

Abstract

A recently constructed dam on the University property, Craigow, at Cambridge is losing some of its water through leakage. Any large scale leakage is occurring under the dam and it is probably due to the cut-off being too shallow to fully penetrate unconsolidated sediments (including gravel and sand) although seepage through bedrock (dolerite and sandstone) is a possibility.

Possible solutions include ensuring the cut-off is to bedrock, blanketting any part of the storage area where relatively permeable material is close to the surface with clay or waiting to see whether the dam will seal naturally with the aid of clay and silt carried there by the water from the catchment area.

INTRODUCTION

The Rivers and Water Supply Commission has been involved with a dam on the University property, Craigow, which appears to be losing some of its stored water through leakage and requested some geological advice on the area. It is sited in a side valley near the lower part of Cross Rivulet [EN361593] and covers an area of about 4 ha. It was built about a year ago and was filled by run-off from Cross Rivulet by diversion down the side valley last winter (1983).

Drawdown in the dam, as measured by the Rivers and Water Supply Commission, is not accounted for totally by evaporation and water usage, and leakage is suspected by the Commission. A seepage downstream from the dam, near Cross Rivulet, is running at the rate of a few tens of litres per minute.

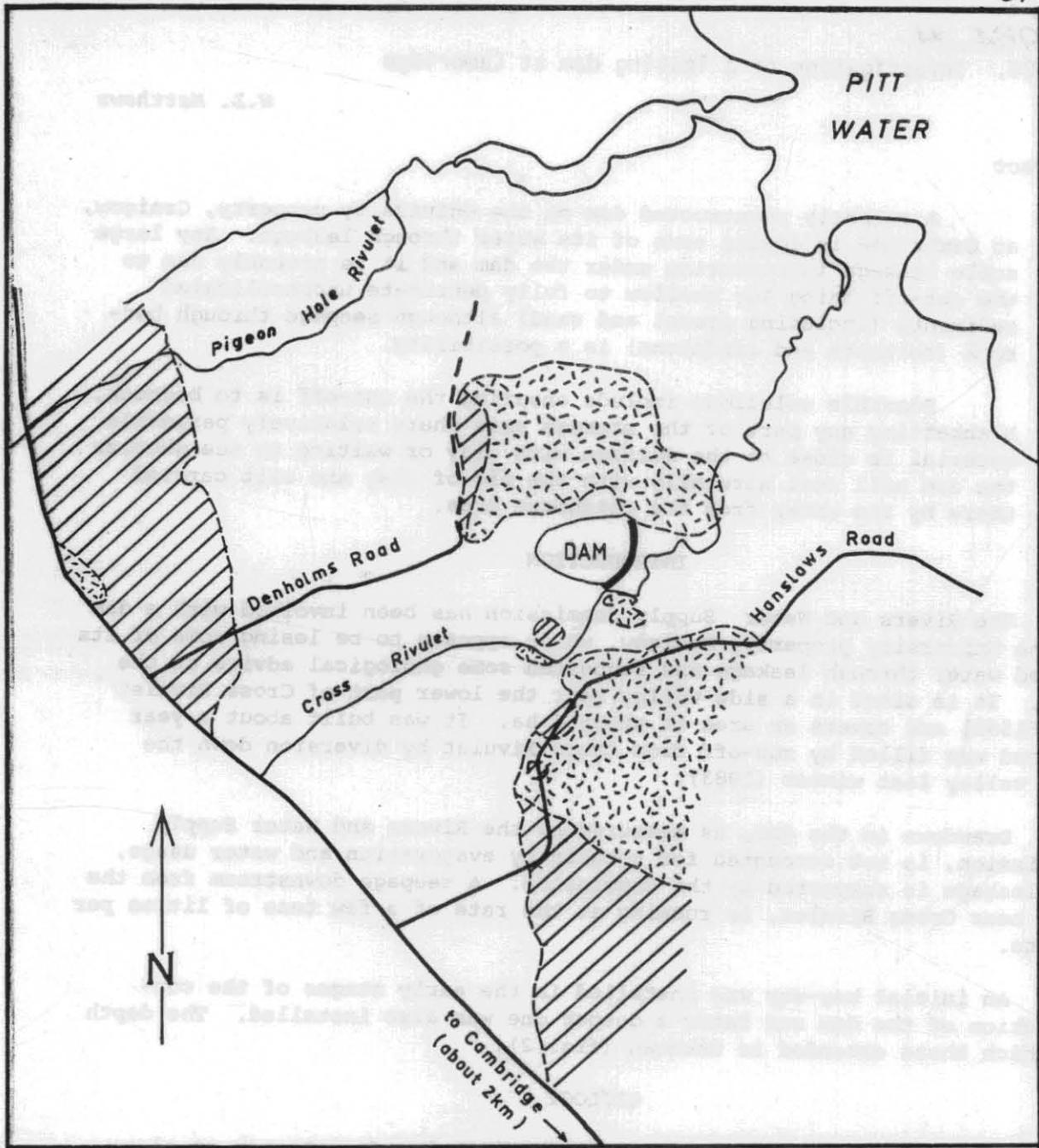
An initial key-way was installed in the early stages of the construction of the dam and later a deeper one was also installed. The depth to which these extended is unknown (fig. 2).

GEOLOGY

A sketch of the geology of the area (largely after Leaman *et al.*, 1972) is shown as Figure 1. Triassic sandstone occurs at several points on either side of the valley. Jurassic dolerite is also exposed on the slopes above the dam as well as in small outcrops in the bed of Cross Rivulet. The unconsolidated material of Tertiary to Recent age consists of clay, sand and gravel.

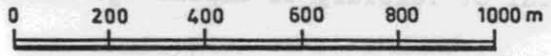
At the dam site, the north end of the wall is probably on *in situ* dolerite (a test pit dug a little away in the storage area struck weathered dolerite). The southern end of the wall is probably also on or near outcropping dolerite as very fine-grained dolerite is exposed in the spillway nearby. The middle part of the dam and the storage area is underlain by an unknown thickness of unconsolidated material. Where test pits have been dug in the storage area, the top section consists of clay and gravelly clay. In and near the small valley which enters the dam, compacted clay with shiny slip surfaces was struck in the lower parts of test pits 4 and 5. Downstream from the dam wall a series of test pits have been dug which have encountered mainly gravel fragments (Permian sediments and dolerite) with one hole having two large angular boulders of sandstone on the spoil dump.

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GEOLOGY AROUND CRAIGOW DAM

W.L. MATTHEWS

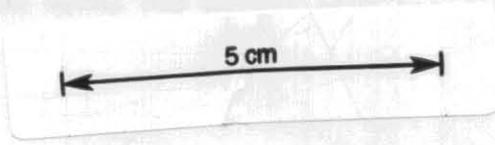


-  Deep soil, recent alluvium and Tertiary sediments
-  Dolerite
-  Sandstone and shale

Geology after Leaman et.al. 1972

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Figure 1.



SKETCH CROSS SECTION - CRAIGOW DAM

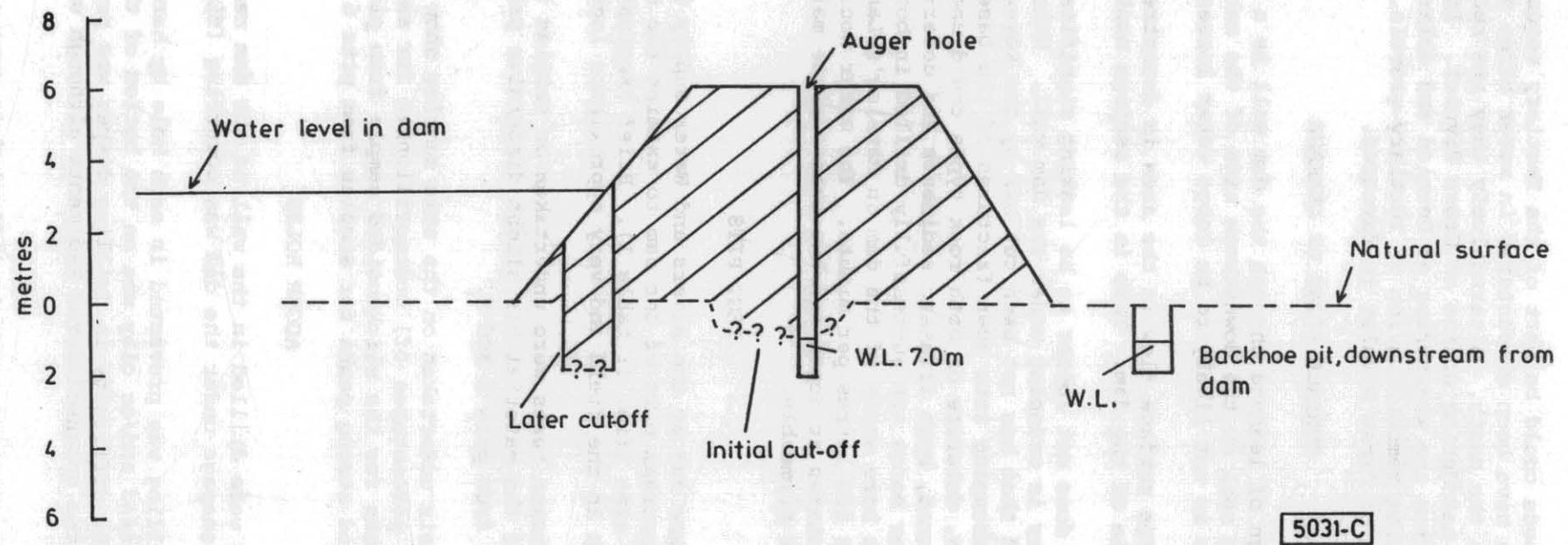
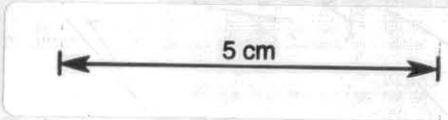


Figure 2.



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The gravel beds could be part of the Tertiary sequence of sediments as gravel horizons have been encountered in water bores near the Richmond road about 2 km to the north. Alternatively they are recent gravels associated with a meandering course of Cross Rivulet. In this case they could be derived from the weathering of Permian and dolerite upstream or partly or wholly from remobilisation of Tertiary gravels. An association with an old course of Cross Rivulet is favoured.

SURFACE SIGNS OF LEAKAGE

The only sign of leakage through the dam wall is a little away from the spillway. The soil on the downstream side of the embankment shows dampness but there is not likely to be large water losses at this point.

The only large surface flow in the area is downstream from a point in about the middle of the dam. This is the seepage mentioned above.

As the wall does not appear to be leaking significantly, it is apparent that water is escaping under the dam wall. This could be through gravel and/or sand that has not been cut off by the key-way or it could be that water is escaping into open fractures of the basement rock. Triassic sediments, dolerite or both rock types could underlie the dam wall. When fractured, both Triassic sediments and dolerite can be quite permeable and water bores are successfully drilled in both rock types. In fact there is a bore south of the dam on Hanslow's Lane in dolerite which yields about 100 litres per minute. The water would be entering the bore from fractures at depth and the near-surface material would in most cases be less permeable.

TEST PITS

Test pits were dug by the Rivers and Water Supply Commission around the edge of the upstream part of the dam to examine the materials underlying the storage area (fig. 3; table 1). Brief examinations of the material were made in the field and very approximate logs were prepared.

Quick dispersion tests were undertaken on samples from pits 1, 2, 4, 6, and 7. Some of the material has slight dispersive properties, particularly that from pits 1 and 4.

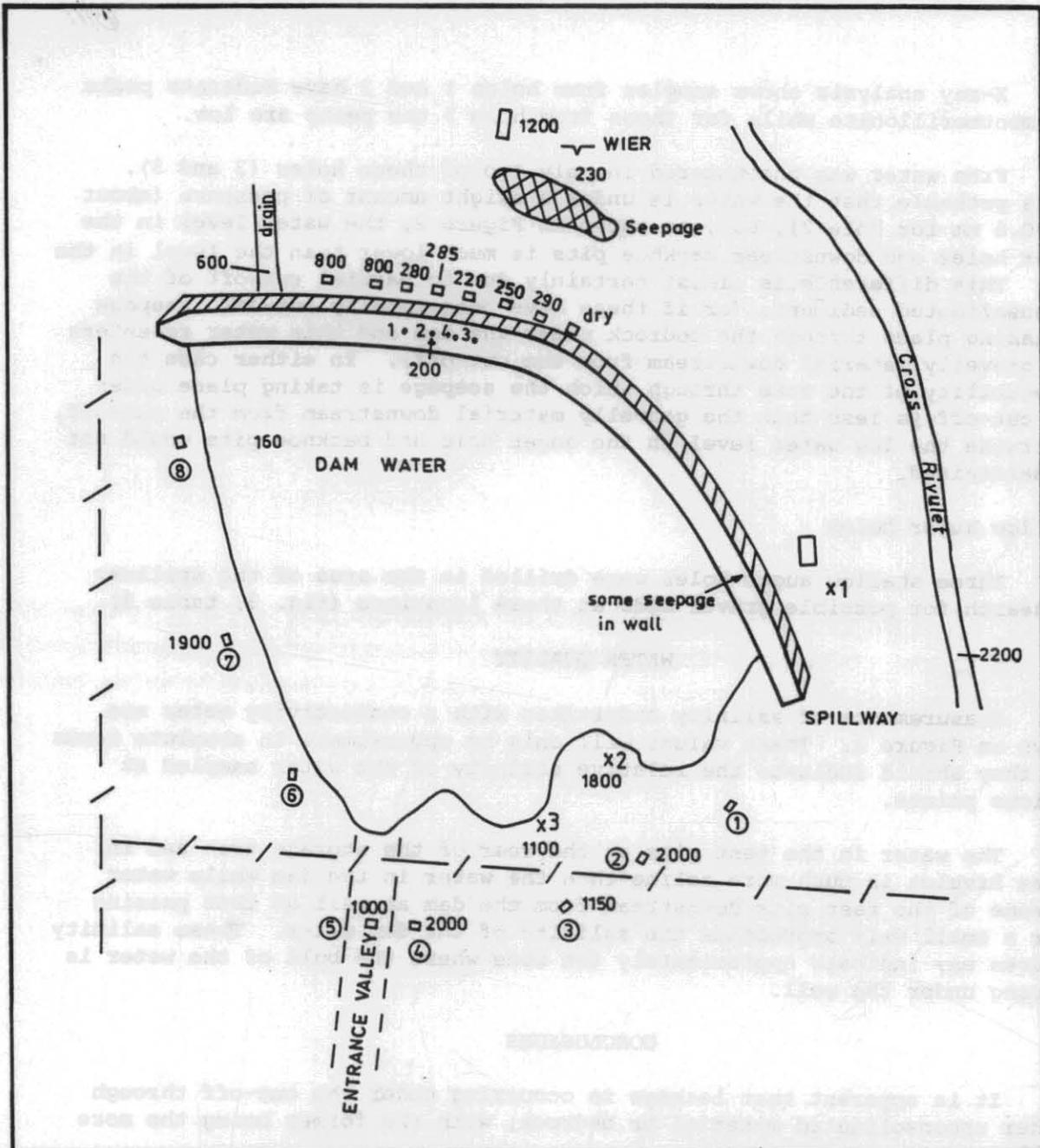
X-ray analysis undertaken on the same samples show small peaks for (and probably low percentages of) montmorillonite for samples from pits 1 and 2, very strong peaks for the slickensided sample from pit 4 (a little kaolinite also) and strong peaks for samples from pits 6 and 7.

AUGER HOLES

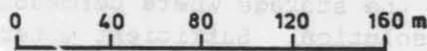
Auger holes were drilled in the wall of the dam near where it was thought that the seepage under the dam was occurring (fig. 3; table 2).

Further drilling was prevented in each hole by hard conditions. In each case gravel sand and/or clay was on the bottom of the augers to the depth drilled. The difficulty in drilling deeper was probably caused by a large boulder in the unconsolidated sediments although unweathered bedrock is a possibility.

Again slight dispersiveness is indicated in some of the samples penetrated.



SKETCH OF DAM AT CRAIGOW
W.L. MATTHEWS

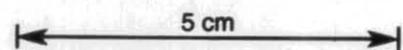


- Backhoe pit
- ⊙ Pit no.
- ◇ Salinity
- x Shallow auger hole
- Auger hole

TASMANIA DEPARTMENT OF MINES, APRIL 1984

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Figure 3.



X-ray analysis shows samples from holes 1 and 2 have moderate peaks for montmorillonite while for those from hole 3 the peaks are low.

Free water was encountered in only two of these holes (2 and 3). It is probable that the water is under a slight amount of pressure (about 0.3-0.6 mm for hole 2), but, as shown in Figure 2, the water level in the auger holes and downstream backhoe pits is much lower than the level in the dam. This difference is almost certainly due to partial cut-off of the unconsolidated sediments (or if these have been totally cut-off, seepage is taking place through the bedrock under the dam and this water re-enters the gravelly material downstream from the cut-off). In either case the permeability of the zone through which the seepage is taking place under the cut-off is less than the gravelly material downstream from the cut-off, otherwise the low water level in the auger hole and backhoe pits would not be maintained.

Shallow auger holes

Three shallow auger holes were drilled in the area of the spillway to search for possible gravel beds at these locations (fig. 3; table 3).

WATER QUALITY

Measurements of salinity undertaken with a conductivity meter are shown on Figure 3. These values will only be approximate in absolute terms but they should indicate the relative salinity of the water sampled at various points.

The water in the test pits at the rear of the storage area and in Cross Rivulet is much more saline than the water in the dam while water in some of the test pits downstream from the dam as well as that passing over a small weir approaches the salinity of the dam water. These salinity figures may indicate approximately the zone where the bulk of the water is seeping under the wall.

CONCLUSIONS

It is apparent that leakage is occurring under the cut-off through either unconsolidated material or bedrock, with the former being the more likely.

If leakage is taking place through permeable unconsolidated material, a deeper cut-off is a possible solution. If the present cut-off extends to bedrock and seepage is occurring through either dolerite or sandstone, a clay blanket over zones of the storage where permeable material is near the surface is a possible solution. Sufficient material to undertake this would need to be proved.

Material from drill holes and test pits around the storage area indicates that low permeability material occurs at the surface at all points examined and perhaps the only areas where relatively permeable material occurs in the storage area is where material was extracted for the wall construction.

As sediment in run-off water is deposited in the dam, the seepage rate may decrease with time and either or both of the two measures outlined above, would be unnecessary. Although some of the materials around the dam have slight dispersive properties, development of pipes is an unlikely cause of the water loss.

POSSIBLE FURTHER WORK

As the auger drilling (and backhoe holes downstream of the dam) has not located the level of bedrock other work could be undertaken to aid in determining this depth.

- (1) A seismic refraction survey could be undertaken downstream from the dam wall. This should produce a profile of the unweathered bedrock surface and indicate the approximate depth to it. Such a survey would take about 2-4 hours and the probable cost would be \$100-200.
- (2) A series of drill holes including diamond drilling could be undertaken to locate bedrock at a few points. Boulder beds and gravel deposits are usually difficult to drill through and it could be a relatively expensive operation.

REFERENCE

LEAMAN, D.E. 1973. Geological atlas 1:50 000 series, sheet 82 (8312S), Hobart. Department of Mines, Tasmania.

[19 April 1984]

Table 1. LOGS OF TEST PITS DUG BY RIVERS AND WATER SUPPLY COMMISSION

Hole	Estimated depth (m)	Remarks
1	0.2	Plastic brown clay passing into gravelly clay.
2	~1.3	Brown plastic clay on surface, fine gravel and sand in clay, some gravel fragments weathered. ~0.3 m of water soon after digging. Salinity of water: 2000 mg/l.
3	~2.8	Appears to be mainly dolerite derived clay to about 2.4 m then travertine around trench. Water coming in at 2.4 m. Salinity of water: 1150 mg/l.
4	0 -0.5 0.5-1.3 1.3-2.6	Brown silty clay. Brown gravelly clay. Clay becoming harder towards bottom - breaks on fissured surfaces which are damp. Travertine on contact of 2 lower materials. Water seeping slowly in from bottom. Salinity of water: 2000 mg/l.
5	- 0 -0.5 0.5-1.2 1.2-2.6	In bed of stream. Gravelling clay and silt - water coming in. Bouldery clay. Clay, becoming harder with depth - fairly dry. Travertine on contact of lower 2 materials - shallower water. Salinity of water: 1000 mg/l.
6	0 -0.3 0.3-1.2 1.2-2.4	Silty brown clay. Brown gravelly clay with fragments mainly up to 6 mm usually but also occasionally up to 75 mm. Grey slickensided clay, becoming fairly compact. Travertine to bottom from contact with gravel. No significant seepage.
7	0 -0.6 0.6-1.2? 1.2?-2.4	Grey silty clay. Gravelly and bouldery clay. Gritty (quartz) clay. Travertine in final 0.8 m. Seepage at about 1.5 m from surface, fairly strong. Salinity of water: 1900 mg/l.

Table 1. (continued)

Hole	Estimated depth (m)	Remarks
8	0 -0.8	Dolerite boulders in clay - became too hard to excavate.

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Table 2. LOGS OF AUGER HOLES

Hole	Depth (m)	Remarks
1	0 -0.9	Gravelly clay.
	0.9-3.3	Brown sandy clay.
	3.3-5.2	Grey brown silty clay.
	5.2-7.0	Grey brown silty clay, a few pebbles. Brown clayey sandy gravel at end.

Further drilling prevented.

2	0 -1.5	Brown sandy clay, abundant gravel fragments.
	1.5-3.3	Brown sandy clay, a few gravel fragments.
	3.3-5.2	Brown sandy clay.
	5.2-7.0	Brown pebbly clay, pebble layer at about 6.1 m followed by clayey sand.
	7.0-8.2	Brown pebbly clay and about 7 cm band of clayey sand.

Further drilling prevented.

Water on the last one metre of augers on withdrawal. Standing water level is about 7.0 m below the surface and the hole was open to 7.5 m on completion. Water conductivity 400 µS/cm (200 mg/l).

3	0 -5.2	Grey brown gravelly clay.
	5.2-7.6	Brown gravelly clay.

Further drilling prevented.

The bottom 5 cm of the augers were wet on withdrawal.

4	0 -5.2	Light brown gravelly clay.
	5.2-7.0	Darker brown clay, some gravel fragments.

Further drilling prevented.

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Table 3. LOGS OF SHALLOW AUGER HOLES

Hole	Depth (m)	Remarks
1	1.2	Plastic clay at the surface with gravelly clay at lower levels. Hard zone prevented further drilling.
2	0 -1.5	Plastic clay and clayey sand (no free water).
	1.5-2.4	Clay with some gravel.

Water struck in final part of hole and this rose quickly to 0.3 m below the surface.

Salinity of water: 1800 mg/l.

3	0 -1.5	Clay and sandy clay (no free water).
	1.5-2.7	Clay and gravel.

Water came in quickly in the final section.

Salinity of water: 1100 mg/l.