UR1985-66

1985/66. Groundwater investigations at Rheban

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Abstract

At Rheban, in south-eastern Tasmania, a series of subparallel beach ridges in the form of a large recurved sandspit are underlain by a coastal sand aquifer which contains useful supplies of excellent quality groundwater.

The sandspit covers an area of about two square kilometres and the unconsolidated coastal sand aquifer is tabular in shape, with an average thickness of at least eight metres.

The recoverable groundwater resource has been estimated at about 3.8×10^6 m³ (3.8×10^9 litres) and the annual safe yield at about 2×10^5 m³ (2×10^8 litres).

INTRODUCTION

A Department of Mines reconnaissance groundwater survey was conducted on the East Coast of Tasmania during 1984. The determination of the groundwater potential of coastal sand bodies was included in this survey. One of the largest coastal sand bodies has developed as a recurved spit in Carrickfergus Bay at Rheban [EN770780]. The Rheban spit was considered to have a potential for providing useful quantities of good quality, easily accessible groundwater.

GEOMORPHOLOGY

The geomorphology of the Rheban spit is presented in Figure 1. The dominant feature is a series of subparallel beach ridges, backed by the tidal marshes of Earlham Lagoon. The Sandspit River drains the hinterland and Earlham Lagoon has been formed by the southerly deflection of the mouth of this river by the formation of the Rheban spit. The spit has formed by the progressive development of beach ridges associated with shoreline progradation as sea level reached its present height after the Last Glacial minimum. The movement of sand in a dominant south-westerly direction has also formed a large, shallow-water sand body between Rheban and Lachlan Island. Aerial photograph examination indicates that the sand may extend as far as Maria Island, further to the east.

The alignment and truncation of the beach ridges provides information as to stages in the development of the Rheban spit. At least three and possibly four main phases of ridge building are evident, separated by periods of erosion. The more arcuate early stages of beach ridge development could suggest that the ridge system was far more extensive than that preserved today. The beach ridges may have originally linked Lachlan Island to the mainland and the period of erosion after Phase II may have been much longer, more energetic, or may represent a change in direction of dominant erosive wave patterns. Phase V in the development of the spit includes the formation of the major frontal dunes backing the beach and Phase VI includes modern beach and river mouth development. Davies (1959) recognised six phases of development and these are outlined on Figure 1. However, Phase III and IV may be contemporaneous.

Bowden and Kirkpatrick (1974) presented a diagram showing the development of the Rheban spit between 1946 and 1966. This has been extended in Figure 2 as 1975 and 1983 aerial photography is now available. Bowden and

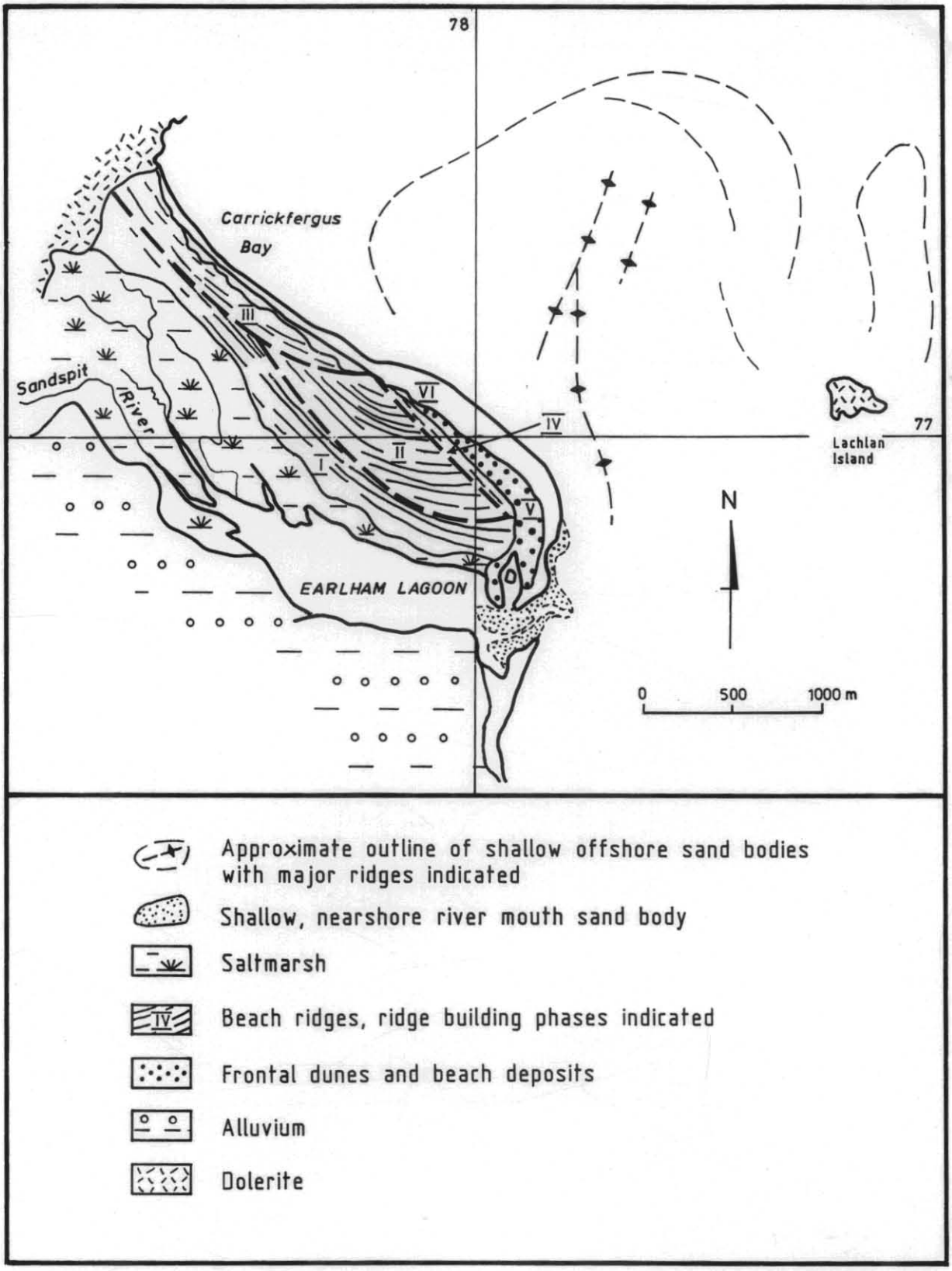
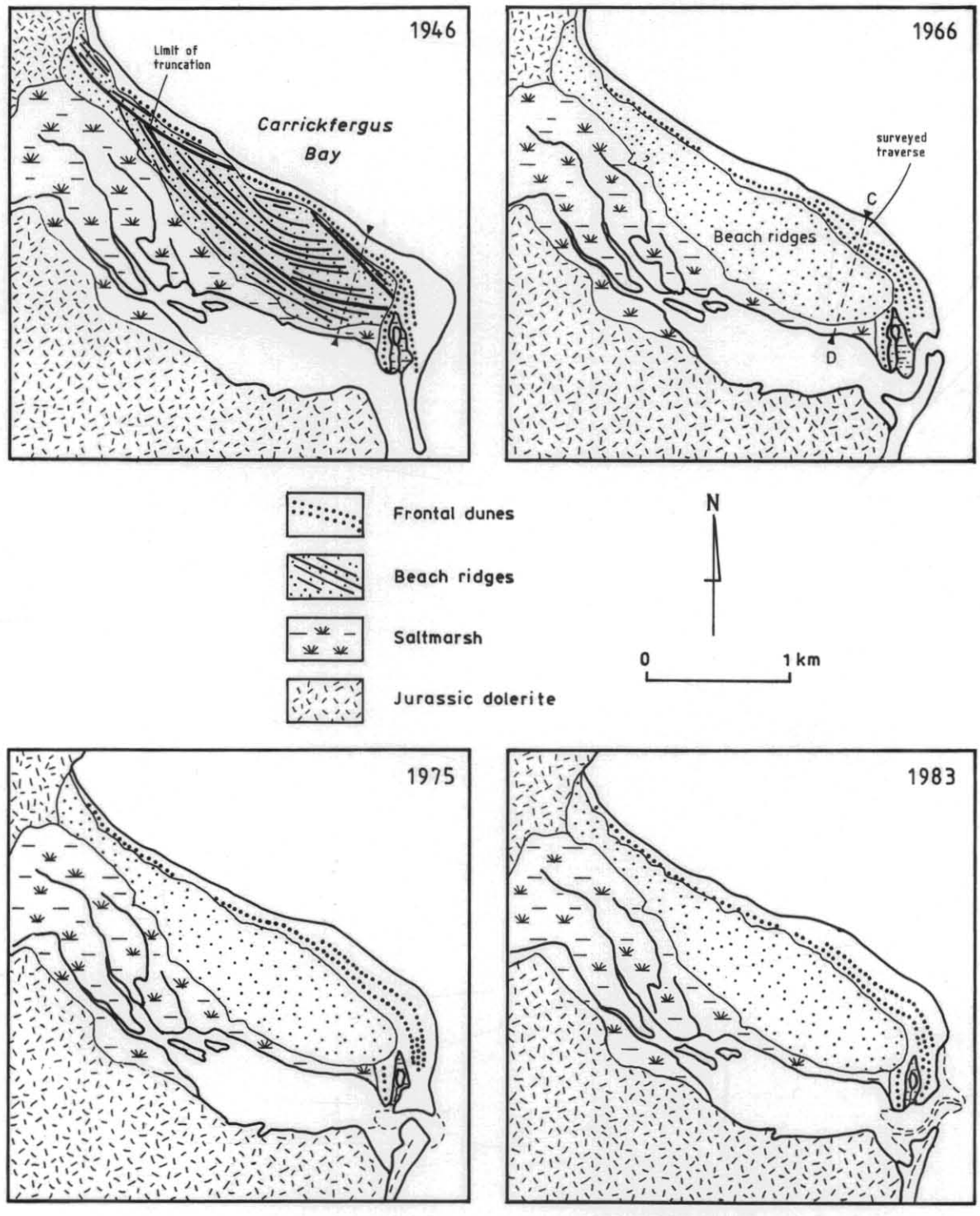


Figure 1. *Geomorphology of the Rheban spit*

5 cm

M 1681



1946 and 1966 from Bowden and Kirkpatrick (1974)
1975 and 1983 interpreted from aerial photographs

Figure 2. *The Rheban spit, showing the evolution between 1946 and 1983*

5 cm

M 1681

Kirkpatrick (1974) considered that unlike other Tasmanian beach ridge systems, which were eroding at their seaward margins (Davies, 1957), the Rheban system has been actively advancing since at least 1946. This rate was estimated to be at about five metres per year at the southern end of the spit in the area of their surveyed transect. A recent comparison of the 1966 1:31 860 and 1985 1:25 000 Lands Department maps of the region, together with a study of 1975 and 1983 aerial photographs, indicates a similar rate of accretion. The rate of shoreline advance in a seaward direction is estimated at about 5.2 metres per annum between 1966 and 1983.

The northern half of Rheban Beach has been relatively stable in outline, although as Bowden and Kirkpatrick (1974) commented some evidence of foreshore undercutting is evident. This is related to the presence of a deeper nearshore channel which concentrates wave attack. An examination of the nearshore morphology from aerial photographs also indicates the presence of the large, shallow-water sand body between the southern end of the beach and Lachlan Island. Major offshore sand ridges are evident. These ridges show no change in outline from the 1945 and 1983 aerial photographs. The beach accretion at the southern end of the spit is undoubtedly related to the location of the nearshore sand deposit.

Variations in the position of the mouth of the Sandspit River are shown in Figure 2. There appears to be little net change in sand volume in this area, perhaps indicating a circulatory sand movement system.

Two distinct soils are present on the Rheban spit. The older beach ridge system has a weak podsol characterised by weak mottling above the water table. The major frontal dunes show little or no pedological development.

GENERAL GEOLOGY

The Rheban spit is composed of Quaternary aeolian, marine and estuarine sands. Jurassic dolerite crops out on Lachlan Island to the east, and on surrounding hills to the west and south. A small coastal plain of Quaternary alluvial clay, sandy clay and minor gravel occurs on the southern side of Earlham Lagoon.

Limited evidence from augered boreholes indicates that the Quaternary sandspit may in part be underlain by dolerite. To the south, the sands are underlain by Quaternary alluvial deposits.

RESULTS OF DRILLING

A Triefus trailer-mounted drill was used to auger seven boreholes. The locations of the drill holes are shown in Figure 3 and the bore logs are presented in Appendix 1.

Drill holes were located in the largest swales and showed that the thickness of sand generally varied from 8.2 m to greater than 10.5 m towards the south-east end of the spit. Only two holes were drilled to basement clay. Hole 1 sampled clay with an apparent remnant doleritic texture. Hole 4 encountered clay at a depth of 6.3 m, which may represent a northern extension of the alluvial terrace deposits which crop out on the southern side of Earlham Lagoon.

In summary, the sand body is at least 10 m in average thickness and thins towards the north-west and south-west ends, where some dolerite shingle was also found.

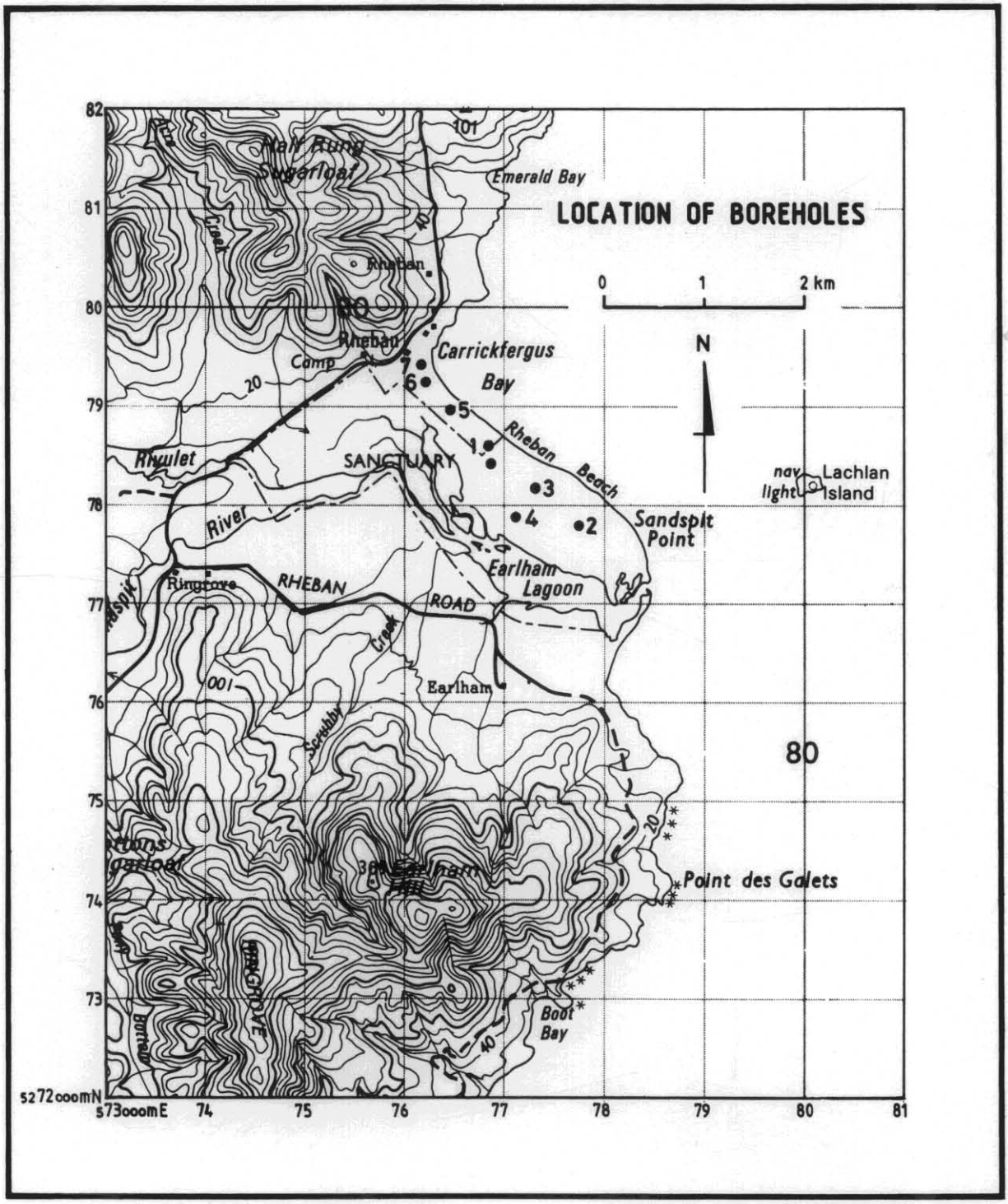


Figure 3. *Location of boreholes*

5 cm

M 1681

The composition of the sand body appears similar to beach ridge systems investigated elsewhere. In the swales, approximately 1.5 m of yellow-brown, fine to medium-grained, well sorted, quartz aeolian sand overlies coarser marine sand. These marine sands are brownish grey, medium-grained and moderate to poorly sorted. Whole shells and shell fragments up to 30 mm in diameter compose up to 10% of the deposit. The lower part of the sand body is much finer in grain size and brownish grey to greyish olive in colour. Shell fragments are more fragile and thinner walled with a greater proportion of gastropod shells evident. The finer grain size and more fragile shells indicate a much less energetic depositional environment than the coarser sands containing thick-walled bivalve shells that are found towards the top of the marine sand sequence. A change in depositional environment from more estuarine conditions to open beach marine conditions is proposed to explain the variations in the sand body.

GROUNDWATER

A 1.5 m long, 50 mm diameter, No. 15 stainless steel well screen was jetted into each of the augered drill holes. Each screen was pump tested for a period of 90 minutes and water samples were taken for laboratory analysis. The results are summarised below and the detailed analyses of selected groundwater samples are presented in Appendix 2.

Hole No.	*Screen Interval (m)*	*Pump Rate (l/min)*	*SWL (m)*	*Conductivity (µS/cm)*
1	3.8 - 5.3	45.5	2.0	800 (690 TDS)
2	4.3 - 5.8	49.3	1.8	380
3	4.1 - 5.6	49.3	1.7	320 (260 TDS)
4	4.3 - 5.8	28.0	1.7	320
5	4.5 - 6.0	50.0	2.5	450 (340 TDS)
6	2.3 - 3.8	28.5	2.0	450 (390 TDS)
7	2.3 - 3.8	28.0	1.6	800

The groundwater body at Rheban is considered to be similar in shape to coastal sand bodies elsewhere. The water table is about two metres below the groundsurface in the beach ridge swales and undoubtedly has a convex upper surface relative to sea level. The base of the aquifer corresponds to the boundary between the Quaternary sand and underlying clay. The seaward boundary probably approximates a steeply dipping interface located near high water mark. A similar interface probably occurs adjacent to the tidal estuary of Earlham Lagoon to the south, although the presence of a dipping clay interface may complicate the form of the boundary. The groundwater body is therefore approximately tabular in form and at least eight metres in thickness.

The groundwater is of excellent quality, suitable for domestic purposes as well as for irrigation and stock. Some lateral and vertical quality variation undoubtedly exists but the determination of any such variation is beyond the scope of the present investigation. Water analyses presented in Appendix 2 show that the range of values of total dissolved solids is generally between 260 and 390 mg/*l*. One sample showed a higher TDS value of 690 mg/*l* but this is still within the range of suitability for human consumption. Conductivity meter readings from other samples confirm the quality of the water. The major chemical components are calcium bicarbonate and sodium chloride, with calcium bicarbonate the more dominant component.

The aquifer reserves are quite large. The unconfined aquifer has an

average thickness of at least eight metres extending over an area of about 2×10^6 m². The volume is therefore 1.6×10^7 m³. If the average storage coefficient is considered to be similar to that determined from other coastal sand bodies, then the recoverable groundwater resource is about 3.8×10^6 m³ (3.8×10^9 litres).

The area receives an average annual rainfall of 0.65 metres per annum. Therefore an average of 1.3×10^6 m³ of rain falls on the area per annum. Assuming a conservative infiltration rate of 0.15, then approximately 2×10^5 m³ of rainfall recharges the aquifer each year by direct infiltration. This is therefore considered to be the safe annual yield of the aquifer.

CONCLUSIONS

Preliminary investigations at Rheban spit indicate that the coastal sand body contains large amounts of good quality groundwater that can be easily extracted by shallow spear bores. The groundwater reserves have been estimated as 3.8×10^9 litres and the annual safe yield of the aquifer is tentatively calculated as 2×10^8 litres. The groundwater is of excellent quality with a total dissolved solids content generally less than 390 mg/litre.

For small scale irrigation and domestic purposes the water is considered acceptable throughout the area, provided it is drawn from shallow wells and spears tapping the upper levels of the aquifer. These upper levels are the only horizons tested and vertical variations in water quality may exist. Deeper bores and large quantity groundwater extraction systems will require further investigation. Spear bores should preferably be sited towards the centre of the spit to minimise the danger of salt water contamination.

REFERENCES

BOWDEN, A.R.; KIRKPATRICK, J.B. 1974. The vegetation of the Rheban Spit, Tasmania. *Pap.Proc.R.Soc.Tas.* 108:199-210.

DAVIES, J.L. 1957. The importance of cut and fill in the development of sand ridges. *Aust.J.Sci.* 20:105-111.

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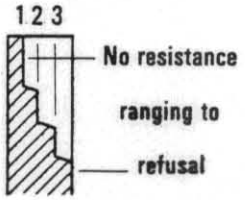
[24 December 1985]

8/16

EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration



Water

22 Jan, 80 Water level on date shown.

Water inflow.

Water outflow.

Notes - samples and tests

U50	Undisturbed sample 50mm diameter.
D	Disturbed sample.
N	Standard penetrometer blow count for 300mm.
N*	SPT + sample.

Material classification

Based on Unified Soil Classification System.

In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

Moisture content

D	Dry, looks and feel dry.
M	Moist, no free water on hand when remoulding.
W	Wet, free water on hand when remoulding.
LL	Liquid limit.
PL	Plastic limit.
PI	Plasticity Index.

eg. M > PL – Moist, moisture content greater than the plastic limit.

Consistency

		hand penetrometer (kPa)
VS	Very soft.	< 25
S	Soft.	25 – 50
F	Firm.	50 – 100
St	Stiff.	100 – 200
VSt	Very stiff.	200 – 400
H	Hard.	> 400
Fb	Friable.	

Notes: X on log is test result

— is range of results.

Density index

		%
VL	Very loose.	0 – 15
L	Loose.	15 – 35
MD	Medium dense.	35 – 65
D	Dense.	65 – 85
VD	Very Dense	85 – 100

Cored borehole log

Case - lift

Casing used.

Barrel withdrawn.

Fluid loss

No loss

50% loss

100% loss.

Lugeons

Lugeon units (μL) are a measure of rock mass permeability. For a 46 to 74mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of 1×10^{-4} mm/sec.

Graphic log

No core.

Rock substances represented by clear, contrasting symbols consistent for each project.

Weathering

Fr	Fresh.
SW	Slightly weathered.
HW	Highly weathered.
EW	Extremely weathered.

Strength

		point load strength index $I_{s(50)}$ (MPa)
EL	Extremely low.	< 0·03
VL	Very low.	0·03 – 0·1
L	Low.	0·1 – 0·3
M	Medium.	0·3 – 1
H	High	1 – 3
VH	Very high.	3 – 10
EH	Extremely high.	> 10

Note: X on log is test result.

Significant defects

Significant defects shown graphically.

Joint.

Sheared zone.

Crushed seam.

Infill seam.

Extremely weathered seam.

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 1

sheet 1 of 1

9/16

project: East Coast Groundwater

location: Rheban Spit

co-ordinates

R.L.

inclination 90°

bearing

drill type: Triefus

drill method: Auger

drill fluid

hole commenced

hole completed

drilled by

logged by B.C.

checked by D.J.S.

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
				0		SM	*SILTY SAND:* Greyish yellow-brown. Fine quartz sand. Root and organic material.	D			
				1		SW	*SAND:* Dull yellow-orange. Fine to medium quartz sand, well sorted.	M			
		▼		2		SW	*SAND:* Dull yellow-orange. Medium grained. Quartz sand. Approx. 20% shell and fragments to 10 mm dia. Bivalves dominant.	W			
				3			As above. Greyish yellow-brown.				
		No. 15 SCREEN	45.5 l/min 800 µS	4							
				5							
				6			*SAND:* Greyish yellow-brown. Fine to medium grained. 5% shell fragments and whole shell. Gastropod and bivalves.				
				7							
				8							
				9		CH	*CLAY:* Brown to red-brown mottled plastic clay. Ironstone pisoliths. Remnant doleritic texture?				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 2 10/16

sheet 1 of 1

project East Coast Groundwater location Rheban Spit

co-ordinates
R.L.
inclination 90°
bearing

drill type Triefus
drill method Auger
drill fluid

hole commenced
hole completed
drilled by
logged by B.C.
checked by D.J.S.

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
				0			*SAND:* Dull yellow-orange. Fine to medium quartz sand, well sorted.	D			
				1		SW		M			
		▼		2			*SAND:* Brownish grey to yellow-brown. Medium quartz sand. Shell fragments and whole shell to 20 mm diameter. Approx. 20% shell.	W			
				3		SW					
				4			*SAND:* Medium fine sand. 10% shell.				
		No. 15 SCREEN	49.3 l/min 380 µS	5							
				6			*SAND:* Fine-medium sand. Brownish grey, well sorted. No large shell fragments. Shell fragments to 2 mm diameter.				
				7							
				8							
				9		SW	*SAND:* Brownish-grey to greyish-olive. Fine sand. Approx. 15% shell fragments to 10 mm dia. Gastropod and bivalve shell.				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 3

sheet 1 of 1

11/16

project East Coast Groundwater location Rheban Spit

co-ordinates

R.L.

inclination 90°

bearing

drill type Triefus

drill method Auger

drill fluid

hole commenced

hole completed

drilled by B.C.

logged by D.J.S.

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
				0		SW	*SAND:* Dull yellow-orange. Fine to medium grain size. Quartz sand, well sorted	D			
				1				M			
		▼		2			*SAND:* Brownish grey. Medium grained, moderately sorted. Approx. 20% shell and fragments to 30 mm diameter.	W			
				3							
				4			*SAND:* Medium grained. Approx. 10% shell fragments.				
		No. 15 SCREEN	49.3 l/min 320 µS	5							
				6							
				7							
				8			*SAND:* Greyish olive. Fine to medium grain size. Approx. 5% shell fragments. Gastropods and bivalves. Well sorted.				
				9							

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 4

sheet 1 of 1

12/16

project: East Coast Groundwater

location: Rheban Spit

co-ordinates

R.L.

inclination: 90°

bearing

drill type: Triefus

drill method: Auger

drill fluid

hole commenced

hole completed

drilled by

logged by: B.C.

checked by: D.J.S.

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
				0			*SAND:* Fine. Quartz sand. Yellowish brown. Well sorted.	D			
				1		SW		M			
		▼		2			*SAND:* Medium quartz sand. Brownish grey. Approx. 15% shell and fragments to 20 mm diameter.	W			
				3		SW					
				4							
		No. 15 SCREEN	28 l/min 320 µS	5			*SAND:* Fine to medium quartz sand. Greyish olive. Gastropod and bivalve shell and fragments approx. 10% to 10 mm diameter.				
				6							
				7		SC	*CLAY:* Brown silty clay. Moderate plasticity.				

TASMANIA DEPARTMENT OF MINES

5 cm

borehole no. 5

sheet 1 of 1

13/16

ENGINEERING LOG – BOREHOLE

project East Coast Groundwater location Rheban Spit

co-ordinates

R.L.

inclination 90°

bearing

drill type Triefus

drill method Auger

drill fluid

hole commenced

hole completed

drilled by B.C.

logged by D.J.S.

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
				0		SW	*SAND:* Yellowish brown. Fine to medium quartz sand. Well sorted.	D			
				1		SW	*SAND:* Yellowish brown. Medium to coarse grained quartz sand. Approx. 20% shell and fragments to 20 mm diameter.	M			
				2							
				3		SW	*SAND:* Brownish grey. Medium sand. Quartz with 10%-20% shell and fragments.	W			
		No. 15 SCREEN	50 l/min 450 µS	4							
				5							
				6		SW	*SAND:* Brownish-grey to greyish-olive. Fine to medium quartz sand. Approx. 5% shell and fragments. Gastropod and bivalve shells.				
				7							
				8							
				9							

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 6

sheet 1 of 1

14/16

project East Coast Groundwater location Rheban Spit

co-ordinates

R.L.

inclination 90°

bearing

drill type Triefus

drill method Auger

drill fluid

hole commenced

hole completed

drilled by B.C.

logged by D.J.S.

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
				0			*SAND:* Fine-medium grained. Quartz sand. Dull yellow-orange. Well sorted.	D			
				1		SW		M			
		▼		2			*SAND:* Medium to coarse grained. 20%-30% shell and fragments to 20 mm diameter. Dull yellow-orange to brownish-grey. Moderate sorting.	W			
		No. 15 SCREEN	28.5 l/min 450 µS	3		SW					
				4			*SAND:* Greyish yellow-brown. Medium grained quartz sand. Approx. 15% shell and fragments to 30 mm diameter. Moderate sorting.				
				5							
				6							
				7		SW	*SAND:* Medium to fine quartz sand. Bivalve and gastropod shell and fragments to 20 mm diameter. Brownish-grey to greyish-olive.				
				8							
				9							

TASMANIA DEPARTMENT OF MINES

5 cm

borehole no. 7 (15/16)

sheet 1 of 1

ENGINEERING LOG – BOREHOLE

project East Coast Groundwater location Rheban Spit

co-ordinates

R.L.

inclination 90°

bearing

drill type Triefus

drill method Auger

drill fluid

hole commenced

hole completed

drilled by B.C.

logged by D.J.S.

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
				0			*SAND:* Fine to medium sand. Quartz. Dull yellow-orange, well sorted.	D			
				1		SW		M			
				2			*COBBLES:* Dolerite beach shingle to 150 mm. Low to moderate sphericity, well rounded.	W			
		No.15 SCREEN	28 l/min 800 µS	3			*SAND:* Medium-coarse quartz sand. Greyish brown. 20%-30% shell fragments to 20 mm diameter.				
				4			*SAND:* Medium-fine quartz sand. Grey-brown to olive-grey. 20% shell and fragments.				
				5							
				6							
				7							

APPENDIX 2

Chemical analyses of groundwater samples

Hole No.	1	3	5	6
Pumping time (minutes)	+ 30	+ 60	+ 60	+ 60
Registered No.	840357	840360	840361	840366
pH	6.9	6.6	7.0	7.0
Conductivity (µS/cm)	820	340	440	530
Item (mg/l)				
CO_3	Nil	Nil	Nil	Nil
HCO_3	155	150	195	160
Cl	71	36	36	68
SO_4	230	<5	22	63
SiO_2	9.0	17.0	10.0	10.5
Ca	105	38	58	63
Mg	14.5	4.1	5.7	5.7
Fe	<0.1	1.1	<0.1	<0.1
Al	<0.2	<0.2	<0.2	<0.2
K	23	2.1	1.1	1.9
Na	33	24	16.5	33
TDS	690	260	340	390
Alkalinity (as $CaCO_3$)	125	125	160	130
Hardness - permanent	195	Nil	8.3	51
- temporary	125	115	160	130