE DRILLED: 17/7/86
TOTAL DEPTH: 33m
REDUCED LEVEL DATUM: ~24m
CO-ORDINATES:
DEPTH TO WATER: 22.69m (23/7/86)
BORE DIAMETER: 100mm



LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
SAND: yellow-brown to orange-brown, fine to medium grained, subrounded, moderately to well sorted, Fe-staining, trace of clayey matrix, becomes very argillaceous in part, calcarenite interbeds near base.		
CALCARENITE: cream to buff, fine to medium grained, subrounded, moderately well sorted, abundant white to buff calcareous matrix, increasing solution of matrix near base, porosity		
SAND: light yellow-brown, fine to medium grained, subangular to sub-rounded, quartz arenite with trace of slightly calcareous argillaceous		
CALCARENITE: as above		
CLAYEY SAND: buff to light brown, fine grained, slightly Fe-stained quartz arenite with moderately abundant clayey matrix (slightly calcareous), with occasional interbeds of cream coloured calcarenite	2400	19.0
CALCARENITE: as above	2550	
CALCARENITE: cream to buff, fine to medium grained, occasionally coarse, subrounded to rounded, poor to moderate sorting, matrix decalcified in places, occasionally very good vuggy porosity interbeds of clayey sand and decalcified calcarenite in places, occasional to moderately abundant secondary calcification and some Fe-staining, varying porosity	9900 9800 9700 9720 9680 9800 23900 35500	20.6 22.0

COMMENTS: Casing Stickup 0.50m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE Nº: PG15

DRILLER: WALLIS DRILLING

DATE DRILLED: 17/7/86

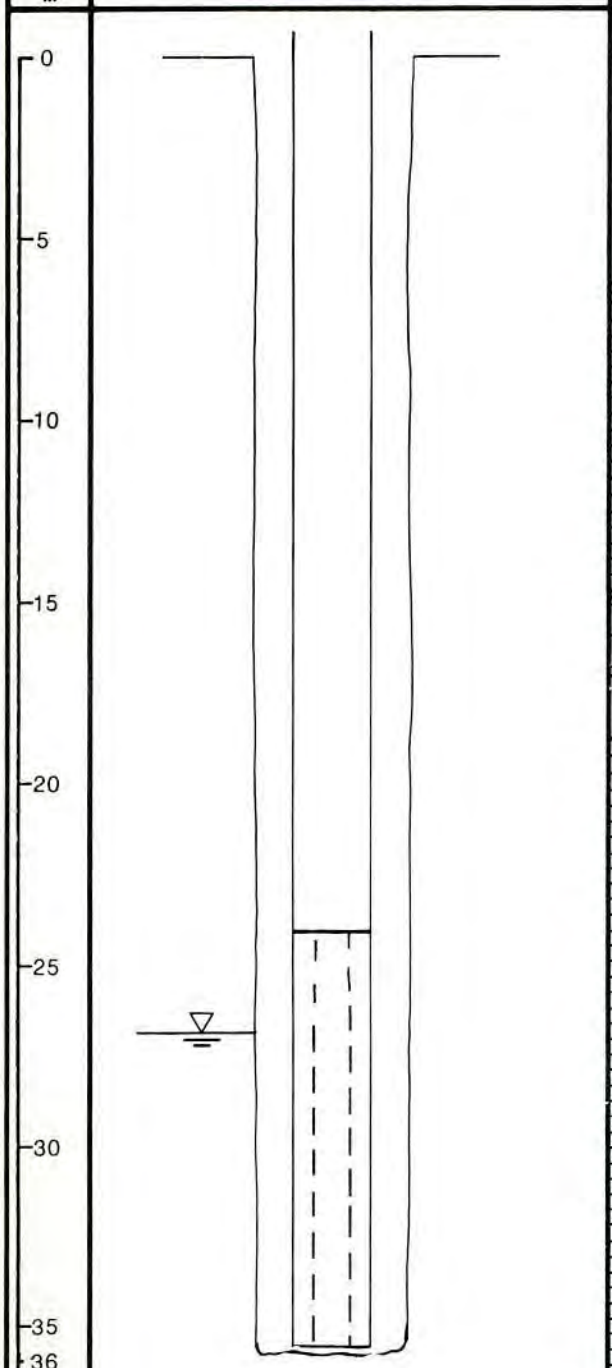
TOTAL DEPTH: 36m

REDUCED LEVEL DATUM: ~28 m

CO-ORDINATES:

DEPTH TO WATER: 26.82m (23/7/86)

BORE DIAMETER: 100mm



DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0 – 5	SAND: yellow-brown to orange-brown, fine to medium grained, subangular to sub-rounded, moderately well sorted, quartz arenite with rare lithoclasts and trace clay matrix in places, grades to clayey sand at base		
5 – 10	CALCARENITE: white to cream, predominantly medium grained, occasionally coarse, fine grained near top, poorly to moderately sorted, quartz arenite with abundant calcareous clayey matrix and occasional Fe-staining of clasts, matrix solution and good vuggy porosity in part		
15 – 20	CLAYEY SAND: red-brown to orange-brown fine to medium grained, subangular to subrounded, moderately well sorted, moderately abundant Fe-staining of clasts and matrix, grades to light-yellow-brown arenite at base SAND: as above		
20 – 25	CALCARENITE: white to cream, becomes light grey to light brown near base, fine to medium, subrounded to rounded, moderately well sorted, moderately abundant calcareous matrix, often slightly decalcified & slightly Fe-stained, varying porosity (but tight at base), light orange-brown clay abundant in matrix near base, some secondary calcification, fossil shell fragments	3920	19.0
		4010	
		4550	
		5300	
		7700	20.0
		10000	
		11100	
		11400	
35 – 36		27100	20.8

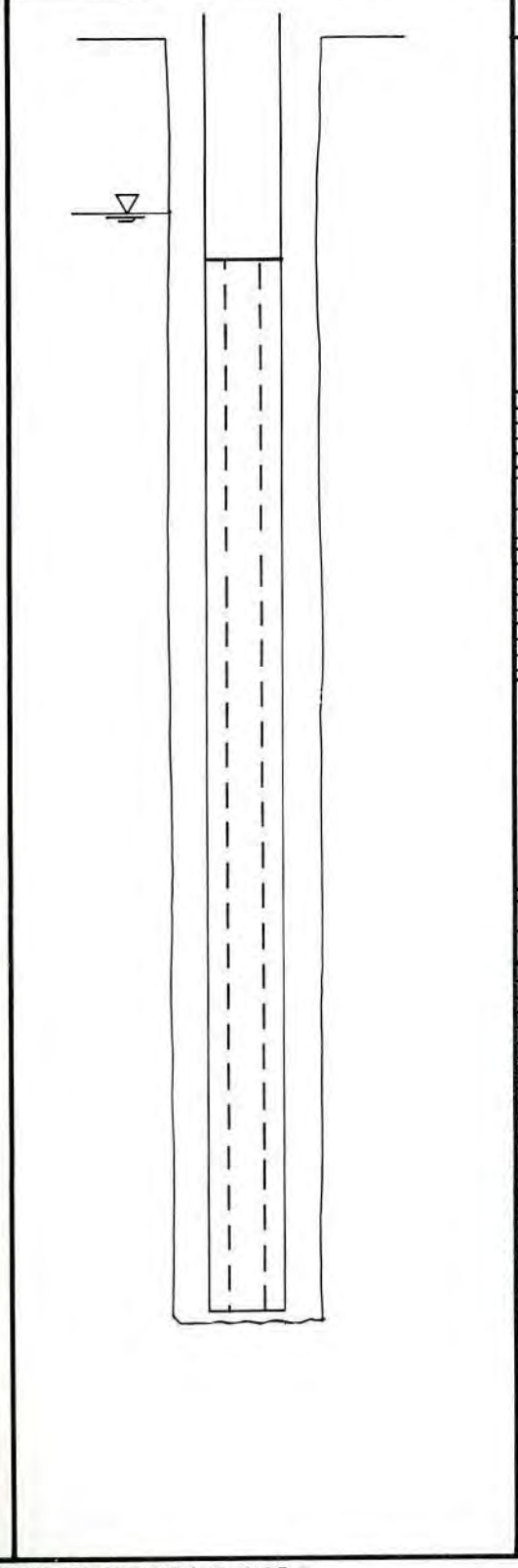
COMMENTS: Casing Stickup 0.35m

Dames & Moore

POINT GREY STUDY
GROUNDWATER OBSERVATION BORE COMPLETION REPORT

BORE Nº: PG16

DRILLER: WALLIS DRILLING
REDUCED LEVEL DATUM: ~3m
DATE DRILLED: 17/7/86
CO-ORDINATES:
TOTAL DEPTH: 18m
DEPTH TO WATER: 2.26m (23/7/86)
BORE DIAMETER: 100mm



DEPTH m	LITHOLOGICAL DESCRIPTION	GROUNDWATER Cond.	GROUNDWATER Temp.
0 – 2	SAND: medium grey to medium brown-grey, fine to medium grained, occasionally coarse, subrounded, moderately to well sorted, occasional Fe-staining, occasional clay matrix near base	1360	17.0
2 – 3		1280	17.5
3 – 5		910	
5 – 6	CALCARENITE: light grey, occasionally Fe-stained & light brown-grey, medium grained, moderately well sorted, subangular to subrounded, abundant calcareous matrix, becoming very clayey & yellow-brown in part, grading to clayey arenite in places, decalcified near base and grading to sand	620	18.5
6 – 7		600	
7 – 8		620	
8 – 9		630	
9 – 10	SAND: decalcified calcarenite, white to very light grey, medium to coarse grained, trace Fe-staining, subangular to subrounded, poor to moderate sorting, trace of calcareous clay matrix, becomes argillaceous & medium grey in colour near base, grades to clayey sand	670	
10 – 11		1030	19.0
11 – 12		1280	
12 – 13	CALCARENITE: buff to medium brown-grey predominantly medium grained, coarse near top, sorting and roundness poor at top, overall moderately well sorted and subrounded, abundant matrix, moderately abundant Fe-stained clasts in part very clayey	1620	19.0
13 – 14		1790	
14 – 15		2240	
15 – 16			
16 – 17	CLAY: very dark grey to black, silty, abundant carbonaceous material, in part well laminated, partially lithified		
17 – 18			
18 – 21			

COMMENTS: Casing Stickup 0.35m

Dames & Moore

ADDENDUM G-III

COMPLETION REPORTS,
LEEDERVILLE FORMATION
EXPLORATORY BORES
PG1 AND PG2

MALLINA HOLDINGS LIMITED

GROUNDWATER PRODUCTION BORE COMPLETION REPORT

BORE Nº: PG 1

DRILLER: Bunbury Boring Co.

DATE DRILLED: 5 / 12 / 86

TOTAL DEPTH: 137·9 m

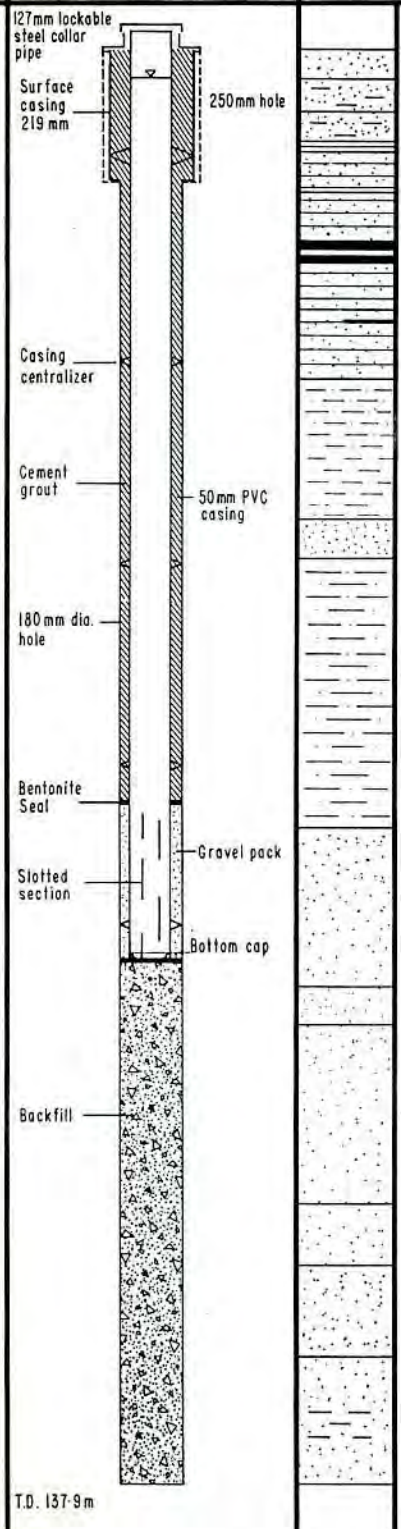
LOCATION: Pt. Grey - Murray

REDUCED LEVEL DATUM: (Top of Collar) 4·445m AHD

CO-ORDINATES:

DEPTH TO WATER: (Below Collar) 2·23 m

BORE DIAMETER: 50 mm



LITHOLOGICAL DESCRIPTION

Sand light grey brown f-mg, moderately sorted becoming clayey 3-6m

Clayey Sand bluish grey

Sandy clay greenish grey with clasts of f-mg poorly sorted sand.

Sand light brown, c.g. well sorted, rounded quartz

Siltstone dark grey, carbonaceous with thin coal seams.

Silty sand dirty f-mg, poorly sorted and thin layers of siltstone.

Sandy siltstone. Dark grey with thin layers of clean sand. m-c.g. well sorted, quartz with secondary mica and and pyrite.

Sandstone clean, c.g. and well sorted.

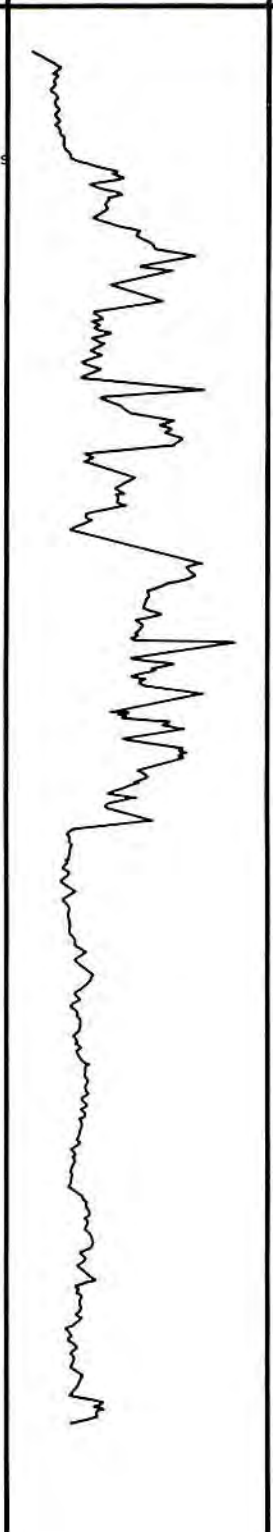
Siltstone dark grey with thin coal seams becoming sandier 70-75m.

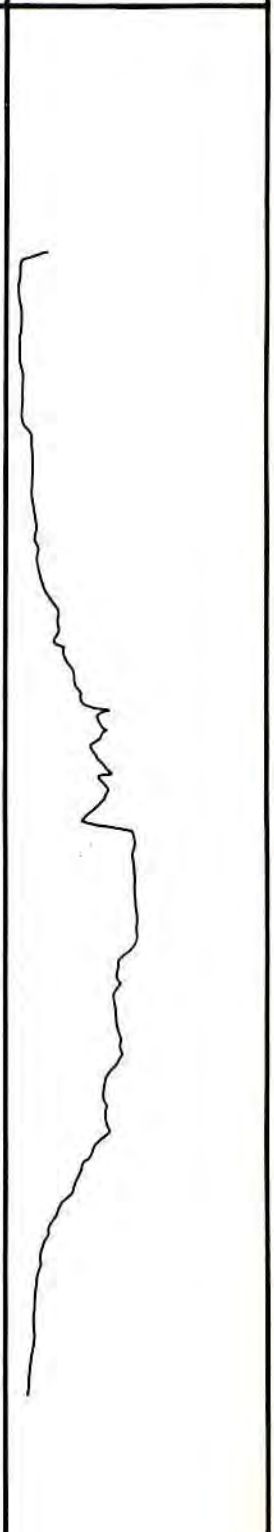
Sandstone clean grey, m-c.g. well sorted sub-rounded quartz and feldspar poorly cemented.

Sandstone grey m-c.g. sub-rounded moderately sorted quartz with occasional haematite.

Sandstone as above becoming finer grained and dirtier.

Sandstone dirty f-m.g. and sandy siltstone dark grey.





COMMENTS:

Estimated depth to green clay marker is 150 m.b.g.l
Water sample collected 12.12.86
pH = 7.3, Electrical Conductivity 123 mS/m at 25°C equivalent to 750 mg/L
Total Dissolved Salts.

MALLINA HOLDINGS LIMITED

GROUNDWATER PRODUCTION BORE COMPLETION REPORT

BORE Nº: PG 2

DRILLER: Bunbury Boring Co.

REDUCED LEVEL DATUM: (Top of Collar) 4·305 m AHD

DATE DRILLED: 17/12/86

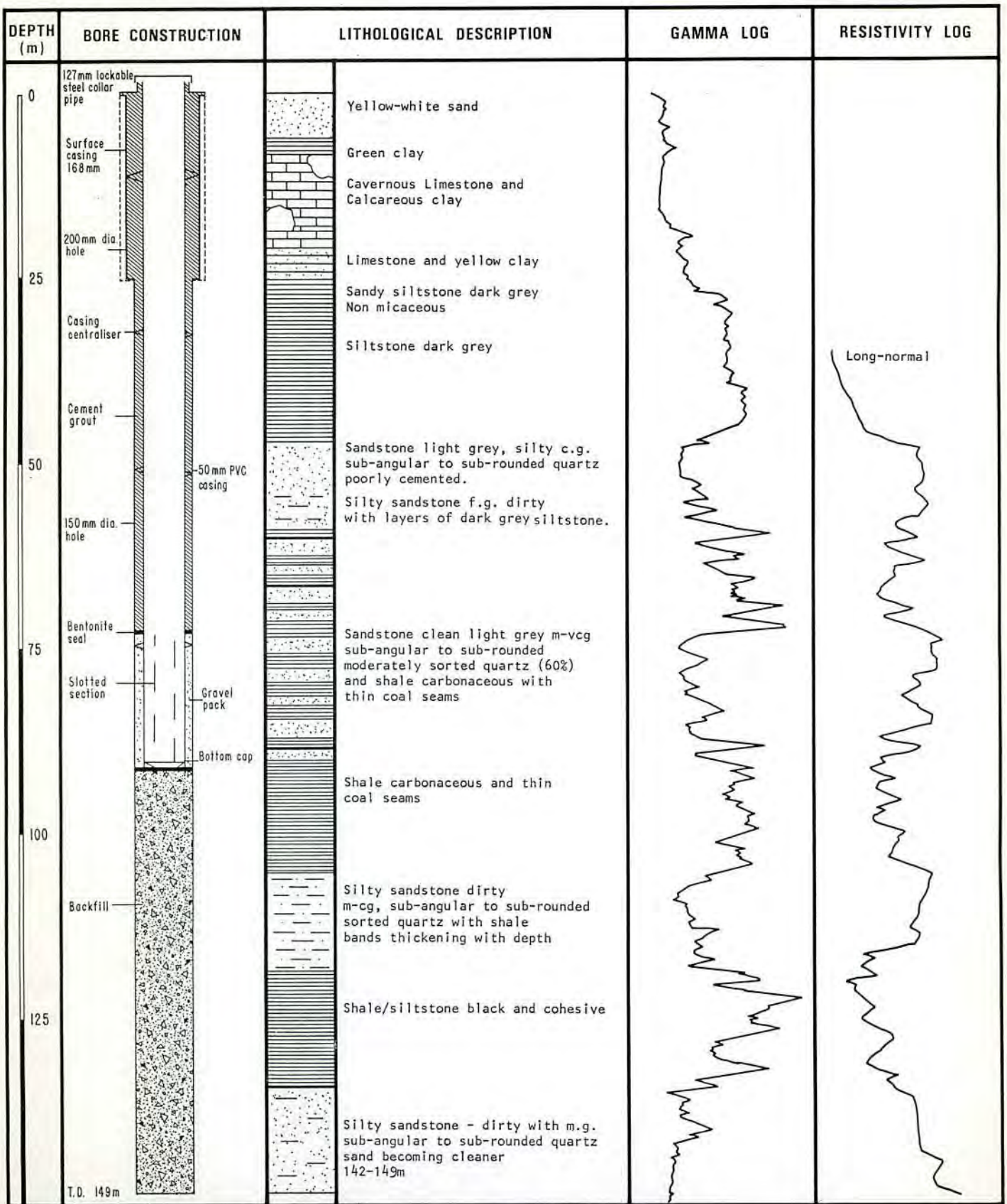
CO-ORDINATES:

TOTAL DEPTH: 149·0

DEPTH TO WATER: (Below Collar) 2·57m

LOCATION: Pt. Grey - Murray

BORE DIAMETER: 50 mm



COMMENTS: Estimated depth to green clay marker is 205 m.b.g.l.
Water sample collected 12.12.86
pH = 6.9, Electrical Conductivity 97.5 mS/m at 25ºC equivalent to 600 mg/L Total Dissolved Salts.

APPENDIX H

APPENDIX H

CORRESPONDENCE

GUIDELINES

POINT GREY PROJECT
GUIDELINES FOR THE ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

1. SUMMARY

This section should contain a brief summary of:

- salient features of the proposal;
- alternatives considered;
- description of receiving environment and analysis of potential impacts and their significance;
- environmental monitoring, management and safeguard and commitments thereto;
- conclusions.

2. INTRODUCTION

This introduction should include:

- identification of proponent and responsible authorities;
- background and objectives of the proposal including development concepts;
- brief details, and timing of the proposal;
- relevant statutory requirements and approvals;
- purpose and structure of the ERMP.

3. NEED FOR THE DEVELOPMENT

This section is concerned with the justification for the project and project costs (in the broad sense) and benefits at local and regional levels. For example the following items should be covered:

- The proposed development should be considered with the context of local and regional residential, educational and tourist requirements;

- benefits to the community of the project including reference to economic, employment and social factors;
- Does the project utilise or make available resources that would otherwise not be available to the community.

4. EVALUATION OF ALTERNATIVES

The evaluation of alternatives is an important part of an ERMP. A discussion of alternative development or land use options should be given. A comparison of these in the context of the stated objectives should be included as well as costs and benefits at both construction and long term stages. In this way, the rationale for not choosing certain alternatives should be clear as will the basis for choosing the preferred option.

The following provide examples of alternatives and their potential impacts for consideration in this section:

- various development options;
- various special arrangements of uses based on environmental consequences.

5. DESCRIPTION OF PROPOSAL

This should include:

- General Concepts
- Leisure Living Areas
- Residential Areas
- College and Campus
- Recreational Areas
- Tourism and Facilities
- Associated Works

    - Water Supply - confined groundwater, unconfined groundwater
    - Access
    - Sewage Treatment
    - Waste Disposal
    - Stormwater Discharge
    - Other Works

- Services to the Development

- The Construction Period

  - Operations
  - Employment
  - Site Housing and Facilities

6. EXISTING ENVIRONMENT

This section should provide an overall description of the environment and an appraisal of physical and ecological systems likely to be affected by it.

It should then concentrate on the significant aspects of the environment likely to be impacted by the development (i.e. in particular the processes sustaining the system). Only the processes, habitats, resources and potential resources which could be influenced should be defined. Detailed inventories should be placed in appendices to the ERMP.

Wherever possible in the discussion of physical and biological processes that are essential determinants in the maintenance of habitats and resources, conceptual models or diagrams should illustrate and synthesize the interactions between the processes.

This section should include:

Point Grey

- Physical
  - Landform and Soils
  - Geology
  - Climate
  - Hydrology
  - Hydrogeology
  - Existing Land Use

- Biological - biota and their ecosystems set in a local and regional context, including:
  - Flora
  - Fauna - with special emphasis on wading bird habitats and fish nursery areas
  - Conservation Areas
  - Estuarine Condition at Point Grey

- Human Environment
  - conservation or recreation aspects, land tenure and zoning;
  - existing human-use patterns;
  - road systems and traffic;
  - landscape;
  - adjacent land uses;
  - historical, archaeological and ethnographic sites;
  - existing social climate and value.

Peel-Harvey Estuary and Hinterland

- The Hinterland
  - Geography and Land Use
  - Population Distribution and Trends
  - Projected Development Trends

- The Peel-Harvey Estuary
  - General Description
  - Existing Uses
    - recreation
    - professional fishing
  - Projected Uses
  - Existing Nutrient and Biological Status
  - Current Management Policy
  - Estuarine Management Alternatives (Stage 2 ERMP for Management of Peel-Harvey Estuary)
  - Development Trends on the Estuary
  - Regional Landscape

System Six Recommendations

7. ENVIRONMENTAL IMPACTS

This is the most important part of the ERMP and the result should show the overall effect on the total ecosystem and social surroundings of the location during and after construction.

The objective of this section is to synthesize all information and predict potential impacts upon the environment in the short and long term, including beneficial impacts and the impacts of alternatives. This should include an assessment of the resilience of the systems identified in 6 to natural and man-induced pressures.

Impacts should be quantified where possible. Criteria for making assessments of their significance should be outlined. In some cases there will be advantage in discussing construction and operation impacts separately.

It will be necessary to determine impacts on individual components of the environment before a final overal synthesis of potential impacts is made.

This section should include but not be limited by consideration of the following:

General

Nutrients (Local and regional context) - Nitrogen and Phosphorus

- Fertiliser
- Treated Sewage Effluent Disposal
- Septic Tank Effluent
- Implications in Terms of Estuary Management (including timing of the project) based on the following alternatives:
  - Existing Status
  - Catchment Management
  - Catchment Management and Dawesville Channel.

It is envisaged that nutrient input from the proposal will constitute one of the major impacts of the project, accordingly it is anticipated that it will be addressed in considerable detail with clear statements on assumptions and philosophies adopted.

General

Water Supply

- Supply requirements until full development
- Alternative supplies
- Expansion and supplementation requirements

Location of Groundwater Supply Area

Prediction of Long Term Harvesting Impacts

Local Shallow Groundwater Responses to Urbanisation

- Water Balance
- Unconfined Groundwater Usage

Conservation Reserves

- Population Pressure
  - Tourist Needs
- Development Impacts
  - Roads
  - Other

Estuarine Fish Resources

- Amateur Fishing
- Professional Fishing

Boating Facilities/Dredging Impacts

- Without Dawesville Channel
- With Dawesville Channel
- Boating Pressure
- Dredging and Spoil Disposal

Flora and Fauna (including habitats) lost or displaced due to project

Solid Waste Disposal

- General
- Waste Disposal Sites
- Site Selection and Impacts

Foreshore Areas

- Boating/Carparks
- Fishing
- Recreation Areas
- Conservation Areas
- Sociological Impacts
- General
- Economic Benefits
  - Employment during Construction
  - Tourism and Foreign Exchange

Project Development in Relation to Existing Project Population Growth of the Area

Estuary Status and Impacts on the Developments' Population

Construction and long-term impacts on existing adjacent community i.e. noise, increased traffic

Access

Landscape Aesthetics

Existing community services

The final synthesis should include an assessment of the significance and timing of the various potential impacts identified.

8. ENVIRONMENTAL MANAGEMENT

An environmental management programme should be described on the basis of (and cross-referenced to) the synthesis of potential environmental impacts described in 7.

The purpose of the mangagement programme is to demonstrate the manner in which potential environmental impacts can be ameliorated.

Authorities responsible for management should be clearly identified as should management administration, costs and funding including long-term financial contingency. Reference should be made to environmental standards expected.

Elements of monitoring and the environmental management programme should include the impacts identified in 7.

Emphasis should be placed on the manner in which monitoring results will lead, where appropriate, to amendments to the management programme.

Environmental safeguards should be described.

Procedures for reporting the results of monitoring and management to appropriate authorities should be given.

- Nutrient Management - including contingencies if nutrient input and export exceeds anticipated or acceptable levels
- Development of Stage Water Supply
- Management of Conservation Areas
- Management of Foreshore Areas
- Management of Localised Algal Accumlations
- Management of Confined or Unconfined Aquifers including Administrative Arrangements for Long-Term Management
- Management and Control of Land Uses on Leisure Lots.

9. SUMMARY OF COMMITMENTS BY PROPONENT

10. CONCLUSION

An assessment of the environmental acceptability of the project in terms of its overall environmental impact and in the context of the proposed management programme should be given.

11. REFERENCES

ERMP GUIDELINES

CONSULTATIONS (details of consultations with government bodies and public interest groups

APPENDICES

Note: These Guidelines should be used in the context of the attached document "Notes for the Preparation of an ERMP".

MINISTER FOR THE ENVIRONMENT

GROUND FLOOR, 20 BARRACK STREET,
PERTH, W.A. 6000

28 OCT 1986

Mr R D Blatchford
Dames & Moore
26 Lyall Street
SOUTH PERTH WA 6151

Dear Mr Blatchford

I refer to your submission on a proposed development at Point Grey in the Shire of Murray.

The proposal has been considered by the Environmental Protection Authority (EPA) and it has advised me that it believes an Environmental Review and Management Programme (ERMP) should be prepared to assess the environmental implications of the proposal. The Authority's decision is based on the scale of the project and the considerable potential it has to impact upon the environment.

In viewing the proposal, the Authority noted that there were several prime issues of an environmental nature which must be addressed in the assessment document. These include:

- Input of nutrients from the proposal into the adjacent water bodies.
- Water supply and impact on groundwater systems.
- Areas of conservation significance, their protection, provision and management.
- Increased boating pressures on the Peel-Harvey system.
- Impact on fish resources of the area.
- Boating facilities and associated dredging works.
- Disposal of solid waste from the development proposed.
- Provision of foreshore areas.
- Impact on adjacent conservation reserves and the overall conservation value of the Peel Harvey Estuary.
- Social impact.
- Impact of algal blooms in adjacent waters on the project.

../2

The Authority also considered the project in relation to present efforts to manage the Peel Harvey System in order to overcome the existing problems with excessive algal growth. In this regard, appropriate management mechanisms are yet to be set in place and accordingly the Authority believes that assessment of the project should include three scenarios of management (and thus environmental quality) of the Peel Harvey Estuary. The three options are:

. With the Dawesville Channel and management of the catchment

. Catchment management alone.

. The existing situation.

Departmental officers will be available to assist in the identification of appropriate guidelines for the ERMP and it is suggested that you liaise direct with them in this regard.

Yours sincerely

B Hodge.

Barry Hodge, MLA
MINISTER FOR THE ENVIRONMENT

ENVIRONMENTAL PROTECTION AUTHORITY
BP HOUSE,
1 MOUNT STREET, PERTH, WESTERN AUSTRALIA 6000
Telephone 322 2477

Dr R D Blatchford
Dames and Moore
26 Lyall Street
SOUTH PERTH WA 6151

Your Ref.
Our Ref 124/80

Dear Sir

The Authority has recently discussed some of the environmental issues relating to the proposed Point Grey Project. In order to assist you in the preparation of the Environmental Review and Management Programme, it has endorsed the attached guidelines for the project. These guidelines are to be read in conjunction with another attachment titled 'Notes for the Preparation of an ERMP'.

The Authority was also appraised of the approach you have adopted in addresssing the issue of nutrient input and has expressed concern as to the basis of your assumptions.

The Authority believes that existing land use practices (and nutrient application rates and types resulting therefrom) within the catchment of the Peel-Harvey system are at an environmentally unacceptable level and well above the assimilative capacity of the system. This conclusion is well supported by field data. Accordingly, the Authority considers that it is not appropriate to base an argument on nutrient input or export from the proposal on current fertilizer (18 kg/ha/year of Phosphorus) application rate.

In essence, the Authority believes that for this project, (or any other change in land use within the Peel-Harvey system) to be environmentally acceptable in terms of nutrient export, it should as a minimum requirement, not exceed that level considered to be environmentally acceptable under the present land use.

In addition, the Authority considers that it is essential to address the impact of the project on the adjacent waterways and the waterways on the project, also under the scenario of the Dawesville Channel proceeding and creating a more marine ecosystem. For example, current accumulation of macro-algae may be unacceptable to adjacent tourist and residential development and these accumulations are predicted in the short term, to increase markedly under more marine conditions.

The Authority suggests that there is a need to pay particular regard to the information contained in Bulletin No 243 when assessing nutrient issues relative to this project and the ability of the Peel-Harvey System to cope with nutrient input.

Officers of the Department of Conservation and Environment are available to discuss any issues relative to the guidelines or the preparation of the Environmental Review and Management Programme.

Yours faithfully

B A CARBON
CHAIRMAN

6 FEBRUARY 1987