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RECLAIMED SEWAGE WATER PROJECT, R M C, DUNTROON
- GROUNDWATER INVESTIGATION, 1976-77

by

P.D. HOHNEN

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CONTENTS

	Page
SUMMARY	
INTRODUCTION	1
FIELD OPERATIONS	"
GEOLOGY AND SOILS	"
GROUNDWATER	"
CONCLUSIONS AND RECOMMENDATIONS	2

FIGURES

1. Flow net showing predicted flow directions for groundwater in perched aquifers.

TABLES

1. Maximum potentiometric-level variations (14.12.76 to 11.10.77)

APPENDICES

1. Duntroon water re-use project - auger hole logs, piezometers 1 to 7.
2. Bacteriological analysis of groundwater from piezometers, by Department of Health laboratory, Fyshwick, ACT.

SUMMARY

Soil and groundwater conditions in perched aquifers have been determined at Duntroon prior to irrigation with partially treated effluent. Travel times to Lake Burley Griffin for groundwater that has infiltrated close to the lake (about 150 m) and for areas furthest from the lake (about 500 m) have been estimated to lie within the range 20 to 200 days and 68 to 680 days respectively. Bacteriological analysis of groundwater sampled from piezometers prior to irrigation with re-cycled water has shown a source of faecal pollution to lie upslope from the area monitored. Seasonal fluctuations of the potentiometric surface of perched aquifers are less than one metre.

INTRODUCTION

BMR has been a member of an inter-departmental working group that is investigating and monitoring the pilot water re-use project at the Royal Military College, Duntroon. On behalf of the National Capital Development Commission (NCDC), groundwater conditions at the site have been investigated and a monitoring program established. The project involves the use of partially treated sewage effluent for spray irrigation of playing fields at the college. Groundwater is to be analysed as it migrates through soil aquifers into the Molonglo River just upstream of Lake Burley Griffin.

FIELD OPERATIONS

In December 1976, Stewart Brothers Drillers, under an NCDC period contract supervised by BMR, drilled seven power-auger holes to refusal in the area to be irrigated (Fig. 1). The holes were continuously cored and fitted with slotted PVC casing to form piezometers. Logs of the soil cores appear in Appendix 1 of this report.

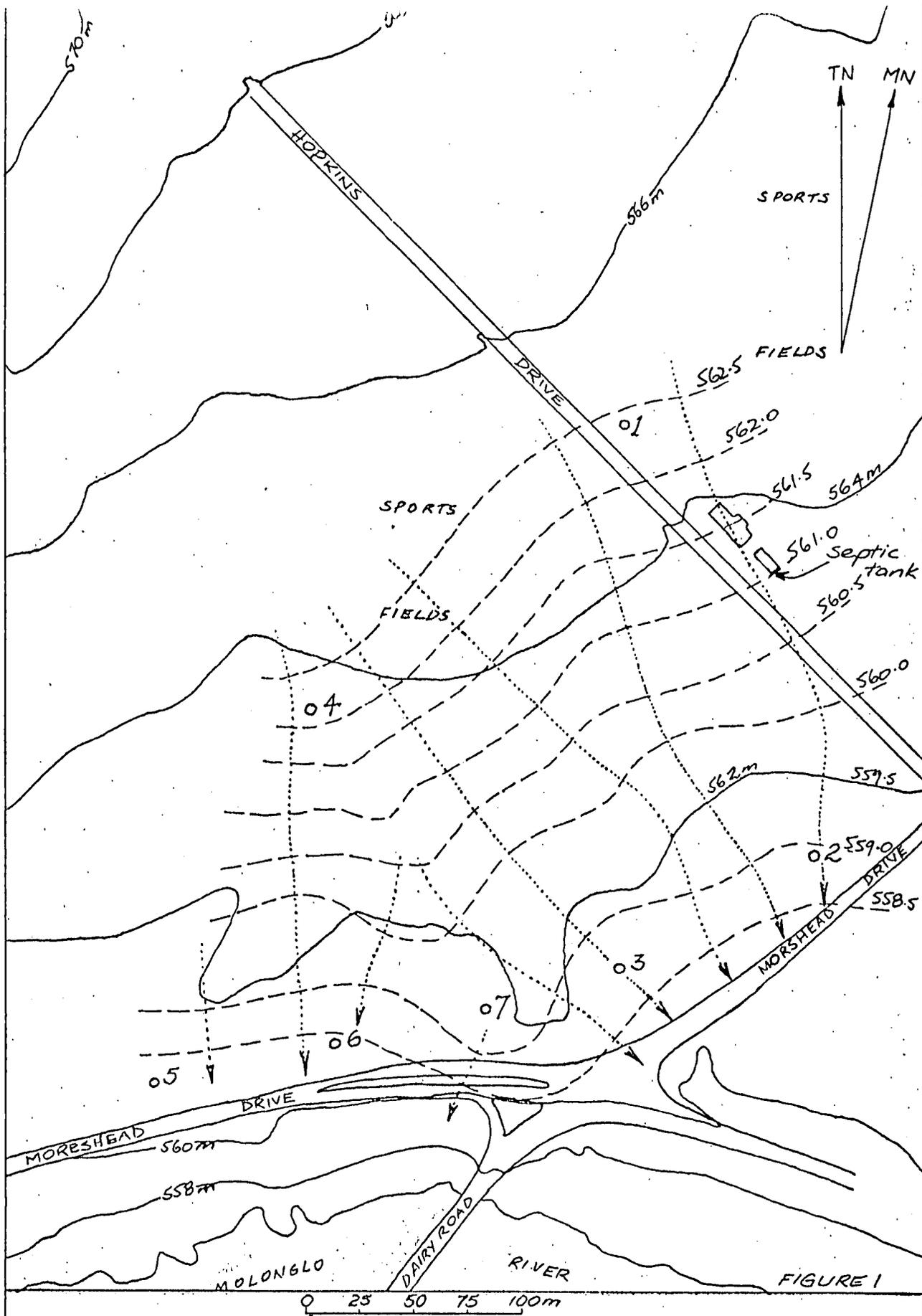
GEOLOGY AND SOILS

The soil logs indicate that the area to be irrigated overlies the geological boundary between acid volcanic rocks (rhyodacite and ashstone) and sedimentary rocks (shale). These rocks are generally extensively weathered to depths of 5-7m, and are overlain by transported soils derived from volcanic rocks. The soils have weathered in situ to lean clay or sandy clay, but include some sand and gravel layers of high permeability which probably represent the deposits of former watercourses. The sand and gravel beds are poorly graded, generally less than 40cm thick, and commonly appear at several levels in the soil profile.

GROUNDWATER

All auger holes intersected groundwater at various depths that are shown in Appendix 1. The water was sampled for bacteriological analysis to obtain pre-irrigation water-quality data. High E. coli levels showed at least four holes to be polluted with sewage (Appendix 2). The pollution was traced to a septic tank (Fig.1).

The various aquifers intersected during drilling are almost certainly interconnected, because the high hydraulic heads



FLOW NET SHOWING PREDICTED FLOW DIRECTIONS FOR GROUNDWATER IN PERCHED AQUIFERS

562 — topography;
 559 — isopiestic contour (m);
 groundwater flow line

in the lower aquifers - often higher than ground surface - promote upward leakage between aquifers. Potentiometric contours (lines of equal hydraulic head) are shown on Figure 1; variations in potentiometric levels measured over the past year (Dec 76 to Oct 77) are shown in Table 1.

The flow lines on Figure 1 show that groundwater in shallow soil aquifers flows towards the Molonglo River near the entrance to Lake Burley Griffin. It is anticipated that travel times to the lake for water that has infiltrated as deep as soil aquifers - and this will only take place during drier periods when the potentiometric surface is low enough - will be fairly long. Assuming the permeability of the most conductive aquifer lies within the range 1 to 10m/day, then travel rates for groundwater moving parallel to the flow lines on Figure 1 would be between 1.6 and 16 cm/day, giving travel times of between 200 and 680 days and 20 and 68 days respectively.

TABLE 1. Maximum potentiometric-level variations (14.12.76 to 11.10.77)

Piezometer No. 1 - 0.76m	Piezometer No. 5 - 0.57m
Piezometer No. 2 - 0.65m	Piezometer No. 6 - 0.53m
Piezometer No. 3 - 0.46m	Piezometer No. 7 - 0.85m
Piezometer No. 4 - 0.73m	

CONCLUSIONS AND RECOMMENDATIONS

1. Background groundwater conditions have been determined prior to irrigation with waste water.
2. Unexpected pollution of shallow groundwater has been demonstrated. Pollutant levels are far higher than can be expected from planned irrigation with waste water.
3. When the source of pollution is removed - it is thought to be a septic tank - it could take a considerable time to flush polluted groundwater from the aquifers.
4. Water samples should be taken from piezometers holes periodically to determine the elutriative effects of infiltrated irrigation water.

APPENDIX 1
DUNTROON WATER RE-USE PROJECT - AUGER HOLE LOGS,
PIEZOMETERS 1 TO 7.

DUNTROON NO. 1

dry 0 - 38 cm very fine brownish yellow sand becoming more orange with increasing depth (SP)

" 38-61 cm brownish orange, fine sandy lean clay (CL)

" 61-90 cm no recovery

" 90-150 cm slightly brownish orange, slightly clayey, very fine sand (ML)

" 150-180 cm no recovery

" 180-213 cm bright yellow clayey sand with manganese nodules (SC)

" 213-223 cm highly weathered rhyodacite with manganese nodules

" 223-275 cm no recovery

v. sl. moist 275-305 cm very stiff yellow clay (CH) with grey streaks and mottles, pebbles and MN nodules

305-366 cm no recovery

sl. moist 366-396 cm mottled pale grey and pale brownish yellow fine sandy CH clay with scattered pebbles and white and pink shale fragments

396-434 cm no recovery

saturated (aquifer) 434-442 cm pink clayey coarse sand (SC)

dry 442-488 cm moderately strong, pinkish, slightly phyllitic shale with some yellow clay bands 11 cm thick and some highly weathered pink, sandy, silty, shale sections

488-526 cm no recovery

DUNTROON NO. 2

0-30 cm yellowish brown fine sandy silt (MC)

30-90 cm no recovery

90-172 cm mottled brownish orange and pale brownish grey clay (CH) with manganiferous tubules and spots

172-180 cm orange clay (CH)

moist 180-240 cm predominantly brownish orange diffusely mottled with yellowish grey, lean clay (CL)

240-270 cm no recovery

270-291 cm saturated sandy, gravelly (2-5 mm) lean clay (GC)

291-338 cm mottled brownish orange and grey, sandy gravelly clay with Mn nodules. Also bands of gravel (2-5 mm diameter) up to 4 cm thick (CL, GP)

(ii)

338-360 cm no recovery

saturated at top, sl. moist at bottom of run 360-438 cm vaguely mottled brownish yellow and yellowish grey sandy and slightly gravelly (grains 2-5 mm diam.), lean clay with some clayey sand bands (CL)

438-450 cm no recovery

saturated 450-475 cm collapse material comprising brown sandy and fine gravelly clay (CL)

475-507 cm pale grey and dark brownish orange mottled slightly sandy, slightly gravelly clay with large Mn nodules near base (CL)

507-540 cm no recovery

540-562 cm mottled yellow-brown and grey sandy clay grading down wards to mottled yellow and pale grey sandy clay (CL)

DUNTROON NO. 3

0-15 cm fine sandy silt (ML)

15-90 cm no recovery (probably loose topsoil)

90-120 cm orange-brown, v. stiff dry sandy clay with incipient grey cutans (CL)

120-165 cm dark orange-brown, v. stiff dry clay with peds 1 to 2 cm diameter with grey cutans (CH)

165-178 cm very compact fine to coarse, cemented lithic sand (SW)

178-180 cm no recovery

180-208 cm medium brownish orange with diffuse grey mottles, sandy clay (poorly structured) (CL)

sl.moist 208-260 cm greyish, brownish, and orange-yellow, lean sandy clay with orange, grading to bright red, spots and mottles surrounding Mn nodules 4-5 mm across (CL)

260-270 cm dark red sandy clay (CL)

270-321 cm orange, brownish yellow and yellow-grey, well-graded sandy lean clay with scattered MnO₂ nodules. Looks like completely weathered intermediate volcanics (CL).

321-360 cm no recovery

360-417 cm mottled orange-yellow and yellow-grey, sandy clay with incipient ped structure; 4 cm of clayey sand at bottom of run. Scattered MnO₂ patches and rare nodules. Rare carbonate nodules up to 1.5 cm across (CL)

417-428 cm no recovery

moist 428-448 cm brownish yellow, compact, slightly clayey lithic (volcanically derived) sand, well graded from fine to coarse sand (SC, SW).

dry 448-455 cm compact, indurated clayey gravel (GC)

455-510 cm no recovery

510-529 cm dark reddish brown silty and sandy clay (CL)

529-554 cm equal volumes of pale grey and orange-yellow, coarsely mottled and banded sandy clay (CL)

554-560 cm laminated brown and pale buff, very fine sand (friable) (SP)

DUNTRON No. 4

0-15 cm yellowish brown silty fine sand (SP)

sl. moist 15-41 cm yellow with scattered orange and manganese-stained patches, fine sandy clay (CL)

41-76 cm mottled brownish yellow, orange and black, very compact, clayey, well graded from fine-gravelly to fine-sandy slopewash derived from volcanic rocks. Numerous MnO₂ nodules (GW)

76-90 cm no recovery

90-98 cm as for 41-76 cm interval

98-138 cm yellow brown grading to red-brown fine sandy clay (CL)

138-180 cm no recovery

180-184 cm reddish brown and black clayey, sandy gravel with MnO₂ nodules (GC)

184-212 cm well structured, yellowish grey and yellow, sandy clay with dark red sesquioxide accretions 1-2 cm across (CL)

moist 212-230 cm pale, slightly yellowish grey with yellow stains and streaks, slightly pebbly, very fine sand (SP)

230-270 cm no recovery

270-303 cm mottled and banded grey, orange, yellow and reddish brown, well graded sandy clay with MnO₂ nodules (CL)

303-398 cm no recovery

wet 428-466 cm medium brownish yellow, rather poorly graded, very slightly clayey, medium grained lithic quartzose sand-aquifer (SP)

466-479 cm buff to pale brown, very finely laminated lean clay (CL)

479-510 cm no recovery

510-584 cm pale yellowish brown to brownish yellow, v. sandy (fine), lean clay with high linear shrinkage evidenced by severe cracking 1 hour after recovery of core (CL)

584-585 cm no recovery

moist 585-663 cm yellow-brown, very fine-sandy lean clay grading to slightly brownish yellow, then mottled yellow and grey clay with MnO₂ stains grading to nodules with depth. Soil cracks within 1 hour's exposure to air (CL)

wet 663-703 cm mottled pale yellowish grey and orange very fine-sandy lean clay and some clayey sand. Last 15 cm very gravelly with angular quartz and ashstone clasts in an indurated, grey clay matrix (CL).

703-720cm no recovery - probably loose sand (SP)

DUNTROON NO. 5

- 0.48 cm mottled yellow brown and yellow-grey sandy clay with reddish brown cutans at 1-2 cm intervals in lower part of run (CL)
- 48-90 cm no recovery
- 90-114 cm brown silty clay - probably collapse material
- v. moist 114-135 cm orange with grey mottled, very sandy clay with rhyolite pebble 3 cm across (CL)
- 135-180 cm no recovery
- moist 180-245 cm very fine-sandy clay with clayey sand lenses, limonite pisolites, some pebbles and MnO₂ nodules. Mottled yellow-grey and reddish orange (CL, SL)
- 245-270 cm no recovery
- saturated 270-276 cm brown, pebbly, coarse sand (SP)
- 276-294 cm mottled grey and predominantly pale brownish orange-red clayey very fine sand (SC)
- 294-313 cm dark reddish brown, very fine sandy clay on clayey sand (SC/CL)
- dry 313-329 cm very compact, very dark reddish brown, dry sandy clay - looks like in situ weathered lithic sand (CL)
- 329-360 cm no recovery
- 360-417 cm very dense, mottled pale grey and yellow sandy clay with scattered pebbles (CL)
- 417-428 cm no recovery
- saturated 428-450 cm saturated, yellowish grey clayey sand (SC)
- dry 450-489 cm dense mottled grey and orange pebbly sandy clay (CL)
- 489-510 cm no recovery
- 510-540 cm mottled yellow, brownish yellow, white and pink, very compact, well graded, coarse gravel, fine gravel, sand and clay (CL)

DUNTROON 6

- 0-30 cm silty fine sand (topsoil) (ML)
- 30-90 cm no recovery
- 90-142 cm well graded coarse to very fine sand, compact but friable, ranges from brownish yellow to yellowish, reddish brown (SW)
- 142-180 cm no recovery
- moist 180-270 cm diffusely mottled yellowish grey and reddish medium brown, slightly clayey very fine sand (SP)
- 270-299 cm as for 180-270 cm interval (SP)
- 299-360 cm no recovery
- saturated 360-387 cm slightly clayey, medium to fine, loose reddish brown sand (SP)

(v)

- 387-400 cm slightly clayey, dark brown, coarse to fine sand with abundant pisolites (limonite) and manganese nodules (SP)
- saturated 387-434 cm vaguely mottled greyish and brownish dark red, very fine-sandy, lean, soft clay (CL)
- 434-454 cm clayey, loose, medium to fine, slightly reddish, medium brown sand (SP)
- sl. moist 454-476 cm very dense, well structured, well graded, medium sand to silt; mottled and banded grey, dark red and orange (SW)
- 476-480 cm no recovery
- v. sl. moist 480-540 cm coarsely mottled, pale grey and orange, very stiff, fine sandy clay with much MnO₂ staining (CL)

DUNTROON NO. 7

- sl. moist 0-24 cm dark brown organic silt and fine sand (ML)
- moist 24-40 cm transition zone grading from organic sandy silt through medium brown sandy clay to mottled greyish brown and orange sandy clay (OL - SC)
- 40-90 cm no recovery
- 90-151 cm mottled medium brown and brownish orange sandy clay with grey tubules (CL)
- 151-180 cm no recovery
- moist 180-215 cm mottled brownish grey and yellowish brown sandy clay with orange spots (CL)
- moist 215-224 cm laminated dark brownish red and minor yellow brown sandy clay (CL)
- 224-270 cm no recovery
- 270-297 cm brownish yellow sandy clay with charcoal fragments to 3 mm. Last 4 cm is clay with subrounded quartz pebbles (CL)
- 297-360 cm no recovery
- 360-378 cm orange-yellow sandy clay with well rounded, Mn-coated pebbles. Refusal after 4 cm of pink to buff rhyolite or ashstone - platy fragments of this to 3 cm (CL, MW, rock)
- 378-390 cm no recovery

APPENDIX 2

Bacteriological analysis of groundwater from piezometers, by
Department of Health Laboratory, Fyshwick, ACT.

Sampling date: 1.3.77

Piezometer	Coliforms/100ml	E. coli/100ml	F. strep./100ml
1	1600+	1600+	1800
2	1600+	49	8000
3	240	2	< 100
4	920	5	160
5	1600+	31	300
6	1600+	240	1400
7	1600+	920	2000
Stormwater drain	1600	109	820

Sampling date: 16.3.77

Piezometer	Coliforms/100ml	E. coli/100ml	F. strep./100ml
1	1600+	920	100
2	1600+	350	8000
3	1600+	1600	1170
4	1600+	130	60
5	1600+	46	150
6	1600+	920	11300
7	1600+	1600+	6800
Stormwater drain	426	95	400