1980/40. Groundwater investigations at Swanwick near Coles Bay

W.C. Cromer

Abstract

Groundwater at Swanwick occurs in unconsolidated sediments occupying a small basin-like structure bordering Swanwick Bay and bounded by Devonian granite and Jurassic dolerite. The aquifer is a clean quartz sand capable of yielding small but useful amounts of moderate quality water from its upper level. The range of salinities encountered was 250-6710 mg/*l* of total dissolved solids. Maximum spear bore yield was 27 *l*/min (350 gph).

An artificial lake excavated below the water table is a feasible proposition, and would also supply water for gardens to a proposed subdivision. The possibility of septic tank contamination cannot be definitely assessed at this stage. Drinking water for the subdivision should be obtained from surface dams.

INTRODUCTION

In July 1978 the Department of Mines reported briefly on the possibility of obtaining groundwater at Swanwick [FP022384] where Swanwick Holdings Pty Ltd is developing the property for subdivisional use. Parts of the land have already been sold, and about 15 ha fronting onto Swanwick Bay (fig. 1) will soon be subdivided. The initial Mines Department report suggested that groundwater might be present in the unconsolidated sediments in the area, and in August 1980 the owners requested that further investigations be made on the proposed subdivision to establish whether suitable groundwater existed for private use.

The area to be subdivided is generally flat or undulating, and marshy in places. Parts have been artificially drained. Most of it is only about a metre above mean sea level, and forms the seaward end of a shallow valley sloping gently north-west to Swanwick Bay. As a result, septic tank approval for individual lots may only be obtained by raising the land surface to provide about 1.5 m of permeable soil above the water table. Swanwick Holdings intends to do this by levelling a 300 m long 6 m high sand dune on the property (fig. 1) and by creating a shallow fresh-water lake adjacent to the dune. The company asked whether the lake could be a suitable water supply for the subdivision, or whether septic tank effluent from the lots would contaminate it.

FIELD WORK

During the period 23-24 September 1980 sixteen augered drill holes were completed on and adjacent to the proposed subdivision. The drilling was done to establish the geological succession in the area, and to locate possible water-bearing horizons. Logs of all bores are listed in Appendix 1. On 25 September 1980 some of the holes were pumped by spear-bores, and two water samples collected for analysis. The analyses are presented in Appendix 2. Details of spear bore installations and pumping rates are included in the log sheets of the relevant holes.

All the bore holes were levelled relative to approximate high water mark in Swanwick Bay. Relative levels are accurate to within 50 mm.

Results of the drilling are summarised in geological cross-sections of the area (fig. 2).

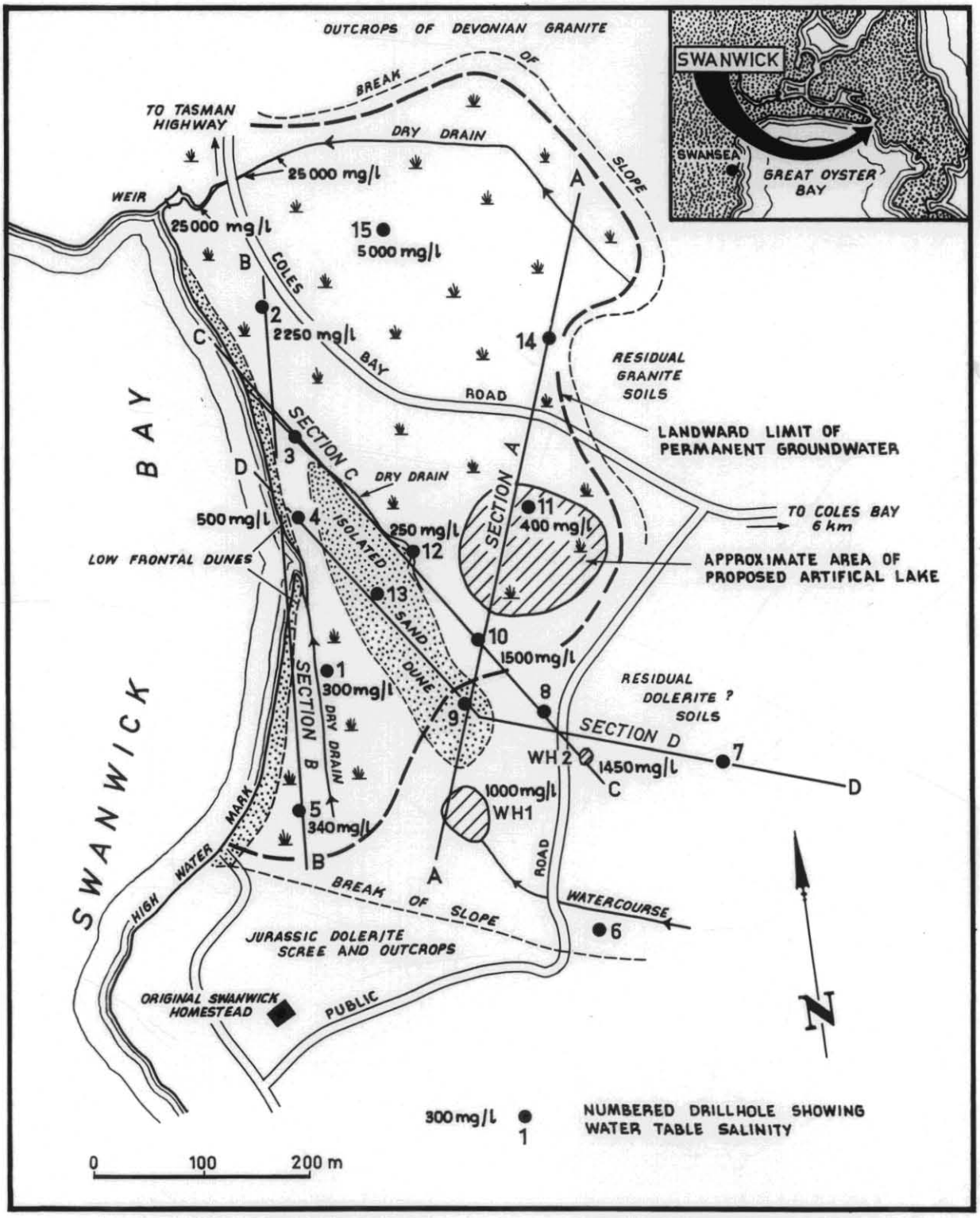


Figure 1. *Sketch map of northern part of Swanwick Subdivision, showing locations of augered bore holes and section lines.*

5 cm

GEOLOGY

Granite and dolerite

The subdivision is bounded on both sides, and underlain by, crystalline basement rocks. Devonian granite crops out to the north and north-east of the Coles Bay Road adjacent to the property. The granite is in places overlain by a variable thickness of residual soil composed mainly of clayey granitic gravel and gravelly clay with minor amounts of silt and sand. The soil contains rare indurated sandstone and chert fragments in places.

The headland at the southern end of Swanwick Bay, and its extension south to Hepburn Point, is composed of Jurassic dolerite. Dolerite is exposed at the original Swanwick homestead and surrounding paddocks, and at sea-level in cliffs and shore platforms south of the existing subdivision.

The contact between the granite and dolerite trends south-east from Swanwick Bay, is obscured beneath residual dolerite and granitic clayey soils, and is part of a much larger structural feature extending along most of the eastern coast of Tasmania. On a local scale, the boundary between the dolerite and unconsolidated sediments is marked by a break of slope at the southern end of Swanwick Bay; a similar but more obvious break of slope marks the boundary between the same sediments and granite east of the bridge and weir at the northern end of the bay.

The present investigations were restricted to a narrow basin-like structure stretching 700 m across the mouth of Swanwick Bay, and extending about 500 m up the shallow valley to the south-east (fig. 1).

Unconsolidated sediments

On the basis of the detailed logs of the sixteen drill holes, the unconsolidated water-bearing sediments of the area form a shallow basin-like infilling resting at shallow depth (about 10 m below HWM) on impermeable clay or basement rocks (fig. 2). The sediments are considered to be Quaternary in age. In Figure 2 tentative correlation lines have been drawn and each unit lettered for discussion purposes.

Unit e. This is a stiff, mottled yellowish brown and greyish brown clay cropping out in the valley behind Swanwick Bay. It is correlated with clay intersected in Holes 2, 3, 4, 9, 10 and 12 beneath younger water-bearing sediments and is therefore assumed to be the oldest unit. The clay is probably a partly transported or residual soil developed on the dolerite, since it abuts against dolerite to the south and apparently contains no weathered granite component. The stratigraphic relationship between Unit e and the adjacent residual granitic soils near the Coles Bay Road has not been investigated.

Unit e dips seawards beneath younger sediments (fig. 2). It is relatively impermeable and is hydrologically the confining bed for the overlying water-bearing sediments.

Unit d. This is the area's main aquifer. It does not crop out but in bore holes it is a distinctive unit of grey or yellowish grey fine- to very fine-grained well-sorted quartz sand. In places it contains fine-grained quartzite gravel and clay horizons or lenses.

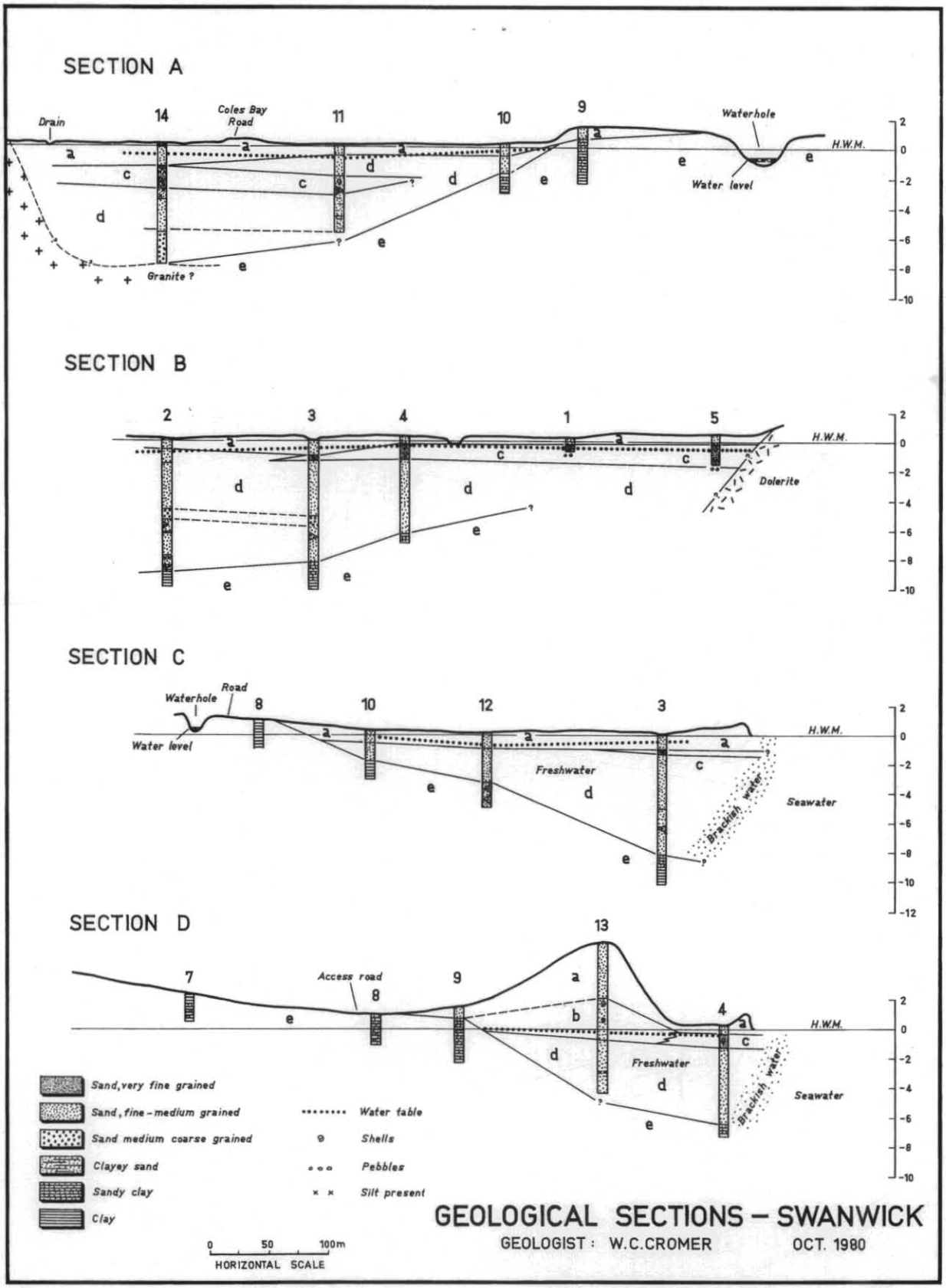

SECTION A
Drain
14
Coles Bay Road
11
10
9
Waterhole
H.W.M.
Water level
Granite ?
SECTION B
2
3
4
1
5
H.W.M.
Dolerite
SECTION C
Waterhole
Road
8
10
12
3
H.W.M.
Water level
Freshwater
Seawater
Brackish water
SECTION D
13
7
Access road
8
9
4
H.W.M.
Freshwater
Seawater
Brackish water
Sand, very fine grained
Sand, fine - medium grained
Sand medium coarse grained
Clayey sand
Sandy clay
Clay
Water table
Shells
Pebbles
Silt present
0 50 100m
HORIZONTAL SCALE
GEOLOGICAL SECTIONS – SWANWICK
GEOLOGIST : W.C.CROMER
OCT. 1980

Figure 2.

5 cm

From Figure 2, Unit d is a basin infilling up to nine metres thick and extending to about 8-9 m below HWM. Since it contains minor fine gravel and clay horizons, and no shell, it is probably fluvial in origin. It wedges out at either end of Swanwick Bay, where it overlies granite(?) (at the northern end) and clay (Unit e, at the southern end).

Unit c. Unit d is overlain by, and in places apparently interbedded with, a thin but distinctive bed of olive-black or brownish black fine- to very fine-grained shelly sand or shelly silt (Unit c). In places, Unit c grades to a sandy or silty shell bed. It varies in thickness from 0-1.6 m, and is probably an estuarine deposit formed in a quiet backswamp subject to intermittent marine incursions.

Unit b. This is probably a sub-unit of Unit a. It is restricted to a narrow zone beneath the isolated sand dune (fig. 1). Since it is slightly coarser grained than the overlying aeolian sand and contains sand sized shell fragments, it is regarded as a beach or near-shore marine deposit.

Unit a. This includes the large sand dune in the centre of the study area, the narrow, low aeolian dune sand bordering Swanwick Bay, and the thin capping of aeolian sand which covers the area between Swanwick Bay and the property access road.

HYDROLOGY

Surface hydrology

The main shallow valley falling to Swanwick Bay has no permanent creek, but runoff is collected in at least three waterholes. Excess water spreads out over the marshy area between Holes 1 and 5, and discharges via an artificial drain to its natural mouth on Swanwick Bay. At the time of the survey, water tables were low and the marshy areas dry. The water levels and salinities in waterholes 1 and 2 (fig. 1) were respectively -0.6 m, 1000 mg/*l*, and +0.45 m, 1450 mg/*l*.

The marshy area north of the Coles Bay Road has also been artificially drained. A low weir has been built on Swanwick Bay where the marsh discharges. Most of the drain was dry, but brackish water (25000 mg/*l*) extended inland 50 m past the bridge over the road. It has been reported that this area is flooded when heavy rains coincide with high tides.

An area near Holes 10 and 11 receives surface runoff from slightly elevated land near the entrance to the property; this is where Swanwick Holdings intends excavating the artificial lake. A drain extends along the side of the adjacent sand dune to Swanwick Bay.

The brackish water in the northernmost drain is in hydrological continuity with the groundwater. In contrast, the water levels in the waterholes at the other end of Swanwick Bay are separated from the permanent water table in the nearby sediments by impermeable clay.

Groundwater hydrology

A permanent water table exists in the sandy sediments (Units d, c, b and a) seawards of the heavy dashed line in Figure 1. At its landward limit, its maximum elevation is approximately equal to HWM. At the coast, the elevation is between 0.6-0.7 m below HWM. It therefore exhibits a seawards gradient of about 1:200 or 1:300, but these are average values because water levels in individual holes vary and are locally influenced

by the drains. Groundwater movement is either to the coast (where it discharges between low and high water mark) or to the artificial drains.

Between high and low water mark, the water table and the underlying groundwater share a brackish zone of mixing with seawater. The approximate relationship and attitude of the transition zone is indicated in Figure 2.

The main aquifer in the area is Unit d, which contains unconfined groundwater with salinities ranging from about 250 mg/*l* (at the water table) to more than 6400 mg/*l* (in Hole 4 at the coast). In general, salinity increases with depth.

Spear bore testing

Spear bores were installed and pumped for short periods in Holes 4, 11, 12 and 14. Details of spears, depths and salinities are included in the log sheets of the relevant holes in Appendix 1.

The tests show that the aquifer is capable of supplying water to spears at useful rates - up to 27 *l*/min (350 gph).

Groundwater quality and results of water analyses

Two pumped samples were submitted for chemical analysis. Results are shown in Appendix 2. Both waters are slightly acidic, very hard, and not unexpectedly of the sodium chloride type. Both are probably the result of salt water mixing with infiltrating rainfall, since although less saline than sea water, the relative proportions of major constituents are similar to sea water. For example, water from Hole 4 is slightly deficient relative to sea water in Na, Cl and SO_4, but is enriched in Ca, HCO_3 and Mg which are derived from shelly material in the aquifer.

Similarly, water from Hole 12 further inland is strongly enriched in Ca, HCO_3 and Fe at the expense of Na and Cl (the relative proportions of which, however, remain similar to that of sea water).

In summary, the salinities measured in various holes are:

Hole	*Water table salinity* (mg/*l*)	*Highest salinity measured* (mg/*l*)
1	300	-
2	2250	-
4	500	5000 (later analysed at 6710)
5	340	-
10	1500	-
11	400	2500
12	250	1100 (later analysed at 1460)
14	-	3500
15	5000	-

Generally, the groundwater is unsuitable for domestic drinking. It may be suitable for gardens in sandy soils, provided the water is pumped from the upper levels of the aquifer. This will reduce the maximum yields from spears, which should perhaps be installed no deeper than about two metres below high water mark. Spear yields can then be expected to be

less than 10 *l*/min. Water table salinities are lowest adjacent to artificial drains near Holes 1, 5 and 12. Private lots in these areas may be able to tap small but useful amounts of moderate quality groundwater. Other adjacent areas have poorer quality water at the water table, but these too may be suitable for gardens (for example, near Holes 10, 11 and 12).

ARTIFICIAL LAKE

The proposed lake will be used for recreational purposes and possibly as a source of water for private lots. It will be perhaps 2 ha in area, between Holes 10 and 12 and extending near the access road and Coles Bay Road. It will be separated from these roads by a residential strip about 50 m wide. Swanwick Holdings intends to raise the level of these perimeter blocks (and all other blocks) about 1.5 m above the water table. The proposed depth of water in the lake will be about one metre.

The lake will in effect be a large diameter well, and except for minor surface runoff, will contain only groundwater. Since the present water table is approximately at HWM, its construction will involve the excavation of about one metre of dry sand and one metre of saturated material (Unit d) over its surface area. Accordingly, the base of the lake should be clean, fine-grained, yellowish grey sand. The water in the lake may be discoloured and pale yellow.

Since the lake will intersect the upper levels of Unit d, the water quality will probably be suitable for irrigating gardens. Water table salinities in Holes 10, 11 and 12 were 250 mg/*l*, 400 mg/*l* and 1500 mg/*l*, so it is difficult to predict the final lake salinity.

Whether the lake will be subject to bacterial contamination from septic tanks along its eastern perimeter cannot be predicted. Provided septic tank effluent is discharged in dry sand at least one metre above the water table, contamination will be reduced. Private lots on the western side of the lake which discharge effluent to the coast should have no effect on the lake. The overall effects of septic tank effluent can only be assessed by monitoring the lake water after the scheme is operating.

[30 October 1980]

8/28

APPENDIX 1.

Geological logs, Swanwick.

Locations are shown in Figure 1, and cross-sections in Figure 2. The logs should be read in conjunction with the accompanying explanation sheet. Borehole 16, at the southern end of the subdivision, is not included in Figure 1.

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 1

sheet 1 of 1

9/62E

project SWANWICK location Beside sand dune

co-ordinates SEE MAP
R.L. 0·19m AHWM
inclination VERTICAL
bearing –

drill type TRIEFUS
drill method AUGER PULL
drill fluid NONE

hole commenced 22.9.80
hole completed 22.9.80
drilled by B. COX
logged by W. CROMER
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
	NONE	22.9.80	Salinity at water table 300 mg/l.	0			SP	SAND, dark brown (10YR3/3), M, WS, trace organic fines. Sand grains well-rounded, high sphericity granitic quartzite, colourless and milky	M	L		
				-0.5	0.5		SM	Silty SAND, olive black (5Y2/2); sand F-M, MS, with trace shell fragments mainly 2-10mm, rarely up to 15mm. Trace hard angular fine-grained dolerite fragments (up to 15mm). Becomes shelly silty sand below 1m.				
				-0.9	1			Drilling refusal at 1.1m on either bouldery or bedrock. Three adjacent holes struck basement (or boulders) at depths ranging from 0.8 – 1.3m				
					1.5							
					2							

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 2

sheet 1 of 1

project SWANWICK

location 1/4 paddock 50m from Coles Bay Road

co-ordinates SEE MAP

R.L. 0.16m AHWM

inclination VERTICAL

bearing —

drill type TRIEFUS

drill method AUGER PULL

drill fluid NONE

hole commenced 22.9.80

hole completed 22.9.80

drilled by B. COX

logged by W. CROMER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
	NONE	22.9.80 ▼	Salinity 2250 mg/l	0			SP	SAND, grey, grading rapidly to brown (10YR4/4), F, WS, and dark greyish yellow (2.5Y4/2) at 0.2m	M	L		
				1	-1		SP	SAND, brownish black (2.5Y3/1) and olive black (5Y3/2), F, WS, with many root fragments	W			
			D	2	-2		SP	SAND, grey (5Y4/1), F, WS, with trace brown root fragments and rare (<5mm) shell fragments: occasional silty clay patches and small (<5mm) black charcoal. Grades at 3.3m to dark greyish yellow (2.5Y5/2), flecked with C white quartzite. Smell of H_2S		Sloppy		
			D	3	-3							
				4	-4							
			D	5	-5		SW to GW	SAND, dark greyish yellow, VC, PS-MS, grading in places to fine granitic gravel; with rare well-rounded dolerite pebbles (up to 30mm). +2mm fraction mainly angular quartzite, granite fragments and rare, hard cemented ferruginous sand pebbles. Darkens below 5.3m, grades to M-C WS sand		VL		
				6	-6		SP	SAND, brownish grey and brownish black (10YR2/2) F-M, MS; lens of silty clay around root.		F MD		
				7	-7		SP	SAND, yellowish grey (2.5Y5/1), F, WS				
								Clayey SAND, yellowish grey (2.5Y5/1), F-M, WS grading to SAND, F, WS				
				8	-8		SM and SP	SAND and silty SAND, brownish black (2.5Y3/2), VF, WS, rapid dilatancy				
				9	-9		SC and GC	Clayey, gravelly SAND, brownish black (2.5Y3/1) +2mm fraction 5-7%, mainly angular quartzite, trace charcoal and small granite fragments	M > PL	F		
								CLAY, olive grey (5GY5/1). Poor recovery. Moderate plasticity				
				10				Hole stopped at limit of augers 10.2m (-10.04m)				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 3

sheet 1 of 1

project SWANWICK

location In drain north of sand dune, 50m from HWM.

co-ordinates SEE MAP

R.L. −0.01m AHWM

inclination VERTICAL

bearing –

drill type TRIEFUS

drill method AUGER PULL

drill fluid NONE

hole commenced 22.9.80

hole completed 23.9.80

drilled by B. COX

logged by W. CROMER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
	NONE	23.9.80 ▼			1		SP	SAND, dark brown (10YR 3/4), F, WS, grading at 0.1m to brownish black (2.5Y 3/2)	M / W	L		
			H_2S smell	-1				SAND, brownish black (2.5Y 3/1), VF, WS, with trace silt, occasional well-rounded dolerite pebbles (up to 50mm) and white shell fragments (up to 15mm)				
					2		SP	SAND, dark greyish yellow (2.5Y 5/2), F, WS grading to yellowish grey (2.5Y 5/1), F, WS, with trace VF dark minerals. Grades to M sand 3–3.3m. often flecked with F quartzite grains. M sand 5.1–6m, in places with trace fines. Between 6 and 6.9m, grey (5Y 4/1) C sand and fine granitic gravel (+2mm fraction ≈ 30%, composed mainly of granitic fragments up to 5mm with trace dolerite pebbles up to 50mm. 6.9–8.2m: M, MS sand; fines (F, WS) yellowish grey (2.5Y 5/1) sand				
			D	-2								
					3							
				-3								
					4							
				-4								
					5							
				-5								
			D					NOTE: Water salinity at water table measured after drilling (and obstructing aquifer) to various depths:				
					6			depth (m) / salinity (mg/l): 1.5 / 4000; 3.1 / 6400; 10.2 / 7500				
				-6								
					7							
				-7								
					8							
				-8								
							SC to CH	Clayey SAND – sandy CLAY, brownish black (10YR 3/1), F, WS, trace silt. Clay possibly in thin lens; sticky, high plasticity; grades at about 9m to sandy CLAY, olive grey (2.5GY 5/1) and greyish olive (5Y 5/2)		F / St		
				-9	9							
					10							

Hole stopped at limit of augers, 10.2m (−10.2m)

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 4

sheet 1 of 1

project SWANWICK

location 25m From HWM, 75m south of hole 3

co-ordinates SEE MAP

R.L. 0.33m AHWM

inclination VERTICAL

bearing –

drill type TRIEFUS

drill method AUGER PULL

drill fluid NONE

hole commenced 23.9.80

hole completed 23.9.80

drilled by B. COX

logged by W. CROMER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		23.9.80	Salinity at water table = 500mg/l.	0			SP	SAND, dull yellowish brown (10YR 5/4), F–M, WS, streaked and mottled with brownish black (10YR 3/2) and brown (10YR 4/6)	M	L		
					1		SP	Shelly SAND, brownish black (2.5Y 3/2), VF, WS–MD. [+2mm fraction approx. 50%, consisting of whole and fragmented shell (up to 15mm and mostly >5mm) and rare well-rounded dolerite pebbles (up to 40mm)] Shell content decreases below 2.3m	W			
			50mm PVC casing.		-1							
					2							
			50mm SCREEN (SLOT SIZE 0.2mm) PUMPED AT 240 gph for 30 min	-2			SP	SAND, grey (5Y 4/1), F, WS; trace VF dark minerals. In places (eg 5.1–6.9m) grades to M sand. Trace white C quartzite grains and rare fine quartzite gravel				
					3							
				-3								
					4							
				-4				NOTE: Water salinity at water table measured after drilling (and disturbing aquifer) to various depths:				
					5			depth (m) / salinity (mg/l): 0.73 / 500; 5.0 / 650; 7.0 / 2800; pumped spear / 5000				
				-5								
					6							
				-6								
					7		CH	CLAY, brownish black (2.5Y 3/1) and olive black (5GY 5/1), high plasticity, slightly silty or sandy and organic near 6.9m	M > PL	F - St		
				-7								
					8			Hole stopped in clay at 7.4m				
								NOTE: Spear jetted to 4m; pumped at 240 gph for 30 mins; smell H_2S. Water initially muddy, cleared rapidly to pale yellow. Salinity at end of pumping = 5000 mg/l				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 5
sheet 1 of 1

13/28

project SWANWICK location 125m SW of hole 1

co-ordinates SEE MAP
R.L. 0.53m AHWM
inclination VERTICAL
bearing –

drill type TRIEFUS
drill method AUGER PULL
drill fluid NONE

hole commenced 23.9.80
hole completed 23.9.80
drilled by B.COX
logged by W.CROMER
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		23.9.80	Salinity at water table 340 mg/l.		0		SP	SAND, yellowish brown (10YR5/8), streaked with dull yellowish orange (10YR6/3); F-M, WS	M	L		
					1		SP	SAND, yellowish grey (2.5Y4/1), VF, WS, flecked with trace VF shell fragments. Becomes shellier below 1.5m, with larger shell fragments	W			
					-1							
					2			Refusal at 2m on cobbles, boulders or basement - possibly dolerite				
					3							

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 6

sheet 1 of 1

14/2E

project SWANWICK location See map

co-ordinates See map

R.L. 1.90m AHWM

inclination VERTICAL

bearing –

drill type TRIEFUS

drill method AUGER PULL

drill fluid NONE

hole commenced 23.9.80

hole completed 23.9.80

drilled by B.COX

logged by W.CROMER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		NOT ENCOUNTERED		+1	1		CL to CH	Sandy CLAY, mainly yellowish brown (2.5Y5/4) mottled with greyish olive (7.5Y6/2). Trace M-C sand above 1m. Moderate plasticity, grading to CLAY (as above) below 1m.	M ≤ PL to D	St		
				0	2			Hole stopped in stiff clay at 2m; refusal.				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 7

sheet 1 of 1

15/2E

project SWANWICK

location On fence line, east of access road - see map.

co-ordinates See map

R.L. 2·45m AHWM

inclination VERTICAL

bearing -

drill type TRIEFUS

drill method AUGER 70MM

drill fluid NONE

hole commenced 23.9.80

hole completed 23.9.80

drilled by B. COX

logged by W. CROMER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		NOT ENCOUNTERED		+2	1		CL	CLAY, mottled yellowish brown (10YR5/6) and greyish yellow brown (10YR5/2), moderate to high plasticity, with trace rare quartzite pebbles (up to 60mm) and patches of iron-cemented sand (laser). In places grades to sandy CLAY	M ≈ PL to D	St		
				+1								
					2			Hole stopped at 2m, tending to refusal.				

40-15

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 8

sheet 1 of 1

16/28

project SWANWICK

location Near access road, 175m W of hole 7

co-ordinates See map

R.L. 1.02m AHWM

inclination VERTICAL

bearing –

drill type TRIEFOS

drill method AUGER PULL

drill fluid NONE

hole commenced 23.9.80

hole completed 23.9.80

drilled by B. Cox

logged by W. CROMER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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 1		CL to CH	CLAY, mottled yellowish brown (10YR5/6) and greyish yellow brown (10YR5/4), moderate–high plasticity, trace sand; some patches of hard iron-cemented sand	D to M < PL	St		
					–1 2			Hole stopped in stiff clay at 2m; tending to refusal				

40-16

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 9

sheet 1 of 1

17/28

project SWANWICK

location 50m NW of hole 8, on S. flank of sand dune.

co-ordinates See map

R.L. 1.46m AHWM

inclination VERTICAL

bearing –

drill type TRIEFUS

drill method AUGER PULL

drill fluid NONE

hole commenced 23.9.80

hole completed 23.9.80

drilled by B.COX

logged by W. CROMER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		NOT ENCOUNTERED					SP	SAND, dull yellowish brown (10YR5/3), F, WS, with trace rare C quartzite grains	D	L		
				1	0		SC to CL	Sandy CLAY – clayey SAND, mainly clayey sand; mottled yellowish brown (10YR5/8) and grey (10Y5/1). Trace rare rounded dolerite pebbles; Grades at 2m to dull yellow (2.5Y6/3) sandy CLAY mottled with grey; 2.4–3.3m light olive grey (2.5GY7/1) in places, and below 3.4m brightens to yellowish orange streaked with dull yellow	M ≈ PL	St		
				2	1							
				3	2							
				4	3			Hole stopped in stiff clay at 3.8m; tending to refusal.				

40-17

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

5 cm

borehole no. 10

sheet 1 of 1

18/28

project SWANWICK

location 75m NNE of hole 9.

co-ordinates See map

R.L. 0.32 m AHWM

inclination VERTICAL

bearing -

drill type TRIEFUS

drill method AUGER PULL

drill fluid NONE

hole commenced 23.9.80

hole completed 27.9.80

drilled by B. COX

logged by W. CROWLER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		▼	Water table Salinity 1500 mg/l	0			SP	SAND, dull yellow (2.5Y6/3), mottled with yellowish brown (2.5Y5/6), M-F, WS	M – W	L		
					1			SAND, yellowish grey (2.5Y5/1), F-M, WS; grains well rounded; trace fines at 2m				
				-1	2			CLAY, mottled greyish olive (5Y4/2) and grey (N4/0), with trace sand, fine gravel and rock fragments, moderate plasticity, grading to light greenish grey (7.5GY7/1) mottled with greyish olive (7.5Y5/2)	M > PL	VSt		
				-2	3							
				-3				Hole stopped at 3.3m. Very hard drilling				
					4							

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 11

sheet 1 of 1

project SWANWICK location 60m SW of Coles Bay Road; 125m NNE of hole 10

co-ordinates See map
R.L. 0.21m AHWM
inclination VERTICAL
bearing –

drill type TRIEFUS
drill method AUGER PULL
drill fluid NONE

hole commenced 23.9.80
hole completed 23.9.80
drilled by B.COX
logged by W.CROMER
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		23.9.80	Water Salinity at water table = 400mg/l.	0			SP	SAND, mottled and streaked yellowish brown (10YR5/6) and dull yellow (2.5Y6/3). F-M, WS, grading to brownish black (2.5Y3/1)	M	L		
				-1	1		SP	SAND, grey (5Y4/1), F, WS, with trace shell fragments below 2m	W			
			N°15 (0.40mm) Stainless Steel Screen	-2	2							
				-3	3		CL	CLAY (loam?), black (10YR7/1), organic, with trace fine sand and shell fragments (up to 15mm)		F St		
							SC	Clayey SAND, grey (5Y4/1), M-C, sticky, grading at 4.2m to yellowish grey (2.5Y6/1), F, WS. In places grades to sandy clay. Near 6m, grades to yellowish grey (2.5Y6/1) sand with trace fines, C sand and charcoal.				
				-4	4							
				-5	5							
				-6	6							
					7			Hole stopped at 6m (–5.79m)				

NOTE: Spear jetted to 2.8m; pumped at 120sph (9 l/min) for 20mins. Initially muddy, cleared to pale yellow after 10mins. Salinity at end of pumping = 2500 mg/l.

Water table salinity measured after drilling (and disturbing aquifer) to 6m = 1000 mg/l.

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 12
sheet 1 of 1

29/28

project SWANNICK

location 100m WSW of hole 11, in drain on E side of sand dune

co-ordinates See map
R.L. 0.13m
inclination VERTICAL
bearing —

drill type TRIEFUS
drill method AUGER FULL
drill fluid NONE

hole commenced 23.9.80
hole completed 23.9.80
drilled by B. Cox
logged by W. CROMER
checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		23.9.80	Water table salinity = 250 mg/l.	0			SP	SAND, dull yellowish brown (10YR4/3), grading to brownish black (10YR3/1), F, WS	M	L		
				1					W			
				-1			SP	SAND, yellowish grey (2.5Y4/1) grading to yellowish grey (2.5Y5/1), F, WS; trace M sand		Sloppy		
			No.15 (0.4mm) Screen	2								
				-2								
				3								
				-3				? ? ?				
				4				Clayey SAND, grey (5Y4/1), PS, M, with trace C sand and fine quartzite gravel. Occasional patches of mottled yellowish brown and grey sandy clay, and lenses (?) of stiff, moderate-high plasticity mottled grey (7.5Y4/1) and olive grey (7.5Y4/2) CLAY. Grades to grey (N4/0) F, WS sand with trace fines		MD		
				-4					M/W			
				5								
				-5				Hole stopped at 5.1m (−4.97m)				
				6				NOTE: Spear jetted to 3.3m; pumped at 350 sph (27 l/min). Water initially muddy, cleared to pale yellow. Trace suspended solids (sand). Salinity 1100 mg/l. Water table salinity measured after drilling (and disturbing aquifer) to 3.3m = 410 mg/l.				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 13 (21/28)

sheet 1 of 1

project SWANWICK

location On top of sand dune, 70m WSW of hole 12

co-ordinates See map

R.L. 5·92m AHWM

inclination VERTICAL

bearing -

drill type TRIEFUS

drill method AUGER DRILL

drill fluid NONE

hole commenced 23.9.80

hole completed 23.9.80

drilled by B. COX

logged by W. CROMER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		NOT ENCOUNTERED		+5	1		SP	SAND, greyish yellow brown (10YR6/2), VF, WS, grading at 0.1m to bright yellowish brown (10YR6/6), F, WS, paling below 1m to dull yellow orange (10YR7/4). Trace roots. Trace shell fragments below 3.7m. Slightly coarser (M, WS), with shell fragments 5.4 – 6.5m	D	VL – L		
				+4	2							
				+3	3							
				+2	4							
				+1	5							
				0	6				M			
Pebbles				-1	7		SP	SAND, greyish yellow brown (10YR4/2), F, WS, shell Acc, with trace dolerite pebbles (up to 25mm), grading to yellowish grey (2.5Y5/1) with rare C sized grains, and then to dark brown (10YR3/3) and brownish black, with trace silt, at 8.6m. Below 8.6m, as for 6.5 – 8.6m.				
				-2	8							
				-3	9			Hole stopped at limit of augers, 10.2m (-4.28m)				
				-4	10							

40-21

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 14 (22/28)

sheet 1 of 1

project SWANWICK

location In flat marshy area on E side of Clear Bay Road

co-ordinates See map

R.L. 0.19m AHWM

inclination VERTICAL

bearing -

drill type TRIEFUS

drill method AUGER PULL

drill fluid NONE

hole commenced 24.9.80

hole completed 24.9.80

drilled by B. COX

logged by W. CROMER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		24.9.80		0			CL	Silty CLAY, very dark brown (7.5YR2/3), many fine roots; low plasticity	M	FB to L		
					1		SP	SAND, grey (10Y4/1), F, WS, trace fines	W			
				-1								
					2		SM	SAND, olive black (7.5Y2/2), VF, MS, trace silt and shell fragments (up to 15mm), grading to clayey silt, sticky, with trace shell fragments. Occasional patches of bright brown silty clay, with trace shell and organic fines		MD		
			50mm PVC casing	-2								
					3							
				-3			SP to SW	SAND, brownish black to black, organic, F, MS, shell-free, with trace silt, and M sand and fine quartzite gravel.				
					4							
			No.15 (0.4mm) screen	-4				SAND, yellowish grey (2.5Y5/1), F, MS-WS, flecked with F-M milky quartzite grains.		L		
					5							
				-5								
					6							
				-6				SAND, yellowish grey (2.5Y6/1), M-C, PS with trace fines and rock fragments (up to 8mm) and fine quartzite gravel. Most grains angular.				
					7							
				-7								
					8							
				-8				Drilling refusal at 8.2m (-8m), possibly on granite basement.				
					9			NOTE: Spear jetted to 6m, pumped at 200gph (15L/min). Salinity 3500 mg/L.				

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

5 cm

borehole no. 15 (23/28)

sheet 1 of 1

project SWANWICK

location 1/4 Flat marshy area, E side of Coles Bay Road

co-ordinates See map

R.L. 0.18 m AHWM

inclination VERTICAL

bearing –

drill type TRIEFUS

drill method AUGER PULL

drill fluid NONE

hole commenced 24.9.80

hole completed 24.9.80

drilled by B. Cox

logged by W. CROMER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		24.9.80	Water table Salinity 5000 mg/l.	0	0			Silty CLAY, brown; many roots	D M	H L		
				-1	1		SP to SM and SC	SAND, olive black (5Y 3/2), F, WS, trace fines and shell fragments (up to 15mm). Interval 1.5–3.3m, similar to hole 14 (1.5–3m), with clayey silt and silty clay pockets, all containing shell fragments. Some organic fines				
				-2	2					M D		
				-3	3							
				-4	4		SM and SC	Silty SAND, in places clayey SAND, dark greyish yellow (2.5Y 5/2), dull yellow (2.5Y 6/3) and greyish yellow (2.5Y 7/2), VF–F, WS. Near 5.1m, trace C sand and fine quartzite gravel				
				-5	5							
				-6	6							
							CL	Silty CLAY, yellowish grey (2.5Y 4/1), soft, sticky, low–moderate plasticity	M PL	S to MD		
				-7	7			Hole stopped at 6.9m (– 6.72m)				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. 16

sheet 1 of 1

24/28

project SWANWICK location Near creek bed at SE end of property.

co-ordinates See map

R.L. Approx. 12–15 m AHLWM

inclination VERTICAL

bearing —

drill type TRIEFUS

drill method AUGER PULL

drill fluid NONE

hole commenced 24.9.80

hole completed 24.9.80

drilled by B. COX

logged by W. CROMER

checked by

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres 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
		NOT ENCOUNTERED.			0		SP	SAND, bright brown (7.5YR5/6), F, WS, grading to dull yellow (10YR5/4); trace fines	D / M	MD		AEOLIAN SAND
					2		SC	Clayey SAND, greyish olive (5Y5/2), grading rapidly to sandy CLAY, mainly (5Y5/2), with mottles and streaks of greyish olive (5Y6/2) and yellowish brown (2.5Y5/4). Below 3.3m grades to moderately plastic slightly sandy CLAY, olive brown (2.5Y4/6)	D to M / M > PL	St		RESIDUAL SOIL ON DOLERITE
					5			Hole stopped at 4.8m.				

APPENDIX 2

Water analyses from Holes 4 and 12

TASMANIAN DEPARTMENT OF MINES
WATER ANALYSIS

Field No. HOLE 4, +30 minutes
Lab. reg. no. 802387
Surface sample?
Groundwater sample? YES

Project SWANWICK — Location SWANWICK BAY. SEE MAP

Co-ordinates Approx FP025398 — Date sampled: 25.9.80 — Sampled by: W.C. CROMER — Date analysed: 24.10.80 — Analysed by: Dept. Mines, Launceston

Sampling conditions: Collected from spear bore 30 minutes after pumping started, at 18 litres/minute.

Landowner and address (if applicable): SWANWICK HOLDINGS PTY. LTD (J. BAIN) P.O. Box 572, LAUNCESTON, TAS.

Field observations — Colour: Pale yellow — Odour: H_2S smell — Taste: salty — pH: — — Eh: — — Temperature (°C): — — Specific conductance (μS/cm at 25° C): 10000 — Turbidity: none — Precipitates: — — Other: —

LABORATORY ANALYSIS

	mg/l	meq/l	% meq/l
Carbonate (CO_3)	nil	–	–
Bicarbonate (HCO_3)	80	1.31	0.62
Chloride (Cl)	3240	91.4	43.0
Sulphate (SO_4)	439	9.13	4.29
Silica (SiO_2)	10	–	–
Calcium (Ca)	251	12.52	5.98
Magnesium (Mg)	258	21.21	9.97
Iron in solution (Fe)	0.3	–	–
Aluminium (Al)	2	0.22	0.10
Potassium (K)	34	0.87	0.41
Sodium (Na)	1750	76.1	35.77
Total dissolved solids (TDS)	6710	212.8	
Permanent hardness as $CaCO_3$	1630		
Temporary hardness as $CaCO_3$	66		
Alkalinity as $CaCO_3$	66		
Other			

pH	6.1
Specific conductance (μS/cm at 25°C)	3900
Colour	pale yellow
Turbidity	none
% difference in anion and cation meq/l	4.3

Previous chemical analysis available? NO
Date –
Lab. ref. number –
Bacteriological analysis available? NO
Date –
Lab. reg. number –

HARDNESS SCALE
(Total hardness as Calcium Carbonate)

Soft	0 — 60 mg/l
Moderately Hard	61 — 120
Hard	121 — 180
Very hard	more than 180 ✓

IONIC RATIOS

Ca: Mg = 0.59	Cl: total = 0.43
Na: total = 0.36	SO_4: total = 0.04
Na: Cl = 0.83	SiO_2: total = –

SUITABILITY
a = no problems, b = doubtful, c = excessive

DOMESTIC		DRINKING	
Total dissolved solids	c	pH	c
Total hardness	c	Iron	b
Chloride	c	Sulphate	c
Sodium	c	Magnesium	c
Colour	a		

DOMESTIC HOT WATER CYLINDER

Total dissolved solids	c	Chloride	c
Cl/alkalinity ratio = 49	c	pH	a

AGRICULTURAL USE

	Value	Suitability (a,b, or c)
Salinity class (C1 — C4)	C4	c
Sodium class (S1 — S4)	S4	c
Percent Sodium	69.5	c
Sodium adsorption ratio	18.5	c
Residual sodium carbonate	nil	a

Remarks: A slightly coloured and acidic groundwater of the sodium chloride type with subordinate magnesium sulphate; highly saline and in its natural state unsuitable for any use except certain stock uses.

TASMANIAN DEPARTMENT OF MINES
WATER ANALYSIS

Field No. HOLE 12, +20mins
Lab. reg. no. 802386
Surface sample?
Groundwater sample? YES

Project SWANWICK Location SEE MAP; SWANWICK BAY

Co-ordinates Approx. FP026388 1:100000 Sheet: Freycinet
Date sampled: 25.9.80 Sampled by: W.C. CROMER
Date analysed: 24.10.80 Analysed by: Dept. Mines, Launceston

Sampling conditions: Collected from spear bore 20 minutes after pumping started, at 27 litres/minute

Landowner and address (if applicable): SWANWICK HOLDINGS PTY LTD. (J. BAIN) P.O. BOX 572 LAUNCESTON TAS.

Field observations
Colour: Pale yellow Odour: Slight H_2S smell. Taste: slight
pH: — Eh: — Temperature (°C): — Specific conductance (μS/cm at 25° C): 2200
Turbidity: None Precipitates: — Other: Trace fine sand

LABORATORY ANALYSIS

	mg/l	meq/l	% meq/l
Carbonate (CO_3)	Nil	—	—
Bicarbonate (HCO_3)	93	1.53	3.40
Chloride (Cl)	637	17.96	40.1
Sulphate (SO_4)	105	2.18	4.9
Silica (SiO_2)	11	—	
Calcium (Ca)	44	2.20	4.9
Magnesium (Mg)	55	4.52	10.1
Iron in solution (Fe)	0.6	—	
Aluminium (Al)	3	0.33	0.7
Potassium (K)	10	0.26	0.6
Sodium (Na)	364	15.83	35.3
Total dissolved solids (TDS)	1460	44.81	
Permanent hardness as $CaCO_3$	278		
Temporary hardness as $CaCO_3$	76		
Alkalinity as $CaCO_3$	76		
Other			

pH	6.0
Specific conductance (μS/cm at 25°C)	2000
Colour	pale yellow
Turbidity	none
% difference in anion and cation meq/l	3.3

Previous chemical analysis available?	NO
Date	—
Lab. ref. number	—
Bacteriological analysis available?	NO
Date	—
Lab. reg. number	—

HARDNESS SCALE
(Total hardness as Calcium Carbonate)

Soft	0 — 60 mg/l
Moderately Hard	61 — 120
Hard	121 — 180
Very hard	more than 180 ✓

IONIC RATIOS

Ca: Mg = 0.49	Cl: total = 0.40
Na: total = 0.35	SO_4: total = 0.05
Na: Cl = 0.88	SiO_2: total =

SUITABILITY
a = no problems, b = doubtful, c = excessive

	DOMESTIC	DRINKING	
Total dissolved solids	b	pH	c
Total hardness	c	Iron	c
Chloride	c	Sulphate	b
Sodium	c	Magnesium	b
Colour	a		

DOMESTIC HOT WATER CYLINDER

Total dissolved solids	b-c	Chloride	c
Cl/alkalinity ratio = 8.4	c	pH	a-b

AGRICULTURAL USE

	Value	Suitability (a, b, or c)
Salinity class (C1 — C4)	C2-C3	b
Sodium class (S1 — S4)	S2-S3	b
Percent Sodium	71	c
Sodium adsorption ratio	8.6	b
Residual sodium carbonate	Nil	a

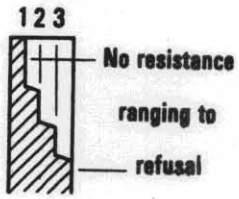
Remarks: A slightly coloured and acidic moderately saline groundwater of the sodium chloride type, with subordinate calcium bicarbonate; very hard, high in iron. In its natural state marginally suitable for domestic drinking, unsuitable for hot water cylinders, but probably suitable for irrigating gardens on sandy soils.

TASMANIA DEPARTMENT OF MINES

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	Undistributed 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.

Colour: Colours accompanie by code are based on *Revis Standard Soil Colour Chart* 1971.

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

GRAIN SIZE (sand range only)

VF Very fine M medium

F Fine C coarse

SORTING

WS, MS, PS: well-, moderately- and poorly-sorted.

Cored borehole log

Case - lift

Casing used.

Barrel withdrawn.

Fluid loss

No loss

50% loss

100% loss.

Lugeons

Lugeon units (pL) 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.