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1984/72. Groundwater prospects at the Mowbray Golf Course, Launceston

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Abstract

A groundwater investigation of the Mowbray Golf Course included a bore record search of previous drilling in the Tamar Valley, a geological examination of the area, and three refraction seismic spreads across the course. The course is on the eastern boundary of the Tamar Trough. Well-jointed dolerite is exposed in nearby railway cuttings and is thought to dip westwards under clay and other sediments of the Launceston Beds of Tertiary age. If upfaulted beneath the golf course, the dolerite could provide a suitable structural trap for groundwater. The seismic survey shows this structural interpretation to be feasible, but the jointed upper horizon of the dolerite was too thin to be an attractive groundwater prospect. Drilling is not recommended. Additional dams and deepening of existing water holes is recommended using the clay present on the eastern side of the course for clay core dams and lining the water holes.

INTRODUCTION

The grounds committee of the Mowbray Golf Club were interested in establishing the groundwater potential of their golf course. If these prospects were considered attractive, the committee were prepared to have an exploratory water bore drilled. The groundwater was to be used as a supplementary supply for the recharging of existing surface storage during summer. An assessment of the groundwater prospects was required before committing the Club to the cost of enlarging the existing surface storage.

The Department of Mines investigation included an introductory visit to the golf course, bore record search, a geological examination of the area east to the railway line, and three refraction seismic spreads.

LOCATION AND TOPOGRAPHY

The Mowbray Golf Course is situated in the Launceston suburb of Newnham [EQ110170]. The course occupies a large section of the flood plain and valley of Newnham Creek between Invermay Road and the abandoned railway formation (fig. 1). The northern boundary of the course approximately follows the south bank of the northern tributary of Newnham Creek. Both creeks are small. The western half of the course is flat and occupies the narrow flood plain between these two small streams. The eastern half of the course is built on a broad, 18 m high spur that separates the northern tributary and the main Newnham Creek valley where the latter swings from a north-trending to a west-trending course.

GEOLOGY

Poor outcrops of clay, thought to belong to the Launceston Beds of Tertiary age (Longman, 1966), occur in the water hole north of the club house. Grey and brown clay was drilled and blown from many of the shot holes. The clay extends up to the eastern boundary of the golf course.

Low flat outcrops of dolerite appear in the northern tributary of Newnham Creek, east of the golf course boundary, and in the old railway cutting. Excellent exposures of the dolerite exist in the three cuttings on the existing railway further to the east.

The dolerite in these cuttings is well jointed, with most joints steep or vertical, but low-dipping sheet joints are also present. The jointing is not tight on the cutting faces but there was no water flowing from any of the joints. The weathered zone between the surface soil and unweathered dolerite was thin. There was no clay horizon typical of a deeply weathered dolerite zone.

The golf course is situated near the eastern margin of the Tamar Trough. This trough consists of a series of down-faulted dolerite blocks tilted to the south-west, with the upthrow of the faults to the west (Longman, 1966). In these blocks were deposited lake and deltaic sediments of clay, sandstone and conglomerate, of which clay appears to dominate in the upper portion of the sequence along the eastern margin of the trough.

GEOHYDROLOGY

The rock types likely to be encountered in a bore drilled on the golf course are the sediments of Tertiary age and dolerite. Neither the dolerite nor the Tertiary sediments are considered, by the author, to have very good groundwater prospects.

The Tertiary sedimentary sequence on the eastern margin of the Tamar Trough is likely to be dominantly clay with minor soft sandstone beds and gravel beds mixed with clay. The sandstone beds contain groundwater which is frequently very saline. The amount of groundwater the Tertiary sediments produce is thought to depend on the thickness and frequency of the sandstone beds at a particular locality.

The dolerite is an unreliable, low yielding, rock-fracture aquifer (groundwater source rock). W.L. Matthews, from his compilation of the Tasmanian water bore records, found that of 196 bores drilled in dolerite 103 or 53.6% were successful, with an average depth of 33.1 m, and an average yield of 81.3 litres per minute (1050 gallons per hour).

There are only 38 analyses available in the records for groundwater produced from dolerite rock. Of these dolerite groundwaters only 18% have a total dissolved salt content (TDS) of less than 500 milligrams per litre (mg/*l*) or parts per million. Water in this range, according to the Australian Water Resources Council (AWRC) classification (Hart, 1974), is a low to medium saline irrigation water and is generally suitable for all types of pastures without any long term salt problems foreseen. By far the greatest percentage, 63%, of dolerite-produced groundwater, is within the 500-2000 mg/*l* range which makes the water a high to very high saline irrigation water in the AWRC classification. The remaining 17% is in Class V, the extremely saline range. From these figures any potential supply of groundwater from dolerite is likely to have water quality problems. Even though Matthews has no figures for groundwater from Tertiary sediments for the State, groundwater in the Tamar Valley sediments is known to be highly saline, as shown by the rising salt groundwater tables appearing in some orchards of the Tamar Valley (Polya, 1982).

The results of 13 bores drilled in the Tamar Valley in Tertiary clay and/or dolerite similar to the geological conditions anticipated at the Mowbray Golf Club are given in Table 1. Of these bores, seven were dry and only two bores produced more than 75 *l*/min (1000 gph) of water. Unfortunately no water quality analyses are available for these 13 bores. The successful drilling rate for dolerite in the Tamar Valley is the same as the State dolerite bore figures but the Tamar Valley yields are lower than the State average for dolerite bores. These lower yields are thought to be due to the presence of the overlying clay. Many of the Tamar Valley bores appear not to have been drilled to what is now considered to be an adequate depth into the dolerite.

Despite the discouraging past record of drilling for groundwater in the Tamar Valley there is one geological model which could conceivably improve the groundwater prospects for the golf course. Given that the jointing in the dolerite exposed in the railway cutting continues at depth, that the dolerite appears to dip westwards below the clay towards the golf course, and a NW-trending fault passes near the golf course, a geological structure similar to the interpretation put forward by Longman *et al.* (1964; cross-section C-D) could result in a structural reservoir trap being present. That there was no water seeping from the joints in the dolerite after a wet winter appears to indicate that the water table was at a lower level and that the jointing continued below the level of the cuttings. To test this geological model appeared to be relatively simple, requiring an inexpensive seismic reconnaissance survey of three or four spreads across the course plus a trial resistivity probe, if the geological conditions appeared suitable.

After receiving the previous drilling records *etc.* and an overall pessimistic appraisal of their groundwater prospects in a letter of 6 July, the Golf Club committee decided that the cost of a limited geophysical investigation for completeness of the investigation was warranted. The committee was made aware that the result would most likely still be a negative recommendation for drilling but the prospects for groundwater would then have been explored completely before the risk of drilling.

GEOPHYSICS

Three refraction seismic spreads were fired in an east-west direction across the golf course. Spread 1 was on the eastern boundary of the course, Spread 2 on the western section and Spread 3 on approximately the middle of the course (fig. 1). A 12 channel Geometrics Nimbus ES 1210 signal enhancement seismograph was used in the survey, with gelignite explosives for the energy input.

Geophone intervals and shot point distances had to be varied so that shots could be fired in water holes, creek beds and under the shelter of trees to reduce damage and the danger of fly rock. A summary of the seismic survey results is given in Table 2.

It had been proposed to undertake a resistivity depth probe after the seismic survey. With the exposure of moist clay in the shot holes it was realised that electric current penetration through this surface clay layer would be very difficult and resistivity results meaningless.

Three velocity layers were present in all seismic spreads. The surface layer (V_0) had a narrow velocity range of 700-1000 m/sec. This surface layer is geologically interpreted as clay of the Launceston Beds. In the eastern spread this clay layer is surprisingly thick, with a calculated thickness of nine metres. In Spreads 2 and 3 the surface layer is calculated to be 2-4 m thick.

The high velocity layer (V_3) of 3000-4000 m/sec is in the velocity range of unweathered, tightly jointed or unjointed dolerite. Such a compact rock is unlikely to contain much groundwater. The top of this 3000-4000 m/sec velocity layer marks the velocity interface with the base

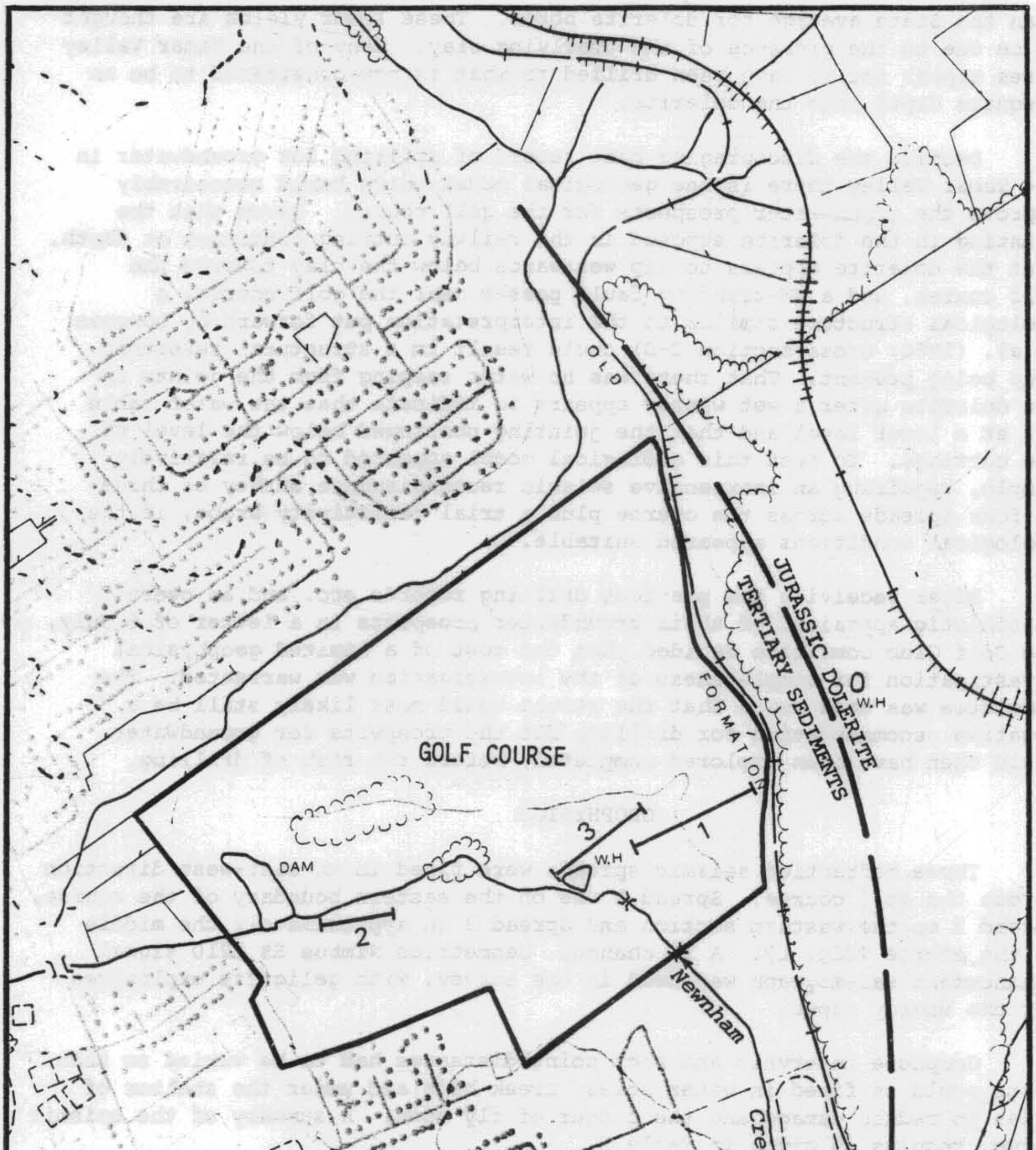

Figure 1. *Location of golf course and seismic spreads*

5 cm

of the potential aquifer horizon in the dolerite. To drill for water in dolerite with velocities in excess of 3000 m/sec is considered wasteful as the joints will be tight and probably infrequent. This velocity interface represents approximately the total depth to which a groundwater bore should be drilled in dolerite.

The intermediate velocities (V_1,V_2) cover a wide velocity range (1400-2700 m/sec). It is in the upper range of these velocities (between 2000-2700 m/sec) that open, well-jointed dolerite (as exposed in the railway cutting) would register. In Spreads 1 and 2 these velocities form distinct and recognisable velocity layers which are eight and sixteen metres thick respectively. These velocities are present in Spread 3 but they do not form a recognisable layer because of the slope of the interface with the thicker surface layer on the end of this spread. It is the 2000-2700 m/sec velocity layer that forms the potential aquifer horizon in the dolerite.

In Spreads 2 and 3 the lower velocities (V_1) of the intermediate range (1400-1700 m/sec) are interpreted geologically as Tertiary age sandstone below the water table and/or weathered dolerite. This layer is calculated to be seven metres thick on the west side, 11 m in the middle and to be pinched out and overlapped by a thicker clay surface layer at the eastern boundary of the golf course.

The deepest section to the high velocity dolerite is in the middle of the golf course, where the total depth to the velocity interface is calculated to be 31-34 metres. The shallowest depth was on Spread 1 with a depth of 18 metres. On the west side of the course the total depth to the high velocity layer is 25-28 metres.

A similar pattern emerges for the interpreted top of the well-jointed dolerite interface (2000-2700 m/sec layer). The depth was calculated as nine metres in Spread 1 in the east, 12-14 m in Spread 3 and 9-12 m in Spread 2. It is this velocity layer that would form any aquifer and the layer is nine metres thick in the east, 20 m thick in the middle and 16 m thick in the west of the golf course.

In Spreads 2 and 3 lower velocities of 1400-1700 m/sec occur in the intermediate velocity range. No such velocities appear in Spread 1. These 1400-1700 m/sec velocities are geologically interpreted as Tertiary age sandstone below the water table and/or weathered dolerite, and are calculated to be 7-9 m thick in Spread 2 and 10-11 m thick in Spread 3.

The simplest structural interpretation of the seismic profile across the Mowbray Golf Course is to have a westerly dipping dolerite body exposed west of the railway line, becoming overlain by eight metres of clay on the east side of the golf course and 12-15 m of clay in the middle of the course. The dolerite then becomes upfaulted and continues to dip west to a depth of 10-12 m at the west side of the course. The interface between the jointed and unjointed dolerite shows a similar dip to the west, with depths of 18 m at the east and 30-35 m at Spread 3 in the middle of the course. This interface is uplifted between Spread 2 and 3 with a calculated depth of 25-28 m on the western side of the course.

A surface clay layer 2-3 m deep extends eastwards to be 3-4 m deep in the middle of the course. It further thickens to nine metres deep towards the eastern boundary where it overlaps onto the dolerite wedging out the underlying sandstone.

CONCLUSIONS

(1) The results of the seismic survey have improved the groundwater prospects because the structural geological model required for a faulted reservoir trap, with the fractured dolerite acting as the potential aquifer, is a feasible interpretation of the seismic survey.

(2) The most favourable drilling site is on the middle spread (3) at its extended western shotpoint end, by the lagoon. Here the greatest total depth to the base of the potential aquifer, the well-jointed dolerite, is calculated to be 35-38 m and the aquifer itself has the greatest thickness of 20 metres.

(3) A second drilling site is at the west end of Spread 2 near the western water hole. Here the total depth is 28 m with an aquifer thickness of 16 metres.

(4) The main potential aquifer, well-jointed dolerite, is only a low porosity and low permeability rock fracture aquifer.

(5) To obtain an adequate bore yield, both the total depth and thickness of the aquifer should be double that calculated from the velocity layers of the seismic survey. If the total depth to the base of the aquifer was 50-60 m it would be an excellent prospect with an aquifer horizon thickness of 40-50 m. Unfortunately as the calculated thickness is only half the required thickness, the predicted yield is low.

(6) Above the well-jointed dolerite there is a possibility of 12-14 m of water-saturated sandstone of Tertiary age. If the 1400-1700 m/sec velocity layer represents this soft sandstone the contained groundwater is likely to be very saline. This could result in very poor quality water being accumulated in the potential reservoir trap. State water bore records show that dolerite water quality is frequently poor.

RECOMMENDATIONS

(1) In spite of the required geological model being a feasible interpretation of the seismic profile across the Mowbray Golf Course, the model is deficient in one important property. The initial porosity and permeability of the potential aquifer is low, consequently a considerable thickness will be required to produce an adequate bore yield. Twice the aquifer thickness than appears to be present from the seismic calculations would be required to warrant the risk of drilling.

There is a strong possibility of dolerite groundwater being saline, more so if sandstone of the Launceston Beds occurs above the jointed dolerite, as is interpreted from the seismic survey.

In the author's opinion, the drilling of even a shallow (40 m deep) exploratory deep water bore is not recommended.

(2) If the committee should decide to risk drilling the best site would be immediately west of the middle water hole, followed by a second hole near the western water hole if the first hole is successful and the water quality is satisfactory. This must

be considered a high risk project and if possible executed under only very favourable terms to the Club.

(3) The committee should concentrate on increasing the surface storage. With such a thick layer of clay present on the east side of the course the possibility of deepening and clay lining the existing water holes should be investigated.

(4) Newnham Creek and tributary appear to have potential for dam storage in the eastern section of the golf course. This will depend on property boundaries and available space *etc.* but the clay found in the shot holes in this area appears ideal material for clay-cored dams. No leakage problems are likely to occur in this impermeable surface horizon.

(5) It should be stressed that seismic interpretation does not replace drilling in water or dam site investigations. Seismic investigations are only a guide, and drilling would be necessary to check that the thick surface velocity layer is composed entirely of clay on the eastern section of the golf course.

This could be done by a limited auger drilling programme. Such a programme is considered essential before any deepening of the existing water holes or before any new dams are planned.

(6) The dispersive properties of the clay in water should be tested to avoid future piping in any clay cored dams.

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[7 November 1984]

Table 1. KNOWN BORES IN THE TAMAR TROUGH IN TERTIARY CLAY AND/OR DOLERITE

No.	Owner	Location	Depth Drilled (m)	Yield (l/min)	Status	Rock type from driller's log (depths in metres)
1	Not known	Strawberry Farm, Dilston	16.76	265	?	Probably dolerite
2	Coward	Dilston, Doctors Hill	11.0	<11.4	Abandoned	0 - 10.7 clay 10.7 - 11.0 dolerite
3	Harris	Hillwood turn-off	10.7	110	Operating	0 - 0.6 topsoil 0.6 - 10.7 decomposed dolerite
4	Northern Casino (1)	West Prospect	91.4	Dry	Abandoned	0 - 82 clay 82 - 91.4 decomposed dolerite
5	Northern Casino (2)	West Prospect	64.0	Dry	Abandoned	0 - 12 clay 12 - 64 decomposed dolerite
6	Reithoff	Bridgenorth Rd	84.7	9	Operating	0 - 3 clay 3 - 11 decomposed dolerite 11 - 84.7 dolerite
7	Stagoll	Abels Hill	47.2	11.4	Operating	0 - 39.6 clay 39.6 - 47.2 dolerite
8	Stagoll	North Abels Hill	94.5	4	?	0 - 12.2 clay 12.2 - 47.7 decomposed dolerite 47.7 - 94.5 dolerite
9	Van Wormd	Dilston	29.0	Dry	Abandoned	0 - 11.6 clay 11.6 - 19.8 decomposed dolerite 19.8 - 29.0 dolerite
10	Shepherd No. 1	Swan Bay	42.7	Dry	Abandoned	0 - 24.4 clay 24.4 - 42.7 soft dolerite
11	Shepherd No. 2	Swan Bay	33.5	Dry	Abandoned	0 - 21.3 clay 21.3 - 33.5 dolerite and ironstone
12	Hill	New Ecclestone Road	35.0	Dry	Abandoned	0 - 0.6 soil 0.6 - 35.0 dolerite
13	Scott	Dunedin Station, St Leonards	39.6	Dry	-	Dolerite

Information collected from Tasmanian water bore records held at the Department of Mines, Rosny Park.

TABLE 2. REFRACTION SEISMIC SURVEY RESULTS

Spread no. & location	Direction & spread length (m)	Geophone spacing (m)	Shot point distances (m)	Velocity layers (m/sec)	Thickness Z_0 (m)	Symmetry of velocity plots	Stepping of velocity plots	Geological interpretation	Remarks
1 Eastern boundary of golf course near old railway line	NE - SW 205	15	15 E 15 W 30 W	V_0 900-1000 V_1 2500 V_2 3500	Z_0 = 8.7 Z_1 = 9.2 Total depth = 17.9	Symmetrical	Not stepped	V_0 Clay V_1 Well-jointed dolerite V_2 Dolerite	Reliable velocities and calculations
2 Western end of course east of large water hole	WSW - ENE 112.5	7.5	SPW 7.5 SPE 7.5 & 30	V_0 700 V_1 1400 V_2 2400-2700 V_3 3900??	Z_0 = 2-3 Z_1 = 7-9 Z_2 = 16 Total depth = 25-28	Symmetrical	Not stepped	V_0 Clay V_1 Tertiary sediments V_2 Jointed dolerite V_3 Dolerite	Reliable thickness calculations
3 Middle of course	NE - SW 157.5	7.5	SPW 30 15 SPE 30 45 Mid SP	<u>West end</u> V_0 1000 V_1 1700-2000 V_2 3500 <u>East and mid SP</u> V_0 400-500 V_1 1000-1700 V_2 3000-4000	<u>West end</u> Z_0 = 3.6 Z_1 = 30-33 Total depth = 35-38 <u>East end</u> Z_0 = 2-3 Z_1 = 10-11 Z_2 = 19.5 Total depth = 31-34	Assymetrical V_0 thicker & slower eastern end	Slightly stepped	<u>West end</u> V_0 Clay & Tertiary sediments V_1 Jointed & solid dolerite V_2 Dolerite <u>East end</u> V_0 Clay V_1 Tertiary sediments V_2 Jointed & solid dolerite	Some error because of averaging of velocities and stepping N.B. V_1 velocities could be weathered dolerite