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Record 1975/19

DRAINAGE INVESTIGATION AT MONARO CRESCENT, RED HILL, ACT

by

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SUMMARY

A soil drainage problem in Monaro Crescent, Red Hill, is caused by groundwater from the underlying fractured-rock aquifer rising under pressure to the surface. The fractured-rock aquifer underlying the basin is overlain by alluvium and colluvium near the surface outflow point. Thick clay soils within the upper part of the alluvium and colluvium have low permeabilities and blanket the aquifers below. The hydraulic head of water in the aquifers is attributed to the higher level of the intake areas of the fractured-rock aquifer in the surrounding foothills. Water from the aquifer rises to the surface as springs within the alluvium and colluvium wherever a more permeable path exists through the clay soils. Construction of a trench drain has been proposed as the first step towards solving the problem; however the presence of clay soils, and the substantial hydraulic head of water in the fractured-rock aquifer, indicate that the effect of the trench drain will be minimal and confined to areas adjacent to the trench.

INTRODUCTION

An extensive drainage problem is located adjacent to Monaro Crescent, Red Hill, near the Canberra Boys' Grammar School (Fig. 1). Areas of saturated soils occupy the recreation ground near Quiros Street; water seeps through cracks in the bitumen pavement of Monaro Cresent, and the nature strip of the Grammar School is waterlogged. The problem was first investigated by BMR Geologists in 1969 and 1970. In February 1972, the Commonwealth Department of Works (now the Department of Housing and Construction) requested additional information, with special reference to a proposed drainage system along the western side of Monaro Crescent, south of Flinders Way. The investigation, which involved augering and sampling of undisturbed soil core, was carried out early in 1972.

Other drainage problems in the catchment had previously been investigated in Torres Street (Wilson & Noakes, 1959), Mugga Way, (Wilson, 1959), and Jansz Crescent, Griffith (E.G. Wilson, pers. comm.).

PHYSIOGRAPHY OF THE CATCHMENT AREA

The catchment area involved in the drainage problem is approximately 10 km^2 (Fig. 1). Two main physiographic elements are discernable (Fig. 2):

(1) the Red Hill-Mugga Mugga ridge and steeper slopes form the high ground to the west, and have a cover of skeletal soils with high infiltration rates; and

(2) lower ground forms a gently sloping depression, covered by alluvium and colluvium in the lowest parts with a development of thick clay soil in the upper part of the profile. Permeability within the clay soils is moderate to very low.

The underlying rocks include weathered igneous rocks (Mt Painter Porphyry) and volcanic and sedimentary rocks of the Red Hill Group (Fig. 1).

The natural watercourses shown in Figure 1 have been infilled as the areas were developed, and stormwater drains have been installed within the fill along these watercourses. Fill has been placed over most of the waterlogged area and formed into playing fields, but waterlogging of the fill is still evident in some places.

SOILS INVESTIGATION

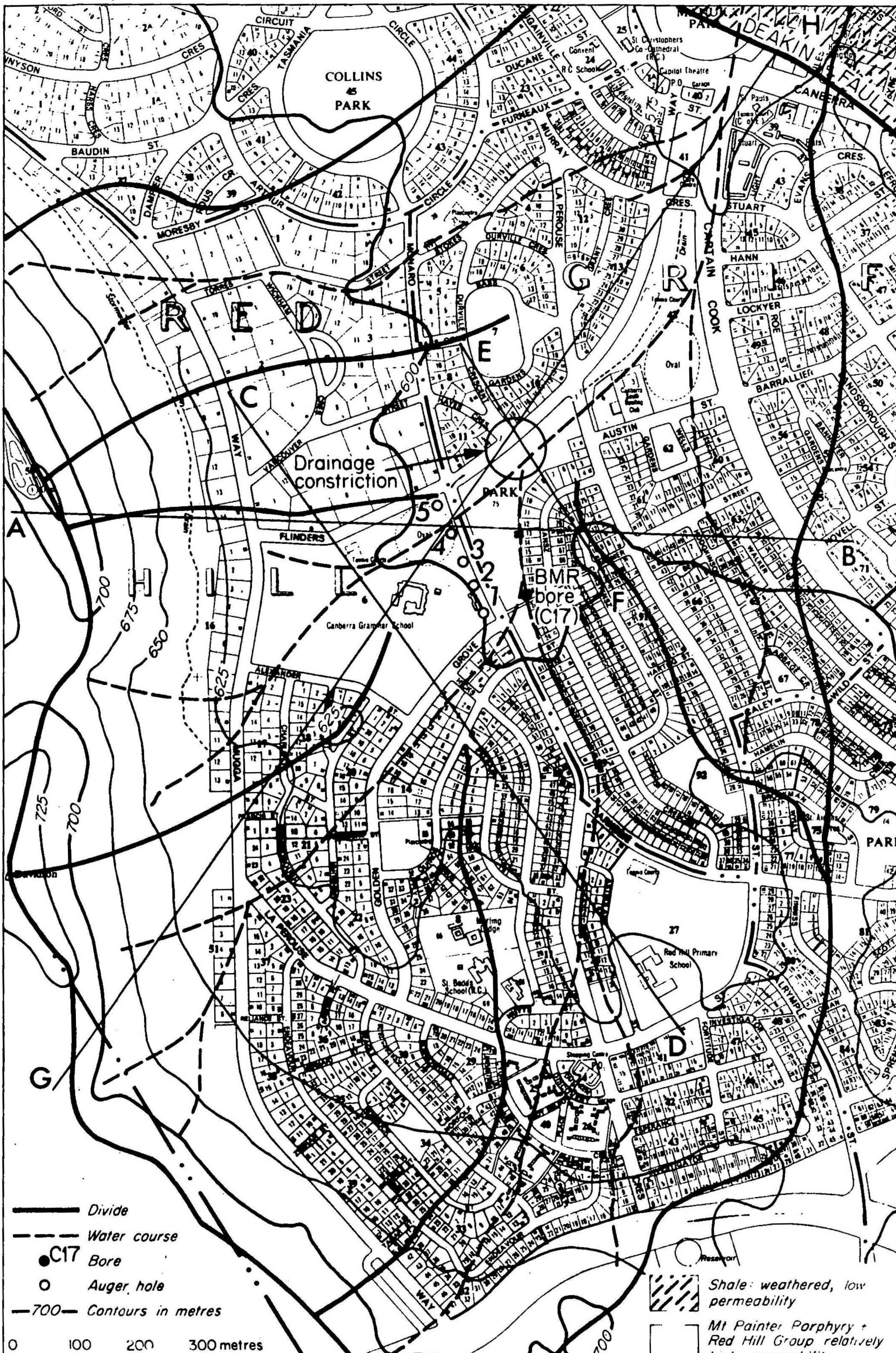
On 28-29 February 1972, 5 auger holes were drilled by a BMR Proline power auger; the locations of the holes are indicated in Figure 1. Undisturbed soil cores were taken from hole No. 2, and augering with flight augers recovered disturbed soil samples from the remaining holes. Logs of the 5 holes are shown in Appendix 1.

All holes were fitted with 5.08 cm I.D. waterpipe, in an unsuccessful attempt to use the holes as piezometers. However, sufficient information was obtained during drilling and immediately before running the waterpipe to determine standing water levels.

A fairly consistent soil profile is indicated by the logs of the 5 holes: clay and sand overlie completely weathered rock. Each hole was drilled to auger refusal.

The level at which water was struck in the holes differed greatly: in hole No. 2 water was struck at 0.6 m and in hole No. 3 at 3.3 m. Although the soil profile is similar in the 5 holes drilled, minor changes in soil texture result in variations in soil permeability.

Holes No. 1 and 5 are situated beside the carriageway of Monaro Crescent. At the time the holes were drilled the road gutter was continuously wet owing to seepage. In both holes water was struck between 1.8 and 2.1 m and quickly rose to the surface.



Record 1975/19 Fig. 1 Map of catchment area, Red Hill. 155/A16/1276

GROUNDWATER HYDROLOGY

Groundwater is present in two different aquifer systems in this area:

1. the more permeable lower layers of alluvium and colluvium in the lower parts of the catchment; and
2. the open fractures in the bedrock which constitute the main aquifer with a higher permeability than other materials in the area.

In the lower parts of the catchment both aquifers are blanketed by clay soils of low permeability, and are confined or semi-confined. As the recharge areas of the fractured-rock aquifer are located in the higher slopes of the catchment, water in the aquifer in the lower part of the catchment is under pressure with a hydraulic lead attributable to the higher levels of the aquifer recharge areas. Water from the fractured-rock aquifer is able to rise under pressure through the more permeable parts of the alluvium and colluvium; the clay soils at the surface become saturated and water emerges as springs and seeps, and much of the area is waterlogged. The level to which groundwater would rise if the confining soils were penetrated is known as the potentiometric surface of the confined aquifer (Fig. 2); the potentiometric levels of BMR bore C17 are shown in Figure 3, and relate to the fractured-rock aquifer. Over much of the area the potentiometric surface lies above ground level and the soils are saturated, and even in adjacent areas where the potentiometric surface is low but still close to ground level, capillary action brings about seepages and waterlogging at the surface.

Transmission of water from the aquifers to the surface depends on the permeability of the overlying materials, and even though permeability may be low, transmission of water will still occur, but follows the more permeable routes which are in many cases associated with artificial disruptions of the soil by removal of trees or the digging of trenches. The larger discharges at the surface are commonly due to a combination of these factors. The placement of large amounts of fill, which generally has a permeability greater than that of the underlying soils, has to some extent provided drainage within the fill, and intercepts water that otherwise would have risen to the surface if the fill had a very low permeability.

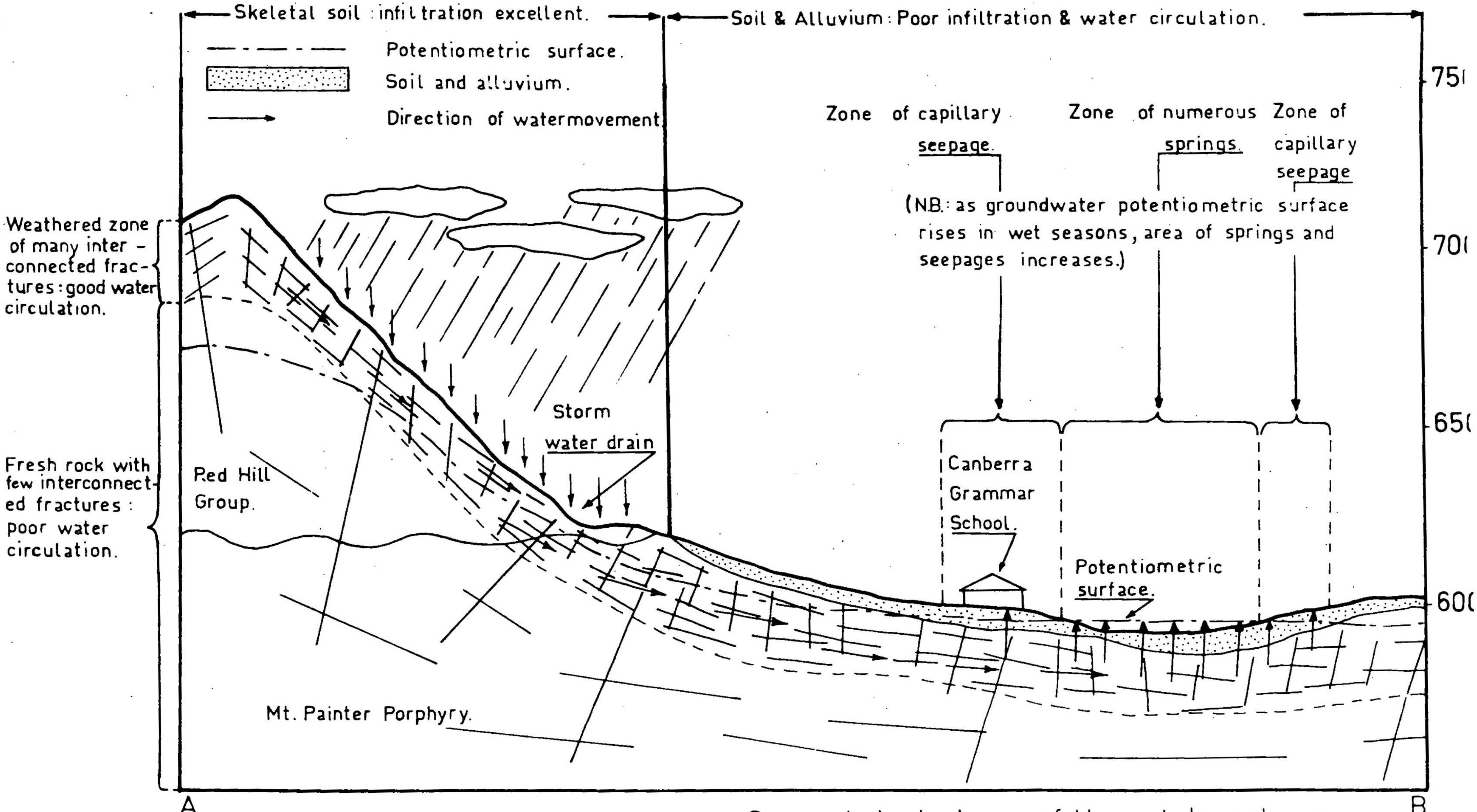
An inspection of the playing fields at the Grammar School shows that seepages are found near the foot of cuts in the natural surface, and that the areas of fill are unaffected. The seepages can be attributed to lowering of the ground levels in the cuts to a level close to the potentiometric surface, and seepages cause the ground to become waterlogged.

The gradient of the potentiometric surface of the main aquifer varies considerably across the area. It is influenced by the general pattern of groundwater movement within the catchment, the rate of recharge, and the discharge that takes place from the lower part of the catchment. Fracture zones aid permeability and extremely weathered zones will reduce permeability, and these zones in the aquifer cause local variations of the potentiometric surface in their immediate vicinity.

Factors, other than rainfall in the catchment, that affect the groundwater regime are recharge from garden watering on one hand and discharge through evapo-transpiration on the other. Effective infiltration on the higher ground from garden watering in Red Hill probably makes a significant contribution to recharge. Discharge from the aquifers is probably restricted by:

1. the Deakin Fault (Fig. 1), where weathered sedimentary rocks of low permeability on the northern (downstream) side of the fault restrict groundwater movement from the catchment (Fig. 4); and
2. a geomorphological constriction or narrowing of the drainage basin with reduction in the cross-sectional area of aquifers near the corner of La Perouse Street and Flinders Way (Fig. 5). Upstream of the constriction the catchment is broad, opening out to take in an extensive area drained by four watercourses.

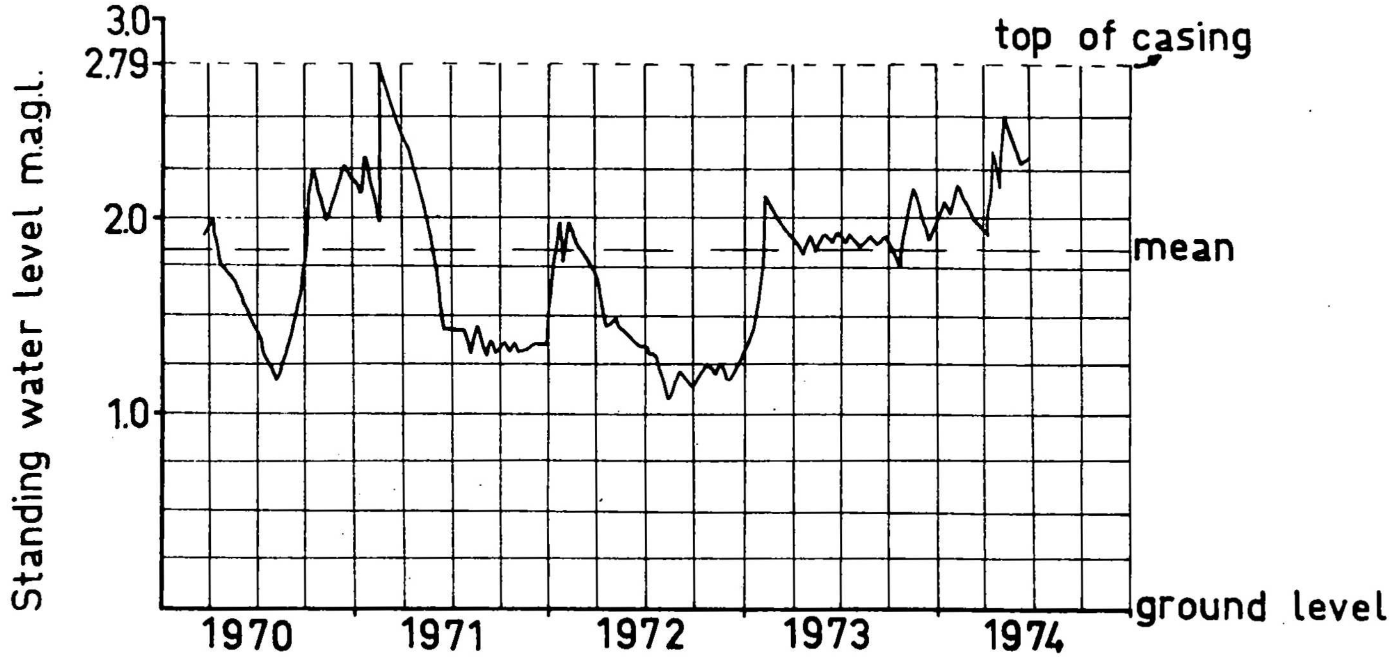
FIG : 2



Record 1975/?9 Horizontal scale : 1 : 10,000

General hydrology of the catchment

WATER LEVELS IN OBSERVATION BORE C17, 1970 TO 1974.



Mean standing water level = 1.82 m.a.g.l.

FIG: 3

EFFECT OF THE DEAKIN FAULT ON GROUNDWATER MOVEMENT.

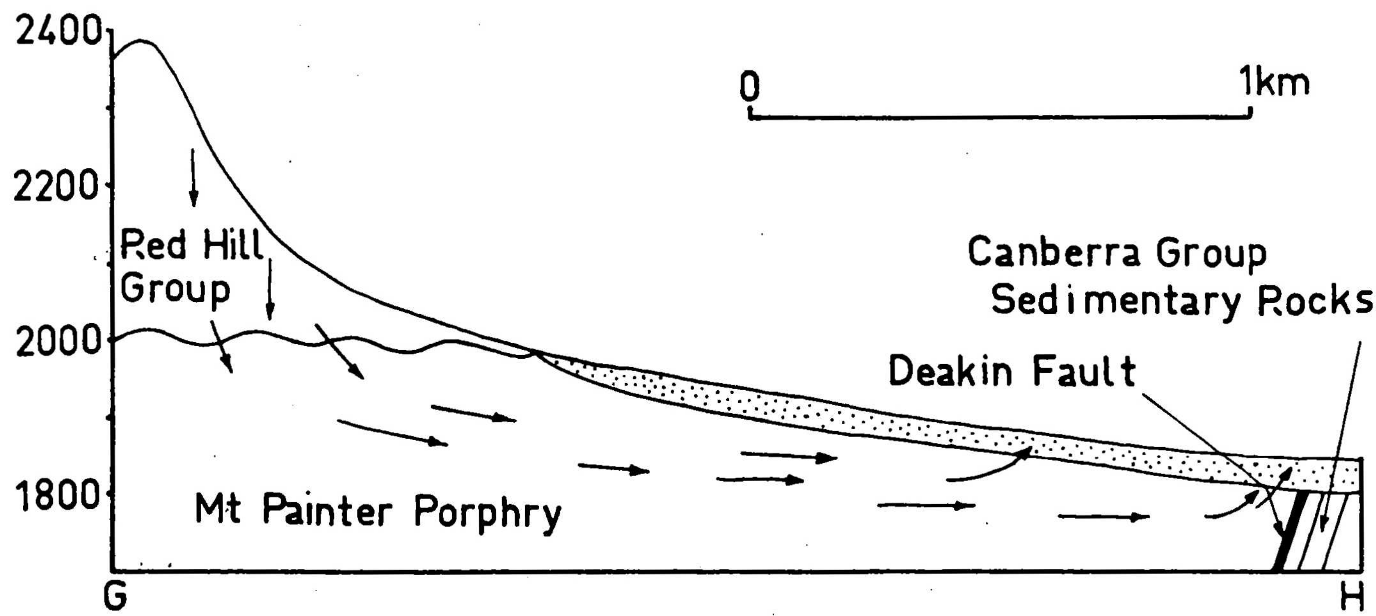
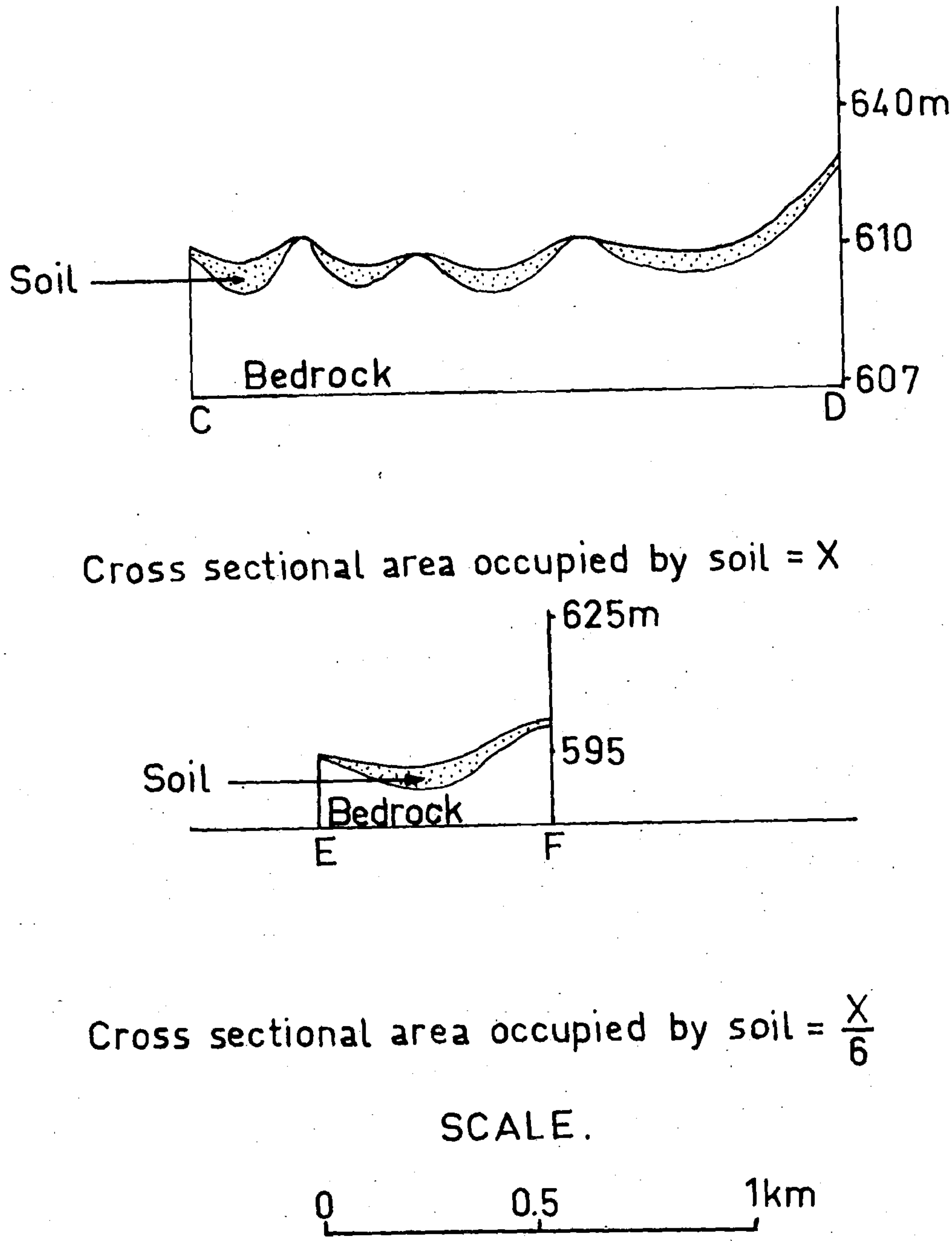


FIG: 4



Schematic cross-section showing the narrowing of the drainage basin near the intersection of La Perouse St. and Flinders Way. Assuming that the cross-sectional area of the soil profile is X in profile C-D, the cross-sectional area of soil in profile E-F is reduced to $\frac{X}{6}$, and hence the ability of the soil to transmit water is reduced. See Figure 1 for location of profiles.

Aerial photographs taken in 1944 show that a drainage problem existed in the area before urban development and is a natural condition; however, it may have been aggravated by the filling of erosion gullies during development. Shallow piezometers (0.9 m deep) installed near Quiros Street in October 1969 showed water level 13 cm above ground level. After heavy rainfall on 30 and 31 October the piezometers showed a rise of the potentiometric surface to more than 25 cm above ground level. Early in 1970, bore C17 was completed and water levels of up to 2 m above ground level were measured immediately after drilling.

Because the auger holes along Monaro Crescent were unable to penetrate the fractured rock aquifer, it was not possible to prove that vertical leakage is taking place upwards into the soil profile from the underlying fractured rock; however, bore C17 positively indicates high pressure in the fractured rock aquifers, and earlier work in the adjacent catchment to the north at Torres Street (Wilson & Noakes, 1959) proved that soil water was directly controlled by pressure from the fractured-rock aquifer below.

Because of the difficulty in completing the holes as piezometers, it was not possible to monitor water levels in the auger holes to assess seasonal variations near the site of the proposed drain. The plot of the water levels in bore C17 shows that the water level in 1972 was the lowest prevailing over the last five years, and that the seasonal variation is about 1 m; however, as the standing water level in this bore has never fallen below a point 1 m above the ground level, it is considered that any seasonal variation in the water level in the auger holes would have been negligable.

In the Monaro Crescent area, not only does the low permeability of the surface soil in the lower part of the valley confine water in the aquifers and permit only slow, persistent seepage to the surface, but it also prevents infiltration. Runoff from the catchment causes some flooding in the lower areas even after light rain. The preservation of a smooth sloping surface on the lower ground and diversion of surface water from the affected area would facilitat runoff; however, it would not reduce the waterlogging that is attributable solely to the confined aquifers below.

ASSESSMENT OF THE PROPOSED TRENCH DRAIN

The purpose of a trench drain is to produce a trough of depression along the line of the basin. The success of the drain will depend on its location and the permeability of the soil adjacent to the drain, and their ability to transmit the quantity of groundwater entering the soils from the aquifers below. Although soil permeabilities were not measured, the nature of the soil is such that permeability will generally be low with some local variation within the soil strata. An extensive trough of depression can best be obtained when highly permeable layers are tapped, and as such layers do not exist in this area, depression of the potentiometric surface by the trench drain will be minimal.

In several pumping tests of bores in fractured-rock aquifers in the Canberra region it has been observed that the cone of depression forms quickly and does not extend far initially because fractured rock is only moderately permeable; extension of the cone of depression takes place only after prolonged pumping for three or four days. The permeability of the sand and clay at Monaro Crescent is much less than that of the fractured-rock aquifer and so the lowering of the groundwater level in the soils will be delayed relative to movement of the potentiometric surface of the pumped aquifer.

Effective drainage of groundwater from the catchment would be achieved only when average discharge from the aquifers is of the same order as average recharge. The flow pattern shows an area of constriction at the northern corner of the hockey fields where the flow lines converge and the cross-section of the fractured-rock aquifer is approximately 10 percent of the cross section within the catchment further upslope. To attain equilibrium between discharge and recharge, water from natural recharge plus artificial recharge through lawn watering must pass through this constriction or be removed by drainage or by pumping. No reliable estimate of groundwater discharge to attain this condition has been made, but about 70 to 90 m^3 per hour has been estimated for the fractured-rock aquifer, and that from the soil aquifers is considered to be minor by comparison.

As the main contributor to the drainage problem is considered to be the fractured-rock aquifer, and as any practicable drain will not have any direct connection with this aquifer, it seems unlikely that the drain can have an appreciable effect. When the trench drains are constructed, a groundwater monitoring system should be set up to assess their effect.

CONCLUSIONS

1. Groundwater in the soil profile is under pressure transmitted from the aquifers below, and is the reason for the waterlogged soils along the nature strip and for the continuous water seepages through cracks in the pavement of Monaro Crescent near the Grammar School.

2. The main shallow aquifer is at a depth of 1.8 to 2.1 m between holes No. 1 and 5, and a minor aquifer occurs at 3.3 m in holes 3 and 4; these aquifers are in extremely weathered rock.

3. At the time of the investigation there was no visible seepage from the fill that had been placed and levelled to provide playing fields for the Grammar School. However, it is noticeable that seepages take place wherever levelling for playing fields has cut into the natural slope, which indicates that the cut has reduced the ground surface to a level at or near that of the potentiometric surface.

4. Although permeability was not measured, the nature of the material in the upper 4.5 m is such that permeability would be low, but would show some variation. A longitudinal trench drain in these soils is not expected to have an effect laterally of great significance, and if recharge is vertical from the fractured-rock aquifer, and this is considered to be the case, then the effect of the drain will be minimal.

RECOMMENDATIONS

(1) If the drainage system proposed by the Department of Housing and Construction is installed, and assuming that it will be in the vicinity of auger holes 1-5 (Fig. 1), it should extend to a depth of at least 2.1 m particularly between holes 1 and 5, and the pipes should be set as deep as possible. To ensure that the aquifer at the 3.3-m level is successfully tapped, regularly spaced vertical sand drains should be excavated to 3.6 m and backfilled with sand or gravel to pipe level and the main drain backfilled with permeable material to within 0.3 m of ground level.

(2) The drainage pipes should be open-jointed and laid in a thick bed (at least 1 m) of well sorted (poorly graded) sand or gravel to increase efficiency.

(3) A confining layer of well-packed clay 0.3 m thick should be placed at the surface to prevent downward infiltration of surface water.

(4) To evaluate the efficiency of the drainage system it is recommended that 3 or 4 piezometers be installed along Monaro Crescent, upstream (Grammar School side) and downstream (hockey field side) of the drain.

REFERENCES

WILSON, E.G., & NOAKES, L.C., 1959 - The effect of pumping from a bore on the drainage problem at Torres Street, Red Hill. Bur. Miner. Resour. Aust. Rec. 1959/66 (unpubl.).

WILSON, E.G., 1959 - The drainage problem at No. 16 Mugga Way, Red Hill. Bur. Miner. Resour. Aust. Rec. 1959/55 (unpubl.).

APPENDIX 1

LOGS OF AUGER HOLES

(See Fig. 1 for location of holes)

HOLE 1 Metres	(Augering)
0 - 0.9	Heavy black clay, moist
0.9 - 1.5	Heavy grey clay, moist
1.5 - 2.1	Sandy light brown and grey clay, moist
2.1 - 2.4	No soil recovered owing to water; slow penetration
2.4 - 4.5	Light yellow, sandy clay, probably completely weathered rock.
	Water was struck at 2.1 m
	Standing water level at ground surface

HOLE 2 Metres	(Undisturbed coring)
0 - 1.2	Black organic clay, becoming lighter in colour with depth, moist
1.2 - 3.6	Weathered rock
	Water was struck at 0.6 m
	Standing water level 0.6 m below ground surface

HOLE 3 Metres	(Augering)
0 - 0.9	Black organic clay, getting lighter with depth, moist
0.9 - 3.0	Grey, sandy clay, moist
3.0 - 4.5	Clayey sand, some water was struck at 3.3 m
	Standing water level 1.2 m below ground surface

HOLE 4 Metres	(Augering)
0 - 3.3	Clay of varying colour and sand content, most likely fill, moist
3.3 - 5.4	Water-saturated sandy, yellow clay, probably weathered rock
	Water was struck at 3.3 m
	Standing water level 1.2 m below ground surface

HOLE 5 Metres	(Augering)