1980/12. Further drilling for water at Currie, King Island

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Abstract

Recent groundwater investigations near Currie have resulted in the location of four areas which appear to be capable of providing useful additions to the Currie water supply, using shallow spear bore methods of extraction from the dune sand. A strong spring north of Currie also appears to be capable of making significant additions to the water supply. These five areas, together with an area outlined in a previous survey, provide a total of six alternatives that can be considered in the extension of the water supply. The five areas examined in the recent survey require long (10-15 day) pump tests to ensure that the supply can be maintained in the long term, before moves are made to establish a system. Two other areas will probably produce lesser amounts of water.

Two areas south of Currie and behind British Admiral Beach would almost certainly provide the greatest quantity of water if developed to their full potential. These are followed by the area tested previously on Dolman's property north of Currie and the spring near the mouth of Three Rivers Creek which, subject to flow test, may supply about the same quantity of water. Lower but useful amounts could be obtained from an area near Wharf Road and the southern part of the golf course. An area just south of the present scheme and another between Dolmans and Three Rivers Creek may be capable of providing lesser amounts. The older dunes east of the newer dunes are thin where tested and appear capable of supplying only small quantities of water.

Water quality compares favourably with the present water supply except in the Wharf Road area, where initially there was a lower total dissolved solids content; after a longer test the salinity increased to about 50% higher. The salinity of water from the golf course area is also a little higher. Salinity may decrease with time in any of these areas (except perhaps for the spring) if they follow the pattern of the present scheme. Bicarbonate is high in all of the areas and this results in the higher temporary hardness values obtained.

INTRODUCTION

In July 1979 the King Island Municipal Council requested that further investigations be undertaken into groundwater occurrences for use in augmenting the present supply. Areas suggested for investigation included the area south of the town and the golf course. In 1978 some investigations were made south of Currie (Matthews, 1978) and although the results overall were very promising from the point of view of likely stored volume, replenishment rate and water quality, the pump test on the small array of spears that was installed indicated a lower permeability than expected. An area investigated north of the town had a smaller storage area and water with a quality a little poorer than the present supply, but the sand was coarse and had a high permeability. Extended pump tests on a small spear array in this area indicated that it was capable of supplying 340 m^3/day (Cromer, 1978). Later it was decided that this volume was not sufficient, as 1000 m^3 of water per day was required. It seems likely that this quantity of water could be taken from the area in peak demand periods, but not for long periods because of the restricted storage area. This extraction rate

could be achieved by installing two to three spear arrays in nearby similar small flat areas 80-200 m distant from that already installed and where it is known that suitable conditions are present. Further investigations to make such a proposition more certain were prevented during the latest survey because it was not possible to get access to the property. It had been proposed to install and pump test one or two small sets of spears.

In September 1979 a brief visit was made to the Currie area and about 20 holes were hand augered to a maximum depth of about three metres to locate areas where the water table is close to the surface and to test the quality of the water obtained. Several areas were selected for further work.

In December 1979 a powered auger was used to investigate the more favourable areas located in September. This work involved the instillation of a single spear in some of these areas and performing short pump tests to determine approximate output and quality. In addition, holes were drilled in the surrounding areas to determine the extent of the aquifer, the thickness of the saturated sand and water quality at these points.

In January and early February 1980, the more successful areas located in December were more intensively investigated by installing small sets of spears and pumping them for 14.6-18.6 hours to examine longer term pumping effects on drawdown. Such tests were expected to give some guidance to the long term output of the areas tested, although much longer pump tests would be required before a scheme could be established.

The work has been undertaken with the aid of Department of Mines technical officers B.Cox, D. Wyatt, E. Johnson and P. Blakeney and with the assistance of King Island Council employees, in particular G. Nash and J. Anfruns.

GEOLOGY

The geology of the area has been described in previous reports and little new information has been obtained. Most of the work has taken place in the 'New Dunes', although the older quartz rich dunes were struck at depth at some locations. Some of the test holes were drilled at the back of or east of the line of the New Dunes and penetrated the 'Old Dunes' from the surface. Logs of the holes are given in Appendix 1 and some descriptions of compositions of the sand are given in Appendix 2. Sizing analyses are shown in Appendix 3 and these are plotted in Figures 8-12. The sizing curves indicate the average grain size for most samples is about 0.2-0.35 mm; exceptions are for a sample from Hole 27 on the golf course where the average size is about 0.6 mm, Hole 28 where it is about 0.4 mm and the top part of Hole 9, where the average size is about 0.5 mm.

The effective size, the size for which 90% of the material is greater, ranges from 0.12-0.19 mm for all except samples from Holes 9, 27 and 28 which range from 0.22-0.3 mm. The uniformity coefficient ranges from 1.5 to 2.7 and a bore in an aquifer containing this material could most efficiently be established using a gravel pack around a screen or slotted casing, although reasonably efficient bores are possible with slotted casing against the aquifer.

Although much of the material drilled is windblown sand, some of the lower material in the bores is fine rounded gravel and is probably a shoreline deposit. Such material occurs in Holes 2, 3 and 5 south of Currie and was found in a few holes just north of these in 1978. Some of the sand size material contains small unbroken shells and sponge spicules, including

three pronged spicules or triaxons (*e.g.* Holes 11 and 13). All of these materials may be shoreline or shallow marine deposits.

DETAILED INVESTIGATION AREAS

From the work undertaken in December, four areas were selected for installation of small arrays of spears (fig. 1). These were;

(1) Near Hole 1 - directly east of the monument on British Admiral Beach.

(2) Near Hole 11 - behind the northern end of British Admiral Beach.

(3) Behind the shore on the southern part of the golf course (Hole 27).

(4) Behind the shoreline near Wharf Road around Hole 28.

Single spears were installed in other areas in December but their performance was not as favourable as the spears in the above areas.

Southern area, British Admiral Beach [about 3 km south of Currie; BR326721]

Five bores were installed in a roughly circular pattern surrounding Hole 1; an approximate plan of the layout, together with pump test information is shown in Figure 2. The array of bores A-B-C-D-E was jointly pumped for about 18 hours at about 224 *l*/min with levels being monitored in the original Hole 1. Recovery was measured over a period of 10.25 hours. A plot of the drawdown and recovery data is shown in Figure 3. Because of the relatively small total drawdown, no correction has been made for drainage of part of the aquifer (the aquifer being unconfined). A projection of the drawdown curve to 100 000 minutes (≈ 70 days) suggests that the drawdown after this time would be about 2.9 m. The observation spear was installed to 5.8 m and the aquifer extends to at least 9.1 m. From the data given below, it is apparent that there is an abundant safety margin in pumping this array at this rate.

Hole	*S.W.L.** (m)	*Total depth saturated sand* (m)	*Depth of water after 18 hours pumping* (m)	*Possible drawdown used* (%)
A	2.06	2.97	1.91	36
B	2.13	2.57	1.37	47
C	1.78	3.32	2.08	37
D	2.06	3.34	2.18	35
E	2.44	2.54	1.63	36

With less than half the possible drawdown used in each hole after this period of pumping, it is likely that the system could sustain this flow in the long term. With spears installed to greater depths, they could probably be pumped at greater rates.

There are extensive flat areas east and south of the area where these spears have been installed. Of the other nine prospecting holes drilled in this area, in only one (Hole 10) was the water table at a depth greater than 2.3 m. Spear arrays could probably be successfully installed at each of Holes 2-9, as indicated by the material encountered. Hole 10 was in a slightly more elevated position and this would account for the deeper water table. An extensive system of spears could be installed in the flat areas

* S.W.L. = standing water level

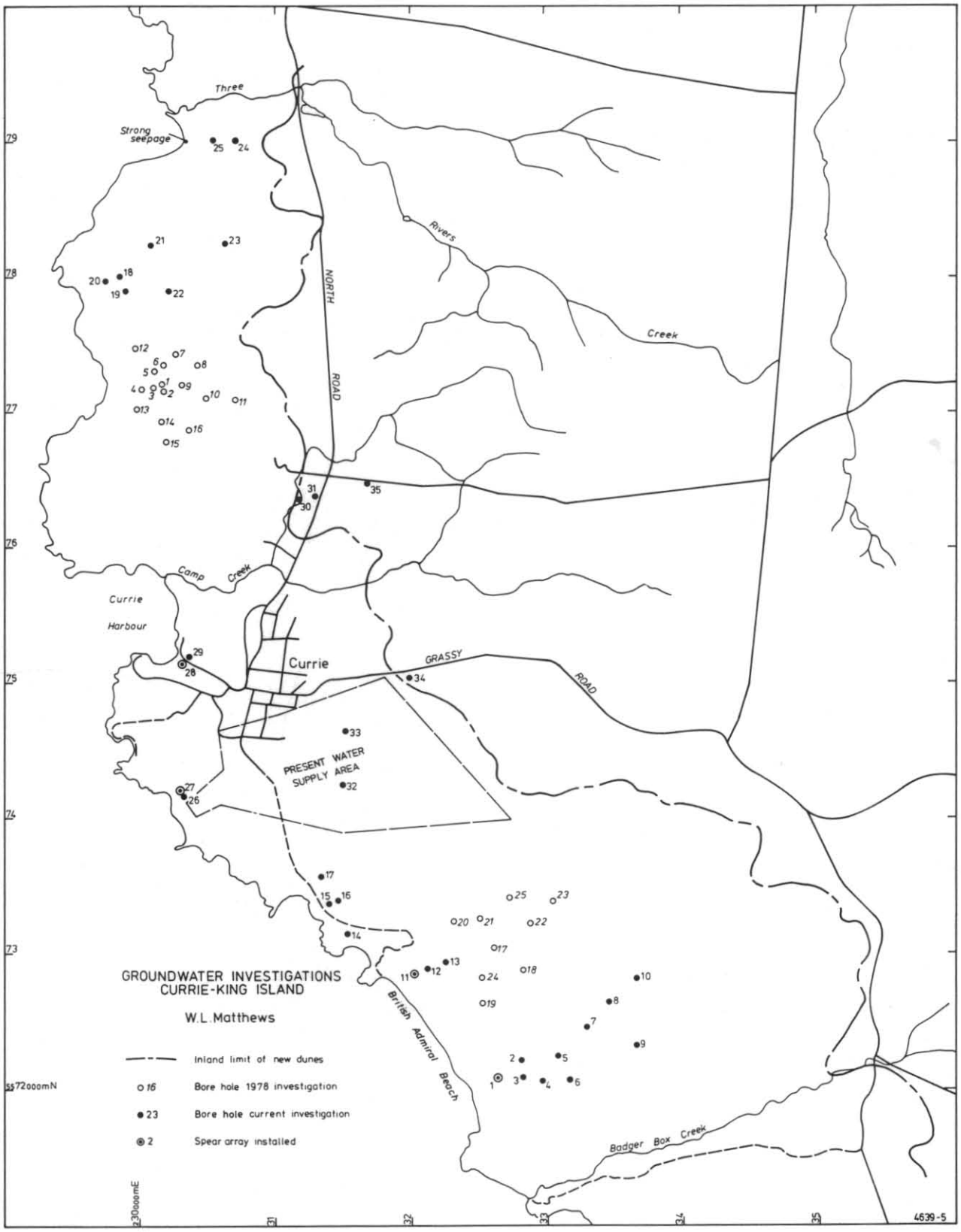
Three
Strong seepage
Rivers
Creek
NORTH ROAD
Camp Creek
Currie Harbour
Currie
GRASSY ROAD
PRESENT WATER SUPPLY AREA
British Admiral Beach
Badger Box Creek
GROUNDWATER INVESTIGATIONS
CURRIE-KING ISLAND
W.L.Matthews
Inland limit of new dunes
Bore hole 1978 investigation
Bore hole current investigation
Spear array installed
5572000mN
230000mE
4639-5

Figure 1.

5 cm

A ● SWL 2.06 m
Depth 5.03 m
TDS 380 mg/*l*
After 5 minutes 2 m water in hole
After 18 hours 1.91 m water in hole

E ● SWL 2.44 m
Depth 4.98 m
TDS 380 mg/*l*
After 5 minutes 1.52 m water in hole
After 18 hours 1.63 m water in hole

O Hole 1 - observation hole
SWL 1.85 m
Depth 5.79 m

D ● SWL 2.06 m
Depth 5.4 m
TDS 365 mg/*l*
After 5 minutes 2.44 m water in hole
After 18 hours 2.18 m water in hole

B ● SWL 2.13 m
Depth 4.70 m
TDS 380 mg/*l*
After 5 minutes 1.5 m water in hole
After 18 hours 1.37 m water in hole

C ● SWL 1.78 m
Depth 5.1 m
TDS 380 mg/*l*
After 5 minutes 1.83 m water in hole
After 18 hours 2.08 m water in hole

Array pumped at 224 *l*/min for 18 hours, five minute pump rate 78 *l*/min.

Logs of holes

Hole A	0 - 4.9 m	coarse shell fragment sand
	4.9 - 6.4 m	thin soil horizon, brown sand
B	0 - 5.2 m	coarse shell fragment sand
	5.2 - 6.4 m	soil horizon, fine brown quartz sand
C	0 - 4.9 m	shell fragment sand
	4.9 - 6.4 m	soil horizon, brown quartz sand
D	0 - 4.6 m	shell fragment, sand
	4.6 - 6.4 m	dark brown quartz sand
E	0 - 5.2 m	coarse shell fragment sand
	5.2 - 6.4 m	soil horizon, brown quartz sand

Scale: 10 mm = 2 m

Figure 2. *Pump test array, south British Admiral Beach*

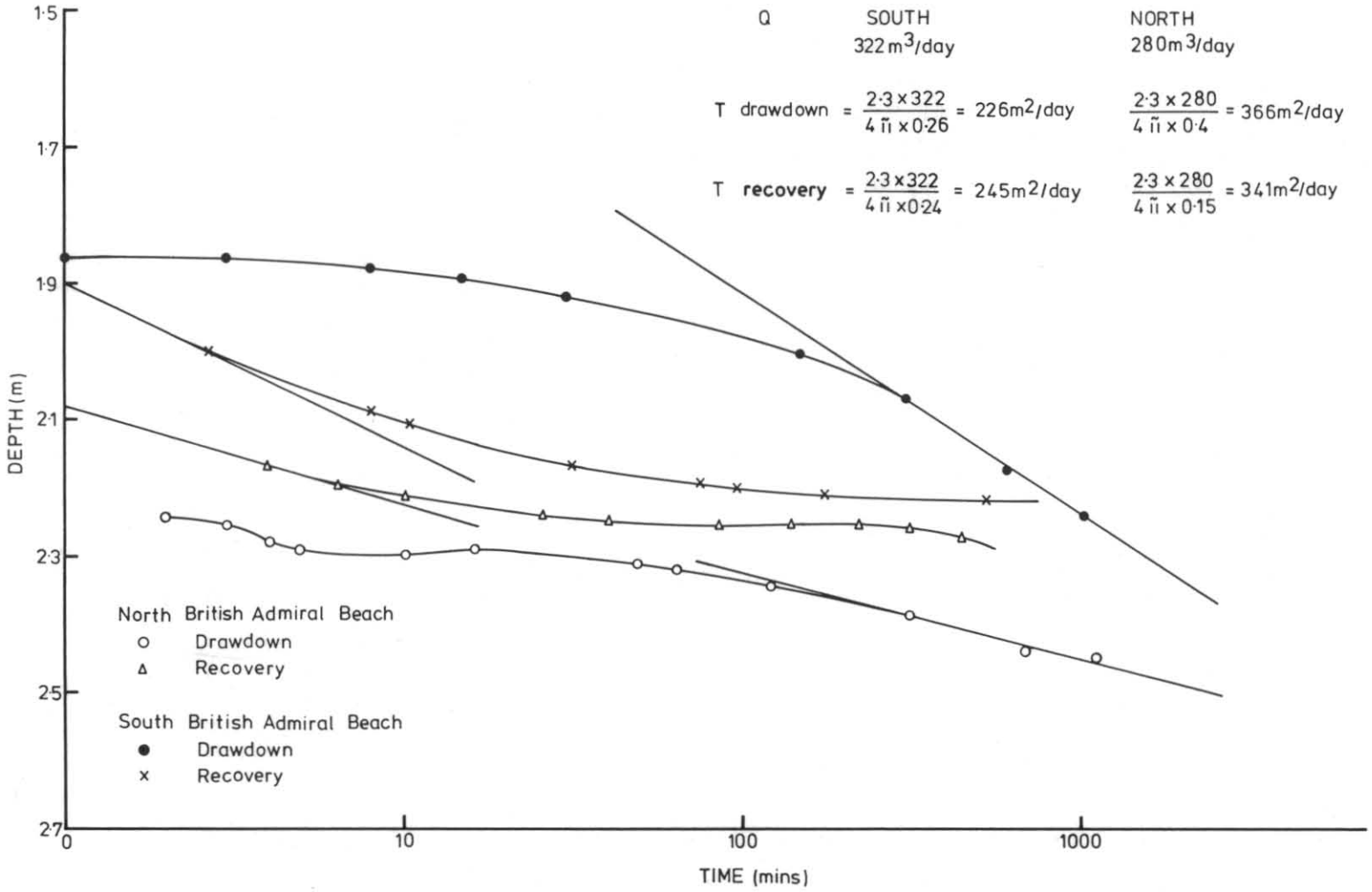

Figure 3. *Drawdown and recovery curves, British Admiral Beach.*

5 cm

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surrounding Holes 1, 2, 3 and 4 and this is probably the best location for intercepting the water flowing through the large area of dunes in this locality.

The water quality of the area is reasonably good (compared to the present supply at Currie). Only two chemical analyses have been made of water from the area, one of these being of a sample taken after pumping Hole 1 for about one hour and the other after pumping the array surrounding Hole 1. Salinity meter readings, which approximate the total salinity of the water, range from 270-425 mg/*l* for all except Hole 6, where 650 mg/*l* was recorded. The two chemical analyses show total dissolved solids of 530 mg/*l* (salinity meter reading 415 mg/*l*) for the water obtained in the short pump test on Hole 1 and for the array as a whole, the water quality was a little poorer with 580 mg/*l* TDS. Bicarbonate ions make up a significant proportion of the dissolved solids with chloride only making up about half the amount of bicarbonate ions. The high bicarbonate content is the reason for the relatively high hardness value which is mainly in a temporary form. Other factors in the analyses are within acceptable limits.

Northern area, British Admiral Beach [about 2 km south of Currie; BR320729]

Five spears were installed near Hole 11 in the approximate positions shown in Figure 4. The array of bores A-B-C-D-E was pumped at a rate of 195 *l*/min for 18.6 hours. Observations of drawdown were made in Hole 11 and recovery in the observation hole was measured for a little over 6 hours. A plot of the drawdown and recovery data is shown in Figure 3. It is probable that the water in this locality is slightly confined as a result of the near surface clayey layer which occurs in the area. There was a fairly rapid drawdown when pumping commenced (0.14 m in two minutes) after which the rate of fall decreased. Similarly after pumping stopped, there was a rapid recovery (0.18 m in 2½ minutes) and then the recovery rate slowed. Because of the low head, the majority of the water available is likely to be delivered under unconfined conditions. A projection of the drawdown curve to 100 000 minutes suggests that at that time the water level in the observation hole would be about three metres below the surface. The observation hole is 5.9 m deep and sand which would almost certainly supply water extends to about 8.7 m. Basement rocks occur below this level. The following table summarises the performance of each bore in the array.

Hole	*S.W.L.* (m)	*Total depth saturated sand* (m)	*Depth of water after 18.6 hours of pumping* (m)	*Possible drawdown used* (%)
A	2.36	3.53	2.5	29
B	2.01	3.88	1.93	50
C	2.03	3.91	2.0	49
D	1.73	4.14	1.78	57
E	2.01	3.81	1.73	55

These results show that there is a reasonable margin of safety when pumping at this rate and it is probable that the rate could be sustained in the long term. A smaller diameter suction base was used in Hole A and this accounts for the smaller drawdown when compared to that of the other holes. If a similar diameter hose was used, drawdown in the other holes would not have been as great. In addition to the safety margin in the existing installation, water bearing sand almost certainly extends to deeper levels under the bores in the array, as in Hole 11.

The sand in this area is finer than in the southern area, as is shown

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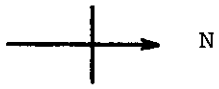
A ● SWL 2.36 m
Depth 5.89 m
TDS 420 mg/*l*

After 5 minutes 0.76 m water in hole (56.9 *l*/min)
After 18.6 hours 2.5 m water in hole

Hole 11 ○ SWL 2.11 m
Depth 5.59 m
TDS 380 mg/*l*

After 5 minutes at 45.5 *l*/min
0.8 m water in hole (45.5 *l*/min)



Scale: 10 mm = 2 m

E ●
SWL 2.01 m
Depth 5.82 m
TDS 350 mg/*l*

After 5 minutes 1 m water in hole
(54.6 *l*/min)
After 18.6 hours 1.73 m water
in hole

B ● SWL 2.01 m
Depth 5.89 m
TDS 440 mg/*l*

After 5 minutes 1.4 m water in hole (60.6 *l*/min)
After 18.6 hours 1.93 m water in hole

D ●
SWL 1.73 m
Depth 5.87 m
TDS 360 mg/*l*

After 5 minutes 0.6 m water in hole
(54.6 *l*/min)
After 18.6 hours 1.78 m water in hole

C ●
SWL 2.03 m
Depth 5.94 m
TDS 380 mg/*l*

After 5 minutes 1.7 m water in hole (68.2 *l*/min)
After 18.6 hours 2.0 m water in hole

Array pumped at 195 *l*/min for 18.6 hours

Figure 4. *Pump test array, north British Admiral Beach*

by the seive analyses. The effective size and average size of the particles are considerably lower. Part of the investigations of 1978 involved the installation of a set of spears 750 m east of this area, where the permeability was much lower. Old soil horizons were present with finer material making up the matrix of the sand.

This latest array shows prospects of being in a very favourable area for the development of a water scheme, where, despite a finer grain size in the aquifer, the average output per bore in the array during the longer pump test was about 40 *l*/min. There is a fairly extensive flat area extending towards the east in which larger arrays could be established. Only three prospecting holes were drilled in this area during the recent investigations. A number were drilled in 1978 further to the east and this indicated an average of about 5 m of saturated sand. Hole 12, drilled during the recent studies, struck basement at about 6 m and this indicates some variation in level on the rocks underlying the sand beds.

The recent array is well sited to intercept water flowing through the extensive sand areas that occur to the east. It appears to be one of the few areas in this region where the water table is close enough to the surface to develop a spear system without burying the spears so that there is enough working range for a suction pump to operate. Hand augering in September failed to locate any other areas nearby where the water table was closer than three metres from the surface.

Water quality is better than the present town supply in this area. Two chemical analyses have been performed, as in the area further south. Total dissolved solids after the short test on Hole 11 was 530 mg/*l* (400 mg/*l* with the salinity meter) and 520 mg/*l* at the end of pumping for the array as a whole. As in the southern area, bicarbonate is the main constituent with chloride making up about half the quantity of bicarbonate. Hardness is high, with most being temporary. Other constituents are only in moderate amounts and are not excessive for a town supply. The other two prospecting holes drilled (12, 13) had water which gave salinity meter values of 410 and 420 mg/*l* TDS respectively. This is an average figure for holes drilled in the area in the 1978 survey.

Golf course area [about 1 km south-west of Currie; BR303742]

The area tested is located on the south-west corner of the golf course and shows some prospect of augmenting the present supply. The area is low lying and swampy, out of which a seepage flows to the coast. It is proposed that a scheme, if installed, would intercept most of this water before it runs out on to the beach. The swamp is some 350 m from the centre of the present water supply area for Currie and about 170 m from the dam which supplies the golf course. It is expected that with long term pumping at a high rate, some effect may be noticed on the output of the present scheme, but total output would be increased overall. Some decrease in the water level in the dam on the golf course would occur before the town supply area was affected. The aim of installing a spear system in this area should be to intercept the water that bypasses the present scheme and the golf course dam.

Two prospecting were drilled in the swamp in December, one of which (Hole 27) had a slotted PVC pipe installed and a short pump test undertaken. The drilling indicated a coarse sand aquifer and pumping showed a high permeability. The depth to basement or clay was only about 3.5 m (2.5-3.8 m in the array) and although this is not a very large thickness of sand, the high permeability made the installation of a set of spears favourable.

● A SWL 0.46 m
Depth 2.92 m
TDS 670 mg/*l*

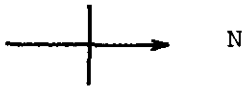
After 5 minutes 1.7 m water in hole

After 16.9 hours 1.8 m water in hole

D ● SWL 0.36 m
Depth 2.5 m
TDS 620 mg/*l*

After 5 minutes 0.8 m water in hole

After 16.9 hours 1.04 m water in hole



Scale: 10 mm = 2 m

SWL 0.84 m
Depth 3.43 m
TDS 630 mg/*l*

After 5 minutes 2 m water in hole

After 16.9 hours 1.8 m water in hole

C ●

B ● SWL 0.89 m
Depth 3.79 m
TDS 660 mg/*l*

After 5 minutes 2 m water in hole

After 16.9 hours 2 m water in hole

○
SWL 0.66 m
Depth 3.12 m
TDS 630 mg/*l*

After 5 minutes 1.8 m water in hole

After 16.9 hours 1.6 m water in hole

Array pumped at 267 *l*/min for 16.9 hours

Five minute pump rates: Holes A, B, C, D at 68 *l*/min., Observation Hole 68 *l*/min.

Figure 5. *Pump test array, golf course*

The layout of the four pumped holes in the array is shown in Figure 5. The original prospecting hole with the slotted pipe installed was used as an observation hole. The four new holes were pumped at about 267 *l*/min for nearly 17 hours. The water level in the observation hole fell 0.2 m to 0.99 m below the surface. If the drawdown curve (fig. 6) is projected to 100 000 minutes, a drawdown to 1.32 m below the surface is suggested. The performance of each bore is summarised below.

Hole	*S.W.L.* (m)	*Total depth saturated sand* (m)	*Depth of water after 16.9 hours of pumping* (m)	*Possible drawdown used* (%)
A	0.46	2.46	1.8	27
B	0.89	2.90	2.0	31
C	0.84	2.59	1.8	31
D	0.36	2.14	1.04	51

At this rate of pumping, only 25-33% of the available drawdown is being used in three bores over this period, the other bore having a larger proportion of the available drawdown used. It is expected that these bores could sustain this rate long term.

The quality of the water is not as good as the areas further to the south, but it compares reasonably well with the present water supply. Two analyses have been undertaken, one from the investigation hole and one from the end of the test on the array. There is some variation in the two, but they are not significantly different. Bicarbonate, chloride and sodium are the predominant ions with proportionately more chloride than in the southern area. Temporary hardness is high with permanent hardness low.

Wharf Road area [BR303751]

A strong seepage or series of seepages occurs in the small bay just south of the jetty at Currie and it was thought that if conditions were favourable, much of this water could be intercepted before being lost to the ocean. A prospecting hole (Hole 28) was drilled on the edge of the small park and some slotted PVC pipe was installed. This hole indicated that there was about 5.5 m of fairly coarse sand present, of which about 3.75 m is saturated with water. Subsequently in January an array of spears, as shown in the Figure 7, was installed.

The array was pumped at a rate of 222 *l*/min for about 14.6 hours and water level measurements taken in two observation holes. The performance of each spear is summarised below.

Hole	*S.W.L.* (m)	*Total depth saturated sand* (m)	*Depth of water after 14.6 hours of pumping* (m)	*Possible drawdown used* (%)
A	2.24	2.56	1.4	45
B	1.75	3.43	2.0	42
C	1.75	3.0	1.7	43
D	1.93	2.62	1.3	50
E	2.31	2.24	1.04	55

After this period of pumping, there was an average of about half the possible drawdown still available. It seems likely that the system, as installed, would be able to maintain this flow rate. There is some potential to produce more water because the spears have not all been installed

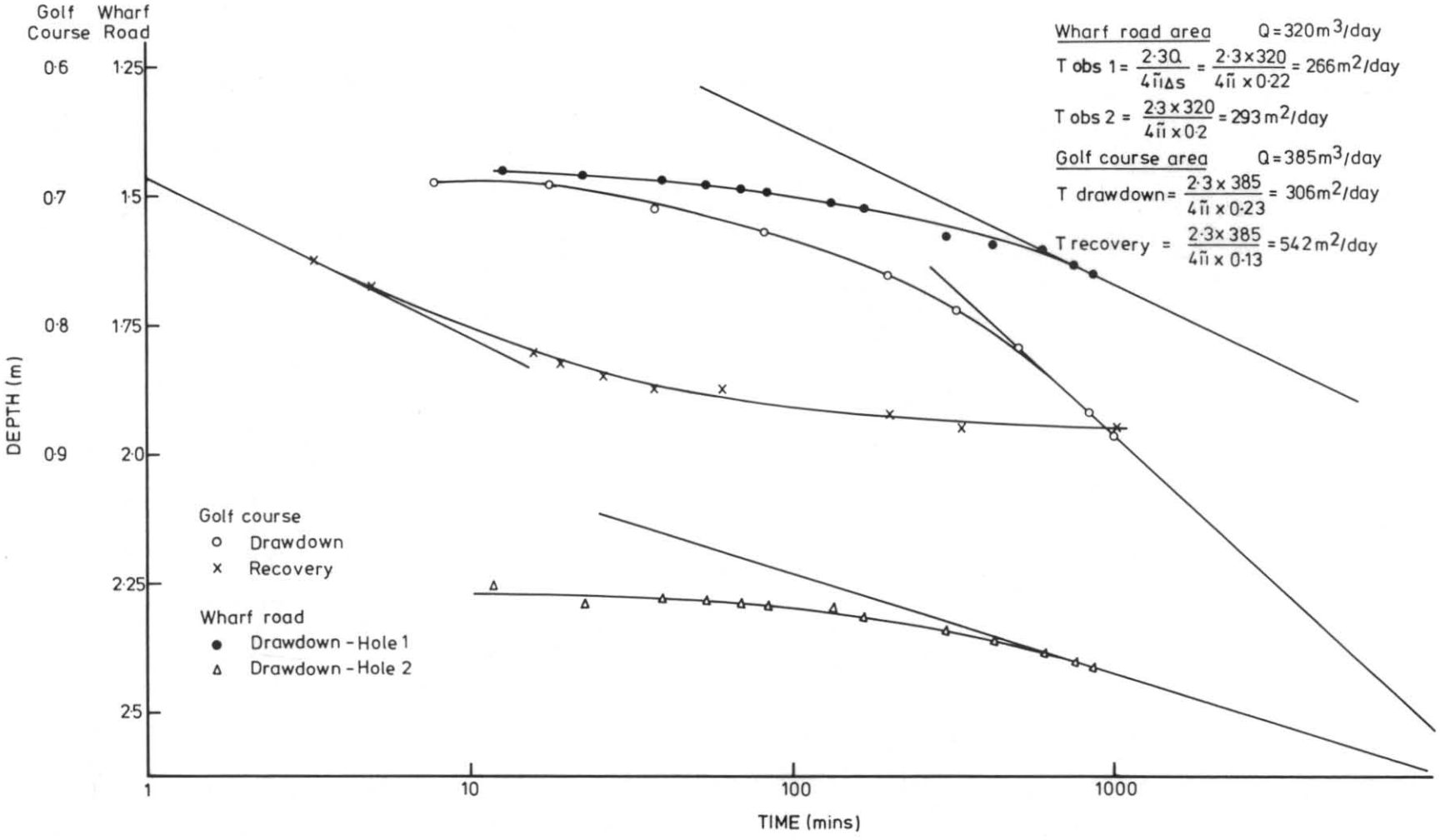


Figure 6. *Drawdown and recovery curves, Wharf road and golf course.*

12/4

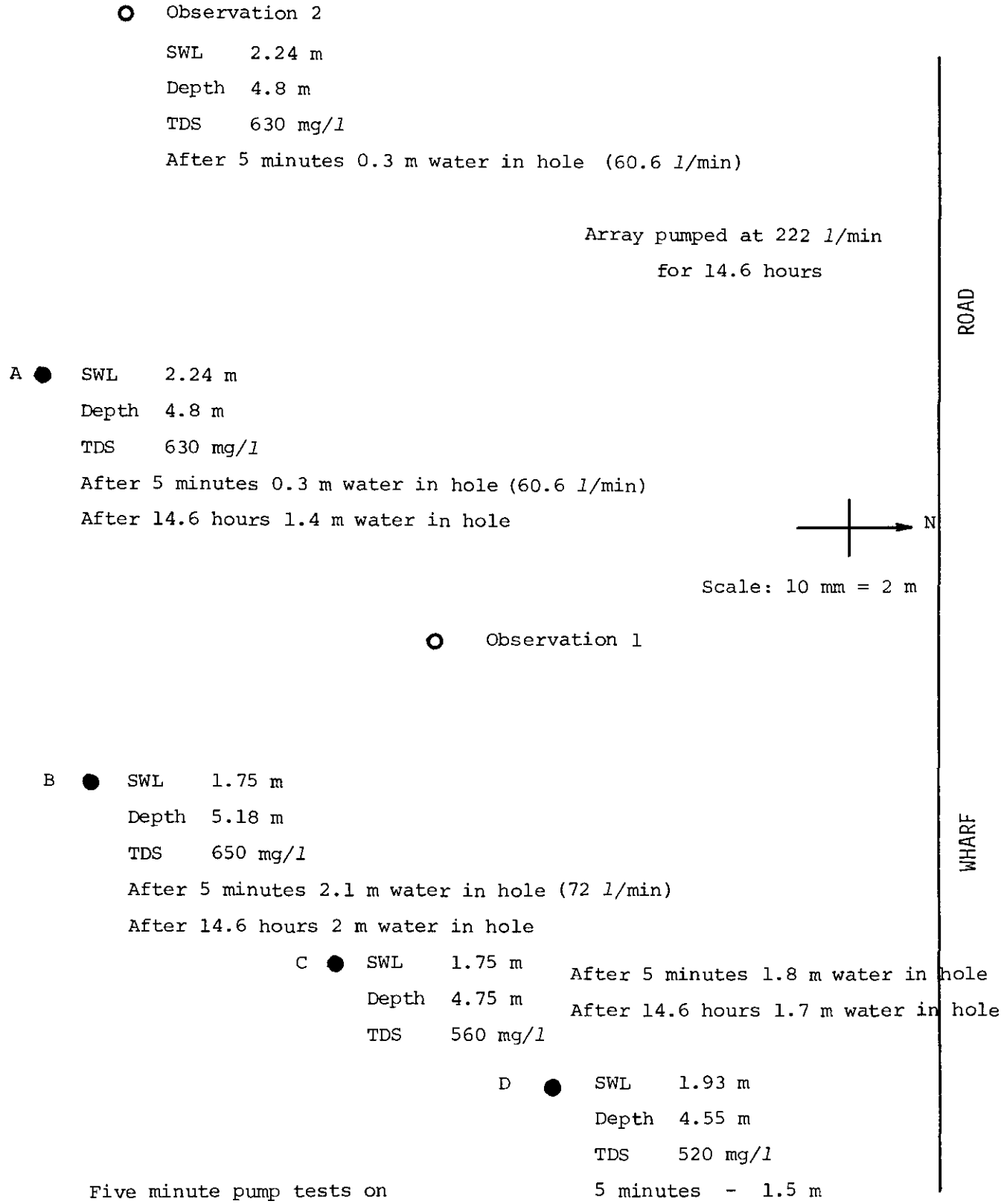


Figure 7. *Pump test array, Wharf Road*

to the base of the sand beds; there might be up to one metre of sand below the base of some spears. A greater quantity could also be withdrawn if more spears were installed.

Plots of the drawdown in the two observation holes are shown in Figure 6. If the plot for Hole 1 is projected to 100 000 minutes, a drawdown to 2.35 m below the surface is suggested, while a projection of the plot for Hole 2 is to 2.8 m. This latter level leaves 1.6 m (total 2.11 m) of saturated sand in the second observation hole. The first hole only had a limited depth of saturated sand before clay sediments were struck.

Only one other exploratory hole (Hole 29) was drilled in the area and this was sited just over Wharf Road from the small park. This hole encountered clay and weathered rock at a shallow depth, indicating a small rise in basement rocks. This basement rise is largely the cause of the concentration of the series of springs on the shoreline in this area. The landsurface rises fairly steeply all around this area and other exploratory holes were not warranted because of the limitations in drilling depth and also in developing a spear system where the water table is deep.

There has been some variation in the water quality in this area. When the single spear was installed in December, total dissolved solids from the chemical analysis was 635 mg/*l* (salinity meter reading 410 mg/*l*). When the array of spears was installed, Bore B was pumped for about one hour before the longer pump test on the array and TDS was 650 mg/*l* with a salinity meter. Holes C, D and E had a slightly lower salt content, while Hole A was about the same as B. The sample collected after the pump test lasting 14.6 hours had a TDS of 940 mg/*l* when chemically analysed (salinity meter reading 600 mg/*l*). This is a value well above the present water supply, whereas the sample analysed in December from the single spear had only a slightly higher TDS than the present supply.

TRANSMISSIVITY

Values of transmissivity, a function of permeability, have been calculated from the plots of drawdown data (figs. 3, 6). The conditions of the tests do not comply with those required for accurate determinations, but the figures may provide a guide to the value of transmissivity, and to some extent the permeability, if the thickness of the aquifer is known. Transmissivity is the product of the permeability and thickness.

For the pumping stage, drawdown is plotted against time on semi-log graph paper, while for the recovery stage a slightly modified form of time is plotted (*i.e.* the ratio of the time since pumping commenced and the time since pumping is stopped, is plotted against drawdown). From the modified non-equilibrium equation, a value of transmissivity can be obtained.

$$T = \frac{2.3\,Q}{4\pi\Delta s}$$ where T is the transmissivity in m^2/day
Q is the output in m^3/day
Δs is the drawdown per log cycle (metres)

The value for the south British Admiral Beach area may approximate the true value, as the observation hole is nearly central within the array and an approximately equal amount of measured drawdown would be contributed by each pumped bore. At the north British Admiral Beach area and the golf course, the observation bore is outside the array and each pumped bore will contribute an unequal amount to the drawdown in the observation bore, with the nearest having the most influence. At Wharf Road, Observation Hole 1 is fairly central to the pumped bores, but Hole 2

is on the end of the array.

INVESTIGATIONS IN OTHER AREAS

Investigations have been undertaken in some other areas. These include;

(1) Area south of present water scheme

(2) Nash's property - spring area

(3) Near works depot

(4) North of Dolman's property (the previous main area of investigation north of the town was on Dolman's property).

Area south of present water scheme [about 1.5 km south of Currie; about BR314734]

Four auger holes, Holes 14, 15, 16 and 17 were drilled in this area as a result of the location of a shallow water table in September at the sites of Holes 14 and 15. Unfortunately basement was encountered at shallow depth in Holes 14, 15 and 16 and in Hole 17 the water table was deep due to its slightly elevated position. There was about four metres of saturated sand in Hole 17.

A slotted PVC spear was installed in Hole 15 to 4.6 m and the hole was pumped for about 1.5 hours at 27 *l*/min. Although this could generally be regarded as a moderate amount of water and with a set of spears, larger in number than in other areas, a considerable output could be expected, it is not as good a prospect as the other locations.

Quality is favourable, being slightly better than the present town supply. Salinity meter readings for total dissolved solids range from 440-670 mg/*l*. Hole 15 was tested with a salinity meter when first drilled at 600 mg/*l* and after the pump test at 445 mg/*l*, while the chemical analysis after the pump test indicated a TDS of 570 mg/*l*. The salinity of Hole 16 (670 mg/*l*) may also decrease with pumping. The higher salinity water is perhaps associated with the weathered basement clay.

Nash's property [4 km north of Currie; BR306790]

A strong spring flows into the sea in a small bay just south of the mouth of Three Rivers Creek, about 4 km north of Currie. Although no measurements were made, the flow could be as high as 750-1000 m^3/day. Flow measurements would be required to ascertain the true flow value.

Two drill holes, Holes 24 and 25, were drilled inland from the spring to determine whether it was possible to intercept the water before being lost to the ocean. Hole 24 encountered only a fairly thin layer of saturated sand and is not regarded as particularly prospective, while in Hole 25 the water table is deep and the depth of saturated sand is fairly thin. The surrounding land is elevated making the installation of a spear system in these higher areas difficult.

Water quality appears to be comparative with the present scheme. T.D.S. (measured with a salinity meter) of the spring was 550 mg/*l*, while a chemical analysis shows a T.D.S. of 680 mg/*l* with bicarbonate being predominant over chloride. The water from Three Rivers Creek is much more

saline, with a T.D.S. of 1250 mg/*l* measured with a salinity meter. The creek has cut through the sand and has exposed granite in some places.

It is apparent that it will be difficult to collect the water flowing out of this area using spears. The valley from which it flows is narrow and it may be possible to construct some kind of collection chamber, cutoff, or weir system to make use of the water in this area.

Works depot, Currie [*BR313764*]

There were suggestions from local residents that this area could be favourable for water extraction. The area is underlain by the old dune system of mainly quartz sand, and is relatively flat compared to the new dunes further west. Holes 30 and 31 were sited in this area. Hole 30 encountered only a thin layer of sand before entering clay and possibly weathered slate. Hole 31 passed through about 7.5 m of fine quartz-rich sand, but appeared to have a small clay content which reduced the permeability. When a slotted PVC spear was installed, the pumping rate was very low.

The quality of the water is poorer than in other areas. Hole 30 had water with 800 mg/*l* T.D.S., while water from Hole 31 had a T.D.S. content of 900 mg/*l* (salinity meter reading). A chemical analysis of water from Hole 31 shows 1060 mg/*l* of dissolved salts present. This is the only chemical analysis which contains more chloride than bicarbonate and reverses the situation by being about double. In addition, permanent hardness is quite high.

Two further holes were drilled in the old dune system east of the newer dunes (Holes 34 and 35). Both had only thin layers of fairly clean sand from which water could be extracted and in general, prospects for large scale water extraction from these deposits appear to be poor. Water quality is variable, with Hole 34 having a low T.D.S. content (290 mg/*l*) and Hole 35 a higher content (700 mg/*l*). Both of these values are salinity meter readings.

North of Dolman's property [*about 3 km north of Currie; BR300780*]

Six test holes were drilled north of Dolman's property, the property on which investigations were undertaken in 1978. Holes 18-23 were drilled in what appeared to be topographically suitable sites. Hole 19 was the only bore which appeared to have good prospects of delivering water in quantity, the others containing only thin layers of clean sand or fine and slightly clayey sand. A slotted PVC spear was installed to a depth of about six metres in Hole 19 and was pumped for about one hour at about 30 *l*/min. At this rate, the hole did not compare very favourably with some of the other pumped holes, although a series of holes in this area could produce a considerable quantity of water.

The quality compares favourably with the present town supply. T.D.S. in the test holes ranged from 420-640 mg/*l* (salinity meter readings). Water from Hole 19 was collected for chemical analysis after the pump test and had a T.D.S. content of 540 mg/*l*, a little lower than the present town supply.

DISCUSSION OF INVESTIGATION RESULTS

From the short pump tests on the four small spear bore arrays, each area has good prospects of supplementing the present water supply. The two southern areas have by far the greatest potential because of the larger area of sand. Development of each area would aim at intercepting water

before it discharges into the ocean. In the case of the golf course and Wharf Road areas, the spears are installed close to the shoreline and the water it is aimed to pick up can be seen issuing from strong seepages. The other areas are further from the shoreline, but seepage can be seen at many places along British Admiral Beach.

Longer pump tests, lasting 10-15 days, would need to be undertaken on these spears to be more definite as to whether they are capable of sustaining large pump rates. There is little doubt that the two areas behind British Admiral Beach would be capable of producing large quantities of water because of the large area of sand inland from them.

Estimates of water available were made in a previous report for the southern area (Matthews, 1978) and these calculations cannot be modified to any great extent from the latest survey. However a reassessment of the amount of water stored in the southern area is possible. From the recent drilling, it is apparent that the depth of saturated sand is a little thicker than that previously assumed (five metres) and may be 7-8 m. In developing a water scheme, it should be planned that only minor amounts of the stored water in dry seasons are taken and the maximum output from the field should be about equal to the long term replacement rate by rain.

One factor that has not been considered in previous estimates of water available is that some of the rain falling east of the dunes from which the water is extracted may eventually add to the supply in the sand. Although some surface streams, such as Badger Box Creek, Camp Creek and Three Rivers Creek carry runoff from further inland to the ocean, some at least is impounded behind the dunes. There are numerous large lagoons on the inland margin of the dunes (Matthews, 1966) and although the situation that was thought to have resulted in their formation would probably not allow water to flow into the dunes, where the lagoons are not present there may be some recharge to the dunes from this source.

If it is proposed to develop any of these areas, as a water source, as well as carrying out a much longer pump test, the holes should be levelled with respect to sea level. This is of particular importance in the areas closest to the sea (*i.e.* Wharf Road and the golf course areas). The base of the spears in all areas are probably near to sea level. If they extended to levels much deeper than sea level, pumping at high rates would make the intrusion of sea water inland a distinct possibility.

Other areas (*e.g.* just south of the present water supply area and north of Dolman's property) may supply some additional water, but the quantity is unlikely to be as great as from the four areas investigated in some detail. The large spring just south of Three Rivers Creek has the potential to supply large quantities of water but the flow would need to be measured accurately and some method of production other than spear bores would probably need to be considered. There may be other areas around Currie capable of supplying water using the present means of extraction, but it is not expected that they will supply water at a greater rate than the areas already tested. One possible exception is the area between the tip and the north margin of Currie Harbour, but it would be difficult to show that the water here is not adversely affected by material from the tip.

The quality of the water compares very favourably with the present water supply to Currie, except in the case of the Wharf Road area. Bicarbonate and temporary hardness are high in all areas, as with the present scheme. The quality of the water from the Wharf Road area compares with the water from Dolman's property, although chloride content and permanent hardness are lower at Wharf Road. Water quality may improve with time, as

has been apparent with the present water supply (T.D.S. change from 1952 to 1978 is 761 mg/*l* to 580 mg/*l*). If the same percentage of improvement took place in some of the areas investigated, particularly the two southern ones, the quality could eventually be very acceptable, except perhaps for temporary hardness.

CONCLUSIONS

Recent investigations have located four areas that could supply large quantities of additional water to Currie. Long term pump tests (10-15 days) would be required to determine with more certainty the amount of water that is available.

These four areas, together with the area on Dolman's property north of Currie investigated in 1978 and the strong seepage just south of Three Rivers Creek, provide a number of alternatives that can be considered to increase the water supply to Currie. The golf course and Wharf Road areas are only likely to supply as additional water about 1/3 of that of the present scheme. Dolman's (in peak demand) and the spring near Three Rivers Creek (subject to flow measurement) may produce about the same quantity as the present scheme. Both of the southern areas probably have a capacity to produce more than the present scheme. If it is decided to develop any of these areas, the long pump tests should be designed to pump as near as possible to the proposed withdrawal rate, as the investment in pipeline for the more distant locations will be fairly high.

Water quality is better or similar to the present supply in four of the areas and a little poorer at Wharf Road and Dolman's. Temporary hardness is the biggest deficiency. No bacterial tests have been undertaken and although contamination from this source is not regarded as likely, water samples should be tested before a decision is made to proceed with a scheme.

No other method has been considered to extract the water from the sand (*e.g.* deeper bores) as the method being used at present is probably the most effective and cheapest.

Water from basement rocks may be possible but exploration would be expensive and the few holes to date in the Currie area were not successful.

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[8 May 1980]

APPENDIX 1

Proline drilling, King Island; December 1979

Hole 1

Depth (m)	*Description*
0-0.9	Brown stained (organic) medium grained shell and quartz sand
0.9-3.7	Coarse yellow sand, mainly shell fragments
3.7-6.4	Coarse sand, mainly shell fragments, some staining, dark grey colour
6.4-9.1	Light grey finer shell fragment/quartz sand

6.0 m slotted 40 mm diameter PVC pipe installed to 5.9 m. After three hours pumping, flow rate 53 *l*/min. Water level was 2.2 m on outside of pipe. Salinity 415 mg/*l*.

Hole 2

0-0.5	Fine brown stained sand
0.5-0.9	Fine light yellow-grey sand
0.9-4.6	Coarse yellow shell fragment/quartz sand
4.6-7.6?	Dark grey quartz/shell fragment sand. Sand stained by soil horizon
7.6?-9.1	Light yellow-grey coarse shell fragment/quartz sand, grit size - occasionally up to 6 mm across but mainly 1-2 mm.

Water level was 1.3 m below surface, T.D.S. 425 mg/*l*.

Hole 3

0-0.3	Dark brown sand stained with humic matter
0.3-6.1	Medium grained yellow quartz/shell fragment sand
6.1-7.3	Brown quartz/shell fragment sand - soil horizon in this section
7.3-7.6	Light grey coarse grit, shell fragments and quartz. Some complete shells up to 15 mm across, rounded quartz fragments up to 30 mm across. Some mica.

Unable to drill further. Water level was at 0.8 m, T.D.S. 270 mg/*l*.

Hole 4

0-0.3	Dark brown shell fragment sand
0.3-0.9	Fine yellow-grey shell fragment sand
0.9-5.8	Yellow medium grained shell fragment/quartz sand
5.8-7.0	Brown shell fragment/quartz sand - soil horizon at 6.1 m? Became harder to drill
7.0-7.6?	Fine quartz (some shell fragments) sand
7.6?-7.9	Green gritty sand with mica, some clay. At 7.9 m became too hard to drill - granite?

Water level 1.3 m, T.D.S. 340 mg/*l*.

Appendix 1 (continued)

Hole 5

Depth (m)	*Description*
0-0.3	Dark carbonaceous sandy soil
0.3-0.9	Light yellow-cream sand
0.9-5.5?	Coarse cream sand, mainly shell fragments
5.5?-8.3?	Grey-brown shell fragment/quartz sand
8.3?-8.5	Quartz sand with fine dark brown matrix - soil horizon?
8.5-9.1	Light yellow shell fragment/quartz sand, some large shell fragments
9.1-9.5	Mid-grey fine sand, shell fragment/quartz, some grit fragments
	Became harder at 9.5 m

Water level at 2.2 m, T.D.S. 370 mg/*l*.

Hole 6

0-0.3	Dark carbonaceous soil
0.3-0.9	Light grey-yellow shell fragment/quartz sand
0.9-1.8	Coarse yellow shell fragment/quartz sand
1.8-3.7	Coarse grey shell fragment/quartz sand, quartz fragments very rounded
3.7-7.3?	Coarse yellow to grey shell fragment/quartz sand
7.3?-8.8	Green clayey grit with mica, angular quartz - weathered granite

Water level at 1.3m, T.D.S. 650 mg/*l*.

Hole 7

0-0.3	Dark carbonaceous sandy soil
0.3-0.9	Cream coloured shell fragment/quartz sand
0.9-1.8	Light fawn shell fragment/quartz sand
1.8-4.0?	Finer quartz rich sand, may contain a little clay
4.0?-9.1	Medium to coarse grained fawn shell fragment/quartz sand, becoming light grey then bright yellow at end

Water level at one metre, T.D.S. 395 mg/*l*.

Hole 8

0-0.3	Dark carbonaceous sandy soil
0.3-1.8	Cream shell fragment sand
1.8-3.7	Mid-brown shell fragment/quartz sand. At 2.7-3.1 m hard cemented zone - carbonate
3.7-8.5	Yellow mainly shell fragment sand
8.5-8.8	Green clayey grit, some mica towards end. Weathered granite?

Water level 2.3 m, T.D.S. 390 mg/*l*.

Water hole south of Hole 8 - T.D.S. 390 mg/*l*.

Appendix 1 (continued)

Hole 9

Depth (m)	*Description*
0-0.3	Dark sandy soil - humic stained
0.3-0.9	Fawn shell fragment sand, fine
0.9-5.5?	Coarse shell fragment/quartz sand
5.5?-8.8?	Quartz sand, some shell fragments, thin soil horizon?
8.8?-9.1?	Light fawn shell fragment sand

Water level at 1.3 m, T.D.S. 370 mg/*l*.

Hole 10

0-0.3	Dark brown humic stained soil
0.3-1.5	Chocolate coloured humic stained sand
1.5-3.4	Coarse yellow shell fragment/quartz sand
3.4-3.7	Dark brown quartz sand
3.7-9.1	Fine quartz sand, mainly clear quartz, begins as grey, then light grey-brown, then at end light brown. Thin zone of clayey sand.

Hole fell in at 3.5 m - approximate position of water table?

Hole 11

0-1.8	Brown organic stained sand
1.8-2.7	Darker brown organic stained shell fragment sand with layer of black carbonaceous clay
2.7-5.5	Light grey-brown fine quartz and shell fragment sand
5.5-8.7	Light cream to grey shell fragment/quartz sand, fine grained
8.7-8.8	Green gritty fragmented weathered granite? with angular quartz and mica

At beginning water level 2.3 m, T.D.S. 560 mg/*l*.

5.5 m slotted 40 mm PVC pipe installed, pumped for 1.5 hours at 44 *l*/min. At end T.D.S. 400 mg/*l*. After 10 minutes drawdown to 3.4 m on outside of PVC pipe. Drawdown a further 0.05 m at end.

Hole 12

0-0.9	Cream coloured quartz/shell fragment sand
0.9-1.8	Humic stained quartz/shell fragment sand
1.8-2.7	Brown quartz/shell fragment sand
2.7-4.6	Brown-grey quartz/shell fragment sand
4.6-5.9	Light grey quartz/shell fragment sand
5.9-6.1	Light brown gritty clay, became too hard to drill - basement?

Water level at 2.4 m, T.D.S. 410 mg/*l*.

Appendix 1 (continued)

Hole 13

Depth (m)	*Description*
0-0.6	Dark humic stained soil
0.6-0.9	Light cream shell fragment/quartz sand
0.9-1.8	Brown shell fragment/quartz sand
1.8-3.7	Light brown shell fragment/quartz sand, some dark humic stained layers
3.7-5.5?	Dark brown quartz/shell fragment sand, becomes lighter with depth
5.5?-9.1	Light brown-cream to cream shell fragment/quartz sand

Water level at 2.1 m, T.D.S. 420 mg/*l*.

Hole 14

0-0.6	Dark humic stained sand
0.6-0.9	Cream shell fragment sand
0.9-4.3?	Yellow coarse sand, dominantly shell fragments
4.3?-5.5	Brown shell fragment sand, some quartz, some clay - dark and carbonaceous. Drilling became hard - granite?

Water level 2.7 m, T.D.S. 490 mg/*l*.

Hole 15

0-0.3	Dark humic stained soil
0.3-4.1	Coarse sand, mainly shell fragments, some quartz
4.1-4.3	Dark brown clayey sand
4.3-	Green gritty clay - weathered granite

Water level at 1.2 m, T.D.S. 600 mg/*l*.

4.6 m slotted 40 mm diameter PVC pipe installed. Pumped for 1.5 hours at 27 *l*/min sucking some air. T.D.S. 445 mg/*l*.

Hole 16

0-0.9	Fine brown (humic stained) shell fragment sand
0.9-1.8	Mainly cream shell fragment/quartz sand
1.8-2.4	Brown shell fragment sand
2.4-5.8	Coarse sand, mainly shell fragments
5.8-6.0	Green gritty plastic clay, micaceous
6.0-	Became too hard to drill, granite

Water level at 2.5 m, T.D.S. 670 mg/*l*.

Hole 17

0-0.3	Dark humic stained sand
0.3-0.9	Cream fine shell fragment sand
0.9-8.2	Coarse cream mainly shell fragment sand, some quartz
8.2-9.1	Dark clayey sand

At 9.1 m gritty clay, then too hard to drill - granite?

Water level at 4.5 m, T.D.S. 440 mg/*l*.

Appendix 1 (continued)

Hole 18

Depth (m)	*Description*
0-0.6	Dark brown humic stained soil
0.6-4.6?	Coarse shell fragment/quartz sand
4.6?-6.7	Gritty clay
6.7-6.9	Green micaceous gritty clay, too hard to drill. Granite?

Water level at 2.6 m, T.D.S. 600 mg/*l*.

Hole 19

0-0.6	Dark brown fine sandy soil, stained with humic matter
0.6-5.5	Fairly coarse yellow shell fragment/quartz sand
5.5-6.1	Sand becoming grey-yellow in colour
6.1-6.4	Green gritty clay

Water level at 2.8 m, T.D.S. 440 mg/*l*.
Slotted pipe was installed and the bore pumped for about 1 hour at a rate of about 30 *l*/min.

Hole 20

0-0.3	Dark brown sandy soil
0.3-2.7	Grey and fawn shell fragment/quartz sand
2.7-3.5	Gritty clay - weathered granite?
3.5-3.7	Green micaceous clay grit
3.7-	Became too hard to drill

Water level at 0.8 m, T.D.S. 420 mg/*l*.

Hole 21

0-0.6	Dark brown sandy soil
0.6-2.7	Grey and yellow sand, mainly shell fragments
2.7-6.1	Fine sand mainly quartz, some shell fragments light grey-brown. May contain some clay
6.1-7.9	Green micaceous grit - weathered granite?
7.9	Became too hard to drill

Water level at 0.9 m, T.D.S. 640 mg/*l*.

Hole 22

0-0.6	Dark brown sandy soil, stained with humic material
0.6-1.8	Light brown-grey shell fragment/quartz sand
1.8-5.2?	Mainly fine quartz sand, probable clayey sand layer at about 3.7 m.
5.2?-6.9	Micaceous green gritty clay - weathered granite?
6.9	Became too hard to drill

Water level at 0.8 m, T.D.S. 490 mg/*l*.

Appendix 1 (continued)

Hole 23

Depth (m)	*Description*
0-0.3	Dark brown sandy soil, humic stained
0.3-1.5	Shell fragment sand
1.5-1.8	Zones of calcite cemented sand
1.8-2.7	A little sand with clayey water
2.7-5.5	Blue plastic clay, some grit and fine gravel fragments, some rounded
5.5-7.0	Weathered micaceous gritty clay becoming harder with depth

Water level at 0.7 m, T.D.S. 460 mg/*l*.

Hole 24

0-0.2	Dark brown sandy soil, humic stained
0.2-0.9	Yellow-grey sand, mainly shell fragments with some coarse quartz grains up to 2 mm across
0.9-1.8	Dark brown stained sand with fine matrix (organic matter causing stain?)
1.8-4.6?	Yellow to grey-yellow coarse shell fragment/quartz sand
4.6?-6.4	Dark grey-green plastic clay
6.4-8.2	Weathered granite? Green gritty micaceous clay becoming harder

Water level at 1.7 m, T.D.S. 600 mg/*l*.

Hole 25

0-0.3	Dark sandy soil, humic stained
0.3-0.9	Yellow shell fragment/quartz sand
0.9-6.1?	Yellow coarse shell fragment/quartz sand
6.1?-7.6	Sand, becoming grey in colour
7.6-8.8	Gritty clay - weathered granite? Became too hard to drill

Hole fell in at 4.4 m and this may be the water table

Hole 26

0-0.3	Dark sandy soil, humic stained
0.3-3.4	Cream to yellow coarse shelly sand
3.4-6.4	Clay and weathered granite

Water level at 0.2 m, T.D.S. 600 mg/*l*.

Hole 27

0-0.2	Dark brown sandy soil
0.2-0.9	Coarse cream sand
0.9-3.6	Coarse cream to yellow sand, mainly shell fragments
3.6-3.7	Sand with fine matrix; probable old soil horizon
3.7-5.5	Clay, becoming gritty with depth. Probable weathered granite.

Water level at 0.6 m, T.D.S. 550 mg/*l*.

Appendix 1 (continued)

Hole 27 (continued)

4.3 m slotted pipe was installed and the hole pumped for 85 minutes at a rate of about 55 *l*/min.

Hole 28

Depth (m)	*Description*
0-1.2	Brown sand, humic stained
1.2-5.5	Coarse shell fragment/quartz sand, yellow to yellow-grey

Water level at 0.6 m, T.D.S. 410 mg/*l*.
4.6 m slotted casing installed, pumped for one hour at a rate of about 68 *l*/min.

Hole 29

0-0.9	Fine yellow shell fragment/quartz sand
0.9-1.8	Dark soil, humic stained, followed by grey-brown shell fragment sand
1.8-3.1	Some sand as above, followed by clay with some rounded pebbles
3.1-3.2	Weathered granite?

Water level at 1.6 m, T.D.S. 470 mg/*l*.

Hole 30

0-0.9	Red sand
0.9-1.8	Brown sand
1.8-3.7	Blue plastic clay
3.7-4.4	Weathered slate?, became too hard to drill

Water level 1.1 m, T.D.S. 800 mg/*l*

Hole 31

0-0.6	Red sand
0.6-1.8	Light brown shell fragment/quartz sand
1.8-7.6	Brown fine grained, dominantly quartz sand. May be some clay content at some levels
7.6-8.2	Clayey sand, some mica At 8.2 m became too hard to drill

Water level at 1.7 m, T.D.S. 900 mg/*l*.
Slotted PVC pipe was installed to about five metres and the hole was pumped for a short period. Only 1-2 *l*/min could be pumped.

Hole 32

0-0.3	Dark brown soil, humic stained
0.3-0.9	Fine brown sand, mainly shell fragments
0.9-3.7	Brown clayey sand
3.7-4.0	Hard calcified layer in sand, could not penetrate

Water level at 2.6 m, T.D.S. 330 mg/*l*.

Appendix 1 (continued)

Hole 33

Depth (m)	*Description*
0-0.9	Yellow sand, dominantly quartz fragments
0.9-2.7	Orange-red quartz/shell fragment sand, some hard bands at 2.4 m
2.7-4.6?	Yellow medium grained shell fragment/quartz sand
4.6?-7.9?	Grey-yellow dominantly quartz sand, some quartz fragments 1-2 mm in diameter
7.9?-9.1	Dark grey clayey quartz sand

Water level at 3.8 m, T.D.S. 360 mg/*l*.

Hole 34

0-0.9	Coarse grey quartz sand
0.9-3.1	Brown clayey sand
3.1-4.6	Light brown quartz sand
4.6-6.1	Weathered granite?, gritty green micaceous clay At 6.1 m it became too hard to drill

Water level at 3.5 m, T.D.S. 290 mg/*l*.

Hole 35

0-0.9	Light grey medium grained sand
0.9-1.8	Clayey mid grey-brown quartz sand
1.8-3.7	Grey clayey sand, a thin layer of blue plastic clay
3.7-6.4	Green gritty, micaceous clay, becoming harder with depth. Weathered granite?

Water level 1.4 m, T.D.S. 700 mg/*l*.

APPENDIX 2

Description of sand composition

The samples sieved have been examined under magnification to examine the composition of the sand in a little more detail than the field examinations, which were made only to prepare the logs.

Hole 1 (3.1-5.5m)

Small magnetic fraction of small angular magnetite. Shell fragments: quartz occurs in the ratio of about 60:40. Shell fragments often larger and rounded, quartz in general is smaller and angular.

Hole 4 (3.1-4.6m)

Very minor magnetic fraction of small angular magnetite. 50:50 shell fragments:quartz. Quartz fragments usually smaller and angular, a few are larger and rounded, than shell fragments.

Hole 6 (3.7-5.5m)

Very minor magnetic fraction of fine magnetite. 60:40 rounded shell fragments:angular fine quartz. Occasional sponge spicules.

Hole 7 (2.8m)

Small magnetic fraction of fine magnetite. Dark brown colour, fine angular clear quartz and occasional broken shell fragments.

Hole 7 (6.1-9.1m)

Small amount of fine angular magnetite. 60:40 clear angular quartz: broken shell fragments. Some quartz grains are large and rounded.

Hole 9 (2.8-5.5m)

Minor amount of fine angular magnetite. 50:50 shell fragments:quartz grains. Quartz is usually fine, clear and angular, some grains are longer and show some rounding.

Hole 9 (6.4-8.2m)

Moderate amount (<0.1%) magnetic fraction of fine magnetite. Almost entirely clear angular quartz, one complete shell and occasional shell fragments.

Hole 9 (8.8-9.1m)

Moderately large magnetic fraction (<0.5%), fine angular magnetite. 50:50 clear angular quartz:shell fragments.

Hole 10 (7.6-9.1m)

Small magnetic fraction of magnetite, some is red? Fine grained brown stained quartz, angular and clear. Occasional carbonate fragments.

Appendix 2 (continued)

Hole 11 (5.5m)

Small fraction of angular magnetite. 60:40 shell fragment:fine clear angular quartz. Shells often broken but some are complete. Forams, echinoderm spines, sponge spicules, bryozoans and ostracods identified. Some sponge spicules appear unbroken, some triaxons?

Hole 13 (6.4-9.1m)

Small magnetite fraction, fine angular. 75:25 shell fragments:angular clear quartz. Similar fossil material to that identified in Hole 11.

Hole 15 (3.1m)

Moderate magnetic fraction of fine angular magnetite. 60:40 shell fragments:clear angular quartz, shell fragments usually much larger than quartz fragments.

Hole 17 (6.1m)

Very small magnetic fraction of angular magnetite. 60:40 shell fragments:angular quartz fragments.

Hole 19

Small magnetic fraction, brown, black and reddish fragments - oxidised magnetite? 70:30 large rounded shell fragments:angular clear quartz. Forams recognised in sample.

Hole 22 (2.7-4.8 m)

Very minor magnetic fraction of magnetite. 98:2 quartz:shell fragments. Quartz is usually clear and angular, occasional grains are rounded.

Hole 27 (1.8-4.3 m)

Small magnetic fraction of angular magnetite. 50:50 shell fragment: quartz. Shell fragments in general are larger and show rounding, quartz fragments usually angular. Some larger rounded quartz, some rounding.

Hole 28 (2.7-4.6m)

Very small magnetic fraction of angular magnetite. 50:50 quartz: shell fragments. Quartz is usually clear and angular, shell fragments are generally larger than the quartz.

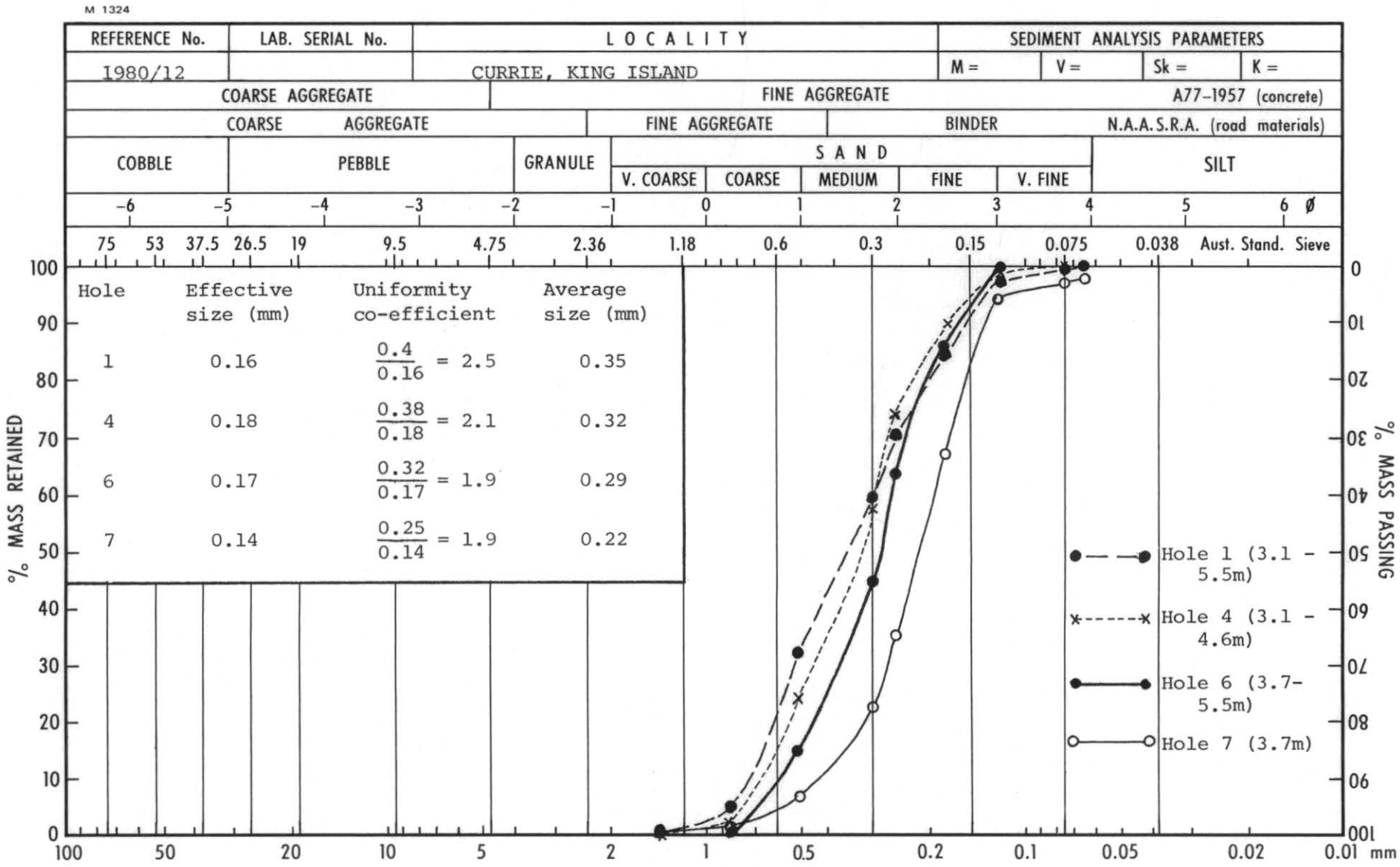
Hole 31 (4.6m)

Moderate magnetic fraction (<0.3%) of magnetite. Angular brown stained quartz fragments. Occasional shell fragments with forams identified.

APPENDIX 3

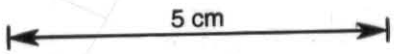
Sizing analysis of sand samples

Size (μm)	Hole 1 mass (g)	Hole 1 %	Hole 1 cum. % retained	Hole 4 mass (g)	Hole 4 %	Hole 4 cum. % retained	Hole 6 mass (g)	Hole 6 %	Hole 6 cum. % retained	Hole 7 mass (g)	Hole 7 %	Hole 7 cum. % retained
2000												
1400	0.43	0.3	0.3	0.29	0.2	0.2				0.54	0.5	0.5
850	6.71	4.7	5.0	3.16	1.8	2.0	0.98	0.8	0.8	1.03	1.0	1.5
500	40.85	28.3	33.3	40.05	22.9	24.9	17.76	13.7	14.5	6.4	5.9	7.4
300	38.39	26.6	59.9	60.64	34.7	59.6	39.82	30.7	45.2	16.17	15.0	22.4
250	16.06	11.1	71.0	26.02	14.9	74.5	23.26	17.9	63.1	13.45	12.4	34.8
180	20.48	14.2	85.2	28.23	16.1	90.6	30.11	23.2	86.3	34.74	32.1	66.9
125	18.44	12.8	98.0	14.71	8.4	99.0	16.34	12.6	98.9	29.46	27.3	94.2
75	1.9	1.3	99.3	1.29	0.7	99.7	1.0	0.8	99.7	2.70	2.5	96.7
63	0.41	0.3	99.6	0.36	0.2	99.9	0.27	0.2	99.9	1.15	1.1	97.8
-63	0.6	0.4	100.0	0.25	0.1	100.0	0.3	0.2	100.1	2.47	2.3	100.1
Depth (m)	3.1-5.5			3.1-4.6			3.7-5.5			3.7		



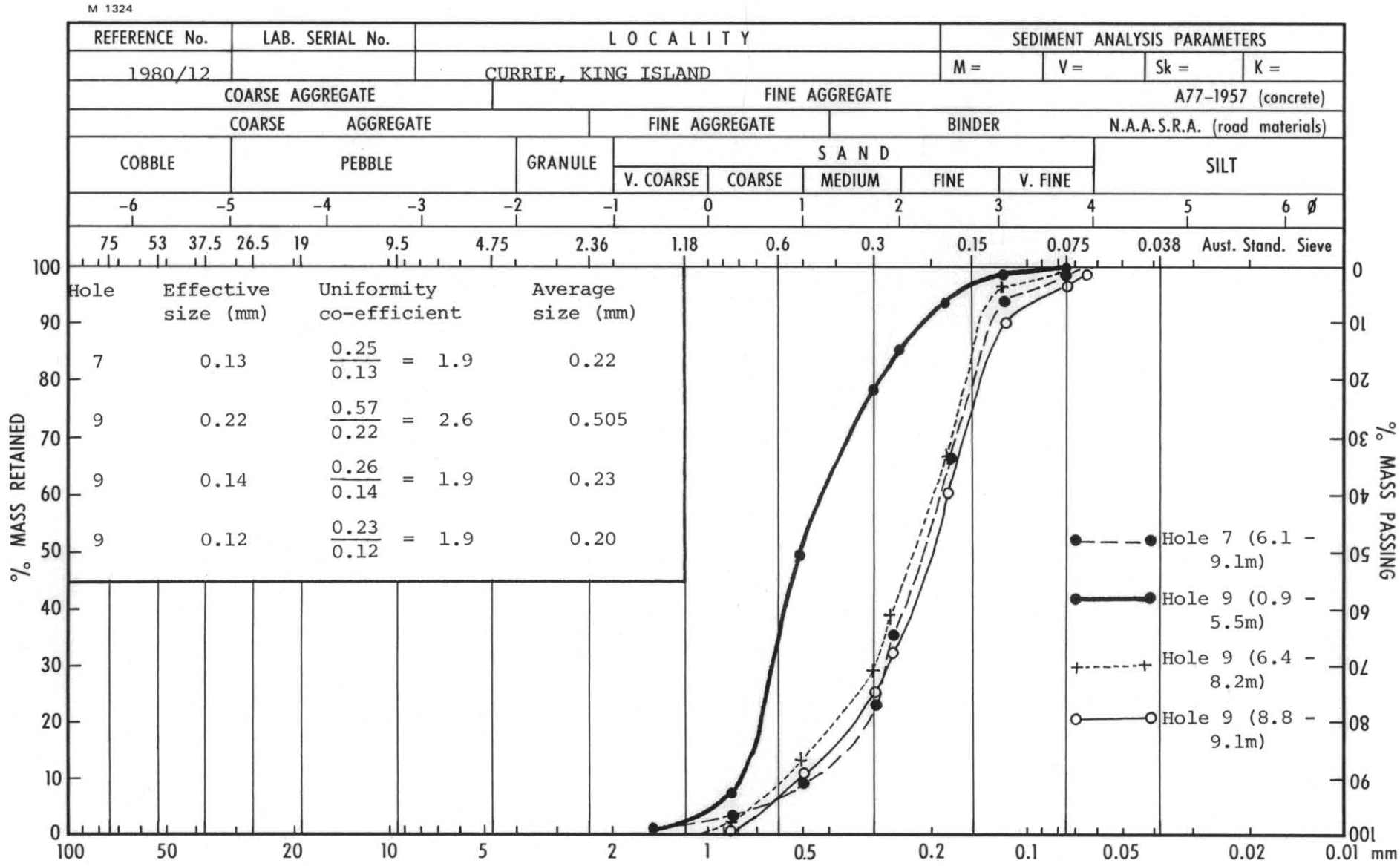
Hole	Effective size (mm)	Uniformity co-efficient	Average size (mm)
1	0.16	$\frac{0.4}{0.16} = 2.5$	0.35
4	0.18	$\frac{0.38}{0.18} = 2.1$	0.32
6	0.17	$\frac{0.32}{0.17} = 1.9$	0.29
7	0.14	$\frac{0.25}{0.14} = 1.9$	0.22

Figure 8. *Sizing analyses of sand samples, Currie area*



Appendix 3 (continued)

Size (μm)	Hole 7 mass (g)	Hole 7 %	Hole 7 cum. % retained	Hole 9 mass (g)	Hole 9 %	Hole 9 cum. % retained	Hole 9 mass (g)	Hole 9 %	Hole 9 cum. % retained	Hole 9 mass (g)	Hole 9 %	Hole 9 cum. % retained
2000												
1400	1.0	1.1	1.1	1.13	0.4	0.4	0.83	0.6	0.6	0.77	0.9	0.9
850	2.11	2.4	3.5	20.23	7.5	7.9	3.46	2.3	2.9	1.28	1.4	2.3
500	5.39	6.0	9.5	117.16	43.5	51.4	16.95	11.5	14.4	8.60	9.6	11.9
300	12.4	13.9	23.4	72.55	26.9	78.3	20.83	14.1	28.5	10.78	12.0	23.9
250	10.57	11.8	35.2	20.98	7.8	86.1	15.31	10.4	38.9	7.96	8.9	32.8
180	29.28	32.8	68.0	22.72	8.4	94.5	41.6	28.1	67.0	23.85	26.6	59.4
125	23.61	26.4	94.4	12.57	4.7	99.2	44.32	30.0	97.0	28.37	31.7	91.1
75	3.26	3.7	98.1	1.37	0.5	99.7	2.90	2.0	99.0	4.74	5.3	96.4
63	1.48	1.7	99.8	0.26	0.1	99.8	0.56	0.4	99.4	2.5	2.8	99.2
-63	0.2	0.2	100.0	0.58	0.2	100.0	1.18	0.8	100.2	0.7	0.8	100.0
Depth (m)		6.1-9.1			0.9-5.5			6.4-8.2			8.8-9.1	



Hole	Effective size (mm)	Uniformity co-efficient	Average size (mm)
7	0.13	$\frac{0.25}{0.13} = 1.9$	0.22
9	0.22	$\frac{0.57}{0.22} = 2.6$	0.505
9	0.14	$\frac{0.26}{0.14} = 1.9$	0.23
9	0.12	$\frac{0.23}{0.12} = 1.9$	0.20

Figure 9. *Sizing analyses of sand samples, Currie area*

5 cm

Appendix 3 (continued)

Size (μm)	Hole 10 mass (g)	Hole 10 %	Hole 10 cum. % retained	Hole 11 mass (g)	Hole 11 %	Hole 11 cum. % retained	Hole 13 mass (g)	Hole 13 %	Hole 13 cum. % retained	Hole 15 mass (g)	Hole 15 %	Hole 15 cum. % retained
2000												
1400	0.76	0.4	0.4	0.79	0.8	0.8	0.13	0.2	0.2	1.81	1.4	1.4
850	2.9	1.7	2.1	1.65	1.6	2.4	0.88	1.2	1.4	3.32	2.6	4.0
500	38.99	22.2	24.3	3.79	3.7	6.1	4.47	5.9	7.3	30.93	24.1	28.1
300	28.7	16.4	40.7	9.60	9.3	15.4	10.94	14.5	21.8	41.45	32.2	60.3
250	19.35	11.0	51.7	9.78	9.5	24.9	8.06	10.7	32.5	17.93	13.9	74.2
180	50.0	28.5	80.2	34.27	33.1	58.0	17.91	23.7	56.2	13.19	10.3	84.5
125	29.76	17.0	97.2	37.01	35.8	93.8	26.70	35.4	91.6	16.98	13.2	97.7
75	2.80	1.6	98.8	4.29	4.1	97.9	3.86	5.1	96.7	1.63	1.3	99.0
63	0.71	0.4	99.2	1.27	1.2	99.1	1.43	1.9	98.6	0.65	0.5	99.5
-63	1.53	0.9	100.1	1.08	1.0	100.1	1.11	1.5	100.1	0.74	0.6	100.1
Depth (m)		7.6-9.1			5.5			6.4-9.1			3.1	

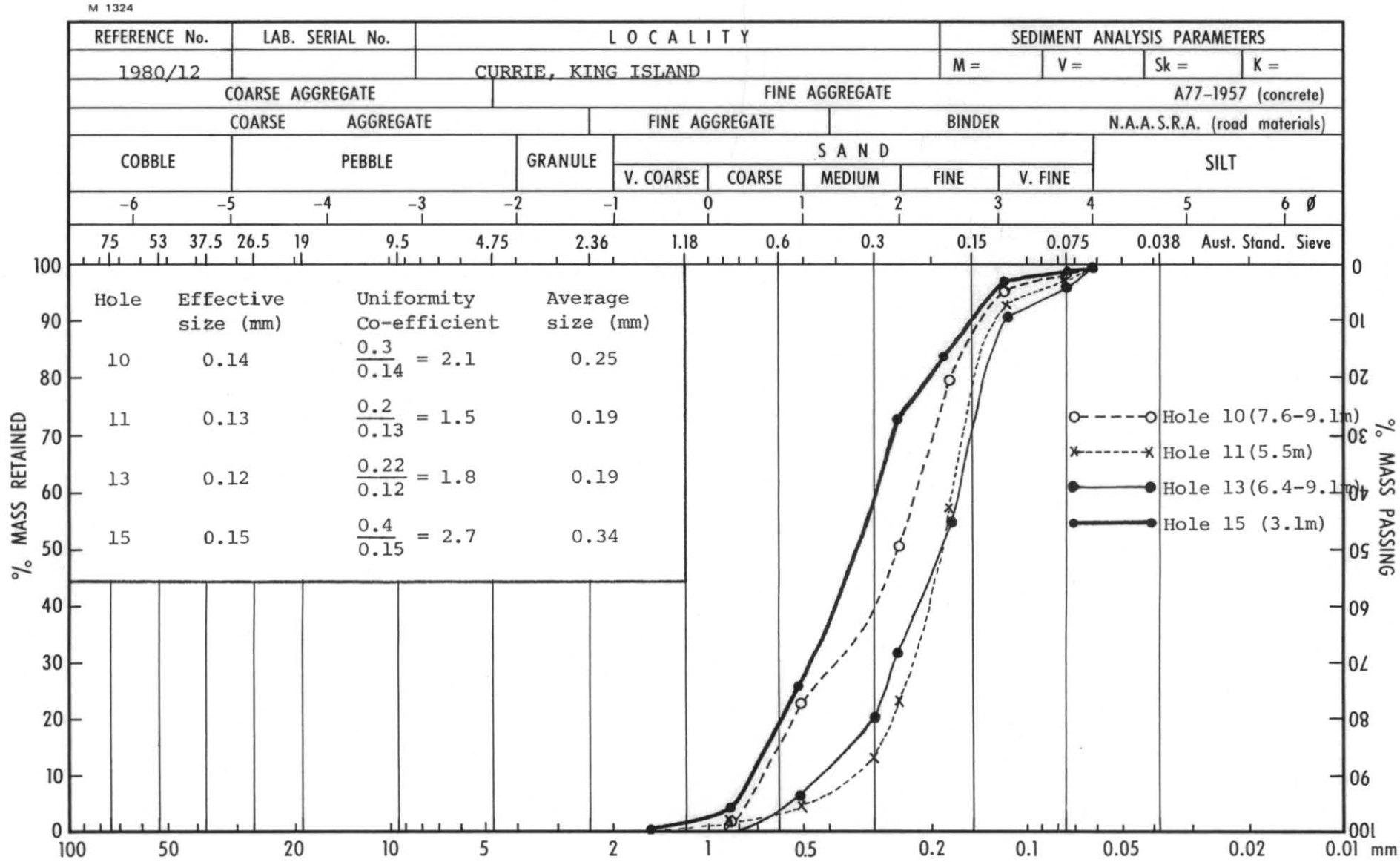
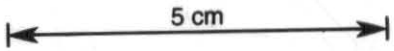
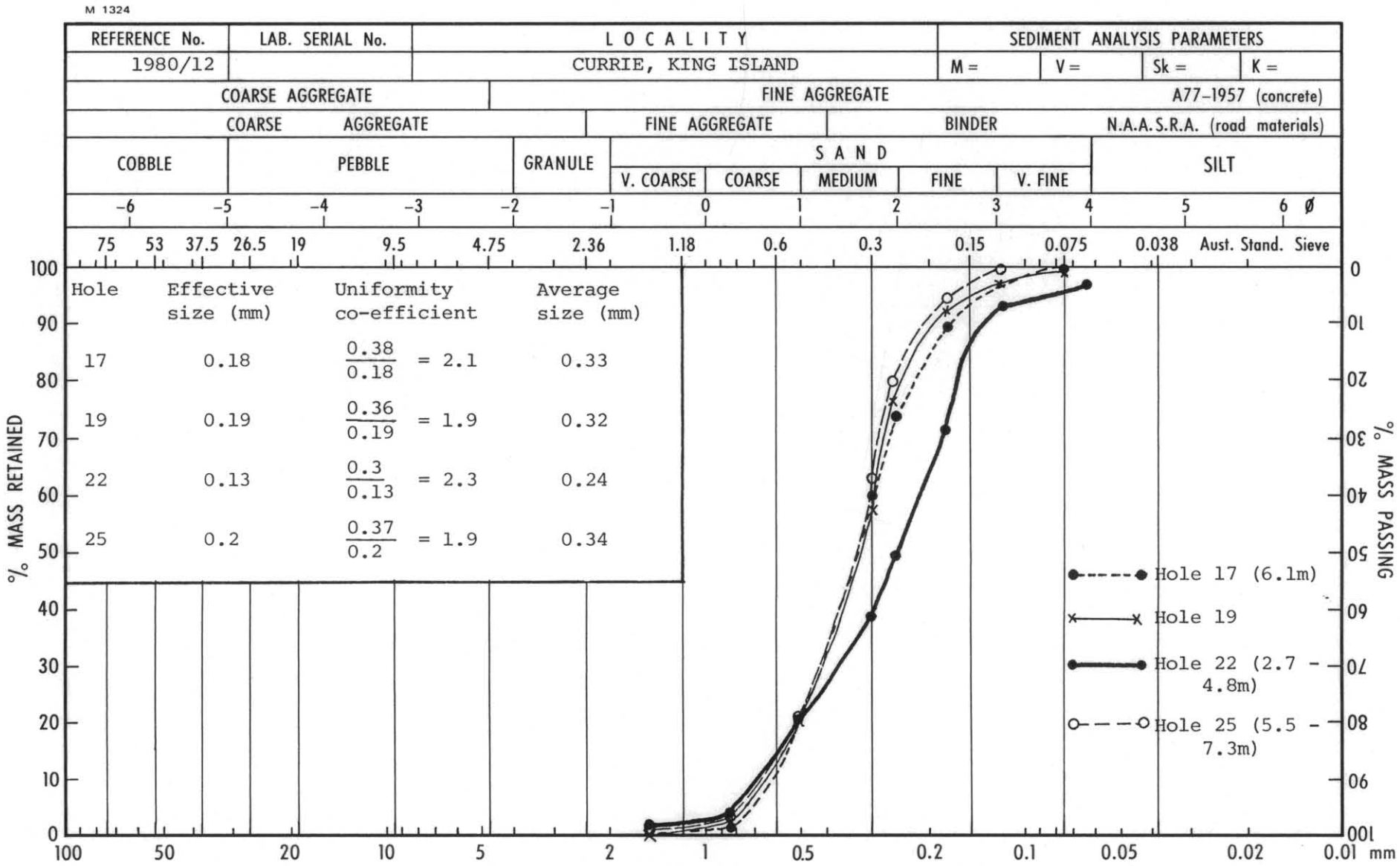


Figure 10. *Sizing analyses of sand samples, Currie area.*



Appendix 3 (continued)

Size (μm)	Hole 17 mass (g)	Hole 17 %	Hole 17 cum. % retained	Hole 19 mass (g)	Hole 19 %	Hole 19 cum. % retained	Hole 22 mass (g)	Hole 22 %	Hole 22 cum. % retained	Hole 25 mass (g)	Hole 25 %	Hole 25 cum. % retained
2000												
1400	0.27	0.2	0.2	1.20	0.7	0.7	1.74	1.3	1.3	0.26	0.2	0.2
850	1.91	1.2	1.4	4.55	2.8	3.5	3.38	2.5	3.8	3.63	2.4	2.6
500	34.60	21.8	23.2	29.6	18.0	21.5	25.25	18.4	22.2	30.9	20.3	22.9
300	57.74	36.4	59.6	60.73	37.0	58.5	24.97	18.2	40.4	61.80	40.6	63.5
250	24.11	15.2	74.8	31.06	18.9	77.4	12.05	8.8	49.2	26.12	17.1	80.6
180	23.96	15.1	89.9	26.05	15.9	93.3	30.83	22.5	71.7	22.33	14.7	95.3
125	13.28	8.4	98.3	7.98	4.9	98.2	30.15	22.0	93.7	6.49	4.3	99.6
75	1.98	1.3	99.6	1.40	0.9	99.1	3.02	2.2	95.9	0.56	0.4	100.0
63	0.44	0.3	99.9	0.79	0.5	99.6	1.16	0.9	96.8	0.14	0.1	100.1
-63	0.45	0.3	100.2	0.84	0.5	100.1	4.34	3.2	100.0	0.13	0.1	100.2
Depth (m)		6.1						2.7-4.8			5.5-7.3	



Hole	Effective size (mm)	Uniformity co-efficient	Average size (mm)
17	0.18	$\frac{0.38}{0.18} = 2.1$	0.33
19	0.19	$\frac{0.36}{0.19} = 1.9$	0.32
22	0.13	$\frac{0.3}{0.13} = 2.3$	0.24
25	0.2	$\frac{0.37}{0.2} = 1.9$	0.34

Figure 11. *Sizing analyses of sand samples, Currie area*

Appendix 3 (continued)

Size (μm)	Hole 27 mass (g)	Hole 27 %	Hole 27 cum. % retained	Hole 28 mass (g)	Hole 28 %	Hole 28 cum. % retained	Hole 31 mass (g)	Hole 31 %	Hole 31 cum. % retained
2000									
1400	2.05	1.9	1.9	0.21	0.2	0.2	0.96	0.7	0.7
850	17.48	16.1	18.0	5.22	4.1	4.3	2.98	2.2	2.9
500	55.24	50.7	68.7	44.22	34.5	38.8	32.0	23.3	26.2
300	24.92	22.9	91.6	46.70	36.5	75.3	35.45	25.8	52.0
250	4.06	3.7	95.3	14.11	11.0	86.0	16.09	11.7	63.7
180	3.03	2.8	98.1	11.02	8.6	94.6	26.66	19.4	83.1
125	1.57	1.4	99.5	5.36	4.2	98.8	18.32	13.3	96.4
75	0.28	0.3	99.8	0.83	0.7	99.5	2.22	1.6	98.0
63	0.10	0.1	99.9	0.19	0.2	99.7	0.69	0.5	98.5
-63	0.17	0.2	100.1	0.18	0.1	99.8	1.93	1.4	99.9
Depth (m)		1.8-4.3			2.7-4.6			4.6	

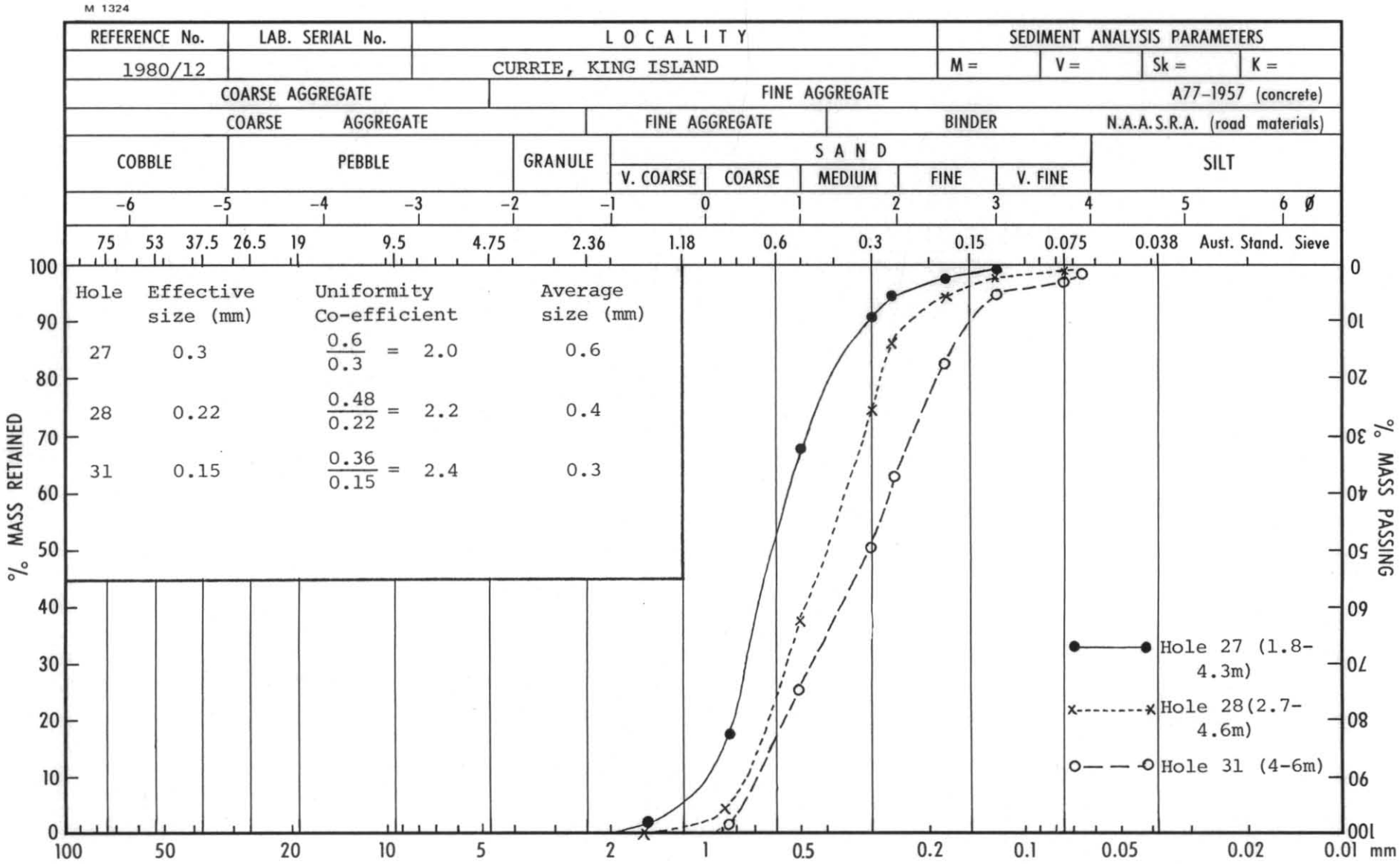


Figure 12. *Sizing - analyses of sand samples, Currie area*

5 cm

APPENDIX 4

Chemical analysis of groundwater samples

Constituent	Analysis (December 1979)								Analysis (January 1980)*			
	Hole 1	Hole 11	Hole 15	Hole 19	Hole 27	Hole 28	Hole 31	Spring (D.Nash)	Wharf Road	Golf Course	South British Admiral Beach	North British Admiral Beach
pH	8	8	8	8	8	8	8	8	7.5	7.6	7.8	7.9
Conductivity (µS/cm)	790	790	900	830	1200	940	1480	960	1380	1200	900	820
	mg/*l*	mg/*l*	mg/*l*	mg/*l*	mg/*l*	mg/*l*	mg/*l*	mg/*l*	mg/*l*	mg/*l*	mg/*l*	mg/*l*
CO_3	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
HCO_3	325	315	300	305	420	430	245	345	430	350	300	270
Cl	170	165	205	180	290	170	400	220	240	210	140	120
SO_4	19	20	34	23	43	39	69	30	53	39	20	21
SiO_2	<5	<5	5	10	13	7.4	<5	5	7	5	<5	<5
Ca	83	76	66	73	100	87	98	86	110	92	86	69
Mg	13	17	21	22	25	27	31	21	33	24	13	17
Fe	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Al	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
K	2.0	3.3	4.8	6.7	7.0	7.6	1.1	4.6	9.4	6.9	2.5	3.4
Na	76	76	110	80	150	96	210	110	160	130	84	66
T.D.S.	530	530	570	540	795	635	1060	680	940	750	580	520
Hardness -												
permanent	nil	nil	nil	23	8	nil	172	21	61	39	18	22
temporary	260	260	250	250	345	330	200	280	350	290	250	220
Alkalinity (as $CaCO_3$)	265	260	250	250	345	350	200	280	350	290	250	220

* Water analyses from longer pump tests

APPENDIX 5

Pump test data

SOUTH BRITISH ADMIRAL BEACH

Pumping stage		Recovery stage			
Time (mins)	Drawdown (m)	Time (mins)	t′ (mins)	t/t′	Drawdown (m)
0	1.85	1044	0	-	2.24
1	1.86	1046	2	523	2.22
3	1.86	1050	6	175	2.21
8	1.88	1055	11	96	2.20
15	1.89	1058	14	75.6	2.19
30	1.92	1077	33	32.6	2.17
150	2.00	1155	111	10.4	2.11
302	2.07	1195	151	7.9	2.10
602	2.17	1503	459	3.3	2.02
1044	2.24	1659	615	2.7	2.00
		NORTH BRITISH ADMIRAL BEACH			
0	2.10	1116	0		2.45
1	2.12	1117	1	1117	2.39
2	2.24	1118½	2½	447	2.27
3	2.25	1119½	3½	320	2.26
4	2.28	1121	5	224	2.25
5	2.29	1124	8	140.5	2.25
10	2.29	1129	13	86.9	2.25
16	2.29	1144	28	40.9	2.25
35	2.31	1161	45	25.8	2.24
49	2.31	1240	124	10	2.21
64	2.32	1296	180	6.6	2.20
124	2.35	1481	365	4.1	2.17
319	2.39				
682	2.43				
1116	2.45				
		GOLF COURSE			
0	0.66	1012	0	-	0.89
8	0.69	1013	1	1013	0.88
18	0.69	1016	3	339	0.88
38	0.71	1017	5	203.4	0.87
84	0.73	1029	17	60.5	0.85
202	0.76	1040	28	37.1	0.85
334	0.79	1052	40	26.3	0.84
525	0.82	1067	55	19.4	0.83
857	0.87	1081	69	15.7	0.82
987	0.88	1266	254	5.0	0.77
1012	0.89	1456	442	3.3	0.75

Appendix 5 (continued)

WHARF ROAD

Time (mins)	Drawdown (m)	
	Hole 1	Hole 2
0	?	?
15	1.45	2.26
23	1.47	2.29
40	1.48	2.29
55	1.48	2.30
70	1.50	2.30
85	1.50	2.31
135	1.52	2.31
170	1.53	2.32
310	1.58	2.33
430	1.60	2.37
620	1.61	2.39
770	1.64	2.41
875	1.66	2.42