1982/36. Investigation of a salt water drainage problem in a Legana orchard

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Abstract

Fruit trees have been killed and stunted over a 0.4 ha area in an orchard at Legana. The cause has been shallow brackish (5000 - 8000 ppm) acidic groundwaters with very high sodium adsorption ratios in poorly drained clays. Restoration of the salt-affected areas will be difficult. The judicious use of trickle irrigation rather than sprinkler irrigation may arrest the development of the problem.

INTRODUCTION

The advice of the Mines Department on a salt water problem at Legana Orchards, Jetty Road, Legana was sought by Mr Don Bulman. Salty water is seeping into an extension of an agricultural dam and trees over about 0.4 ha have been killed over recent years by salt water.

Legana Orchards is located on the west bank of the Tamar Estuary about one kilometre east of Legana. Investigations were concentrated on the north-east portion of the orchard, where the dam is situated and the drainage problems were reported.

INVESTIGATION

The site was investigated briefly in March 1982. Eleven holes were drilled with a Triefus to a maximum depth of 4.3 m by B. Cox. Borehole logs are presented in Appendix 1. Groundwater levels in these holes were monitored during winter and water samples taken. Water analyses (Appendix 2) were carried out by R. Maloney and J. Lethborg.

Geology

The orchard is situated in a flat-lying sequence of clays, sands and gravels (geological plan, fig. 1). Some minor lensing occurs. Clays dominate the base of the section (fig. 2) and sands and gravels the top.

A small thickness (< 4 m) of sandy gravel occurs at the top of the orchard. The gravel is orange-brown and consists of well-rounded ironstone and angular quartz pebbles in a coarse, loose sand matrix. About 9 m of a loose to medium density, friable silty sand underlies the gravel. Beneath this, there is an alternation of layers of a compact blue-grey clay and an ironstained brownish sandy clay. Both these clays are plastic, stiff to hard with variable but small amounts of quartz and ironstone gravel and carbonaceous material. Ironstone occurs as nodules up to a few centimetres across and also as plates. The clay sequence is at least 20 m thick.

Hydrology

The upper gravels and sands are very permeable and provide good drainage. The compact blue-grey clays are impermeable (< 10^{-7} cm/s) and provide very poor drainage: in the lower part of the orchard groundwater flow is provided by three low-permeability aquifers of sandy clay. Fluctuations of water levels in these aquifers is suggested by extensive ironstaining and the occurrence of ironstone plates, interpreted as being

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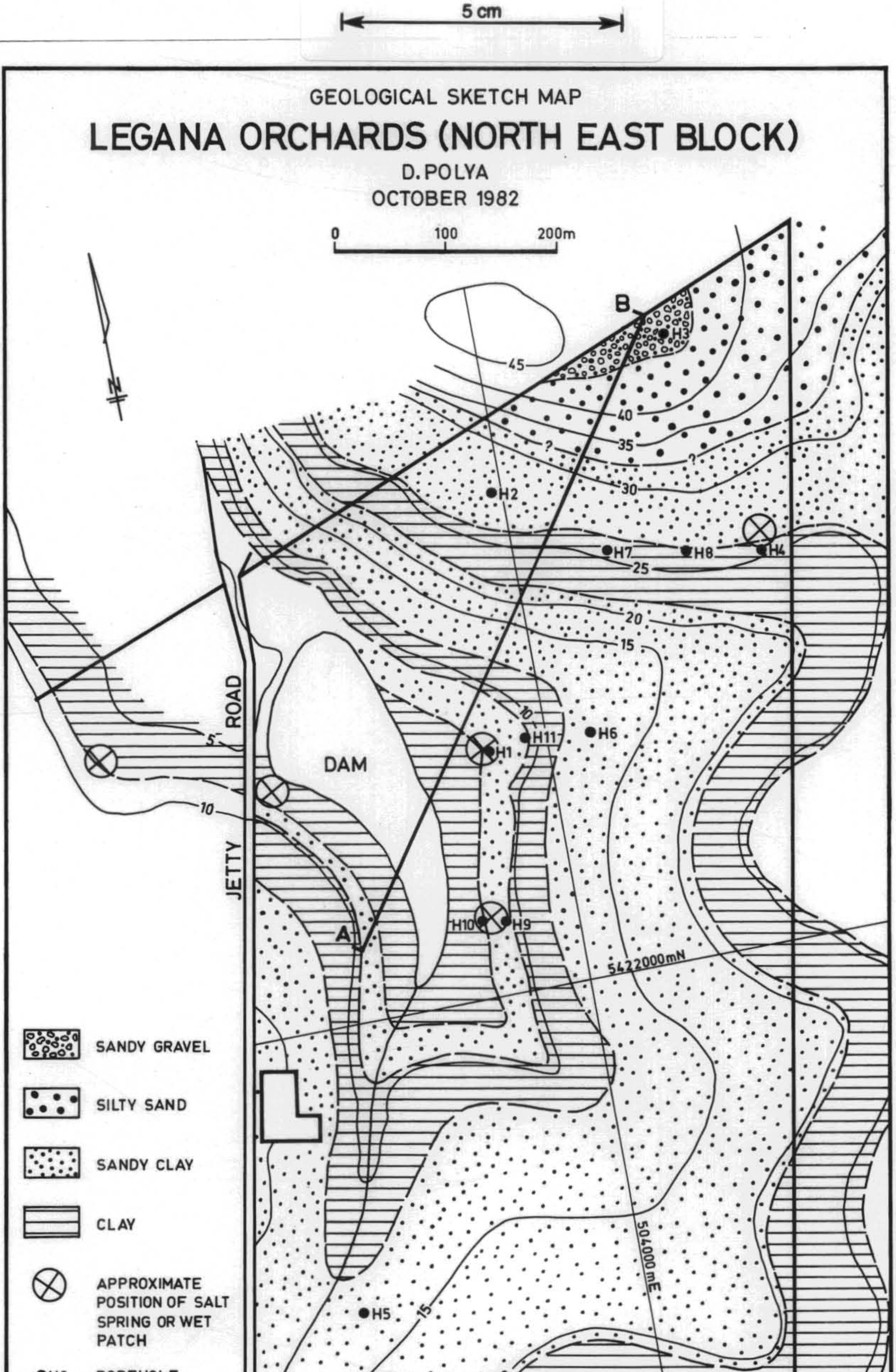

5 cm
GEOLOGICAL SKETCH MAP
LEGANA ORCHARDS (NORTH EAST BLOCK)
D. POLYA
OCTOBER 1982
0
100
200m
N
B
A
H1
H2
H3
H4
H5
H6
H7
H8
H9
H10
H11
45
40
35
30
25
20
15
10
5
DAM
JETTY ROAD
5422000mN
504000mE
SANDY GRAVEL
SILTY SAND
SANDY CLAY
CLAY
APPROXIMATE POSITION OF SALT SPRING OR WET PATCH
H3 BOREHOLE LOCATION

Figure 1.

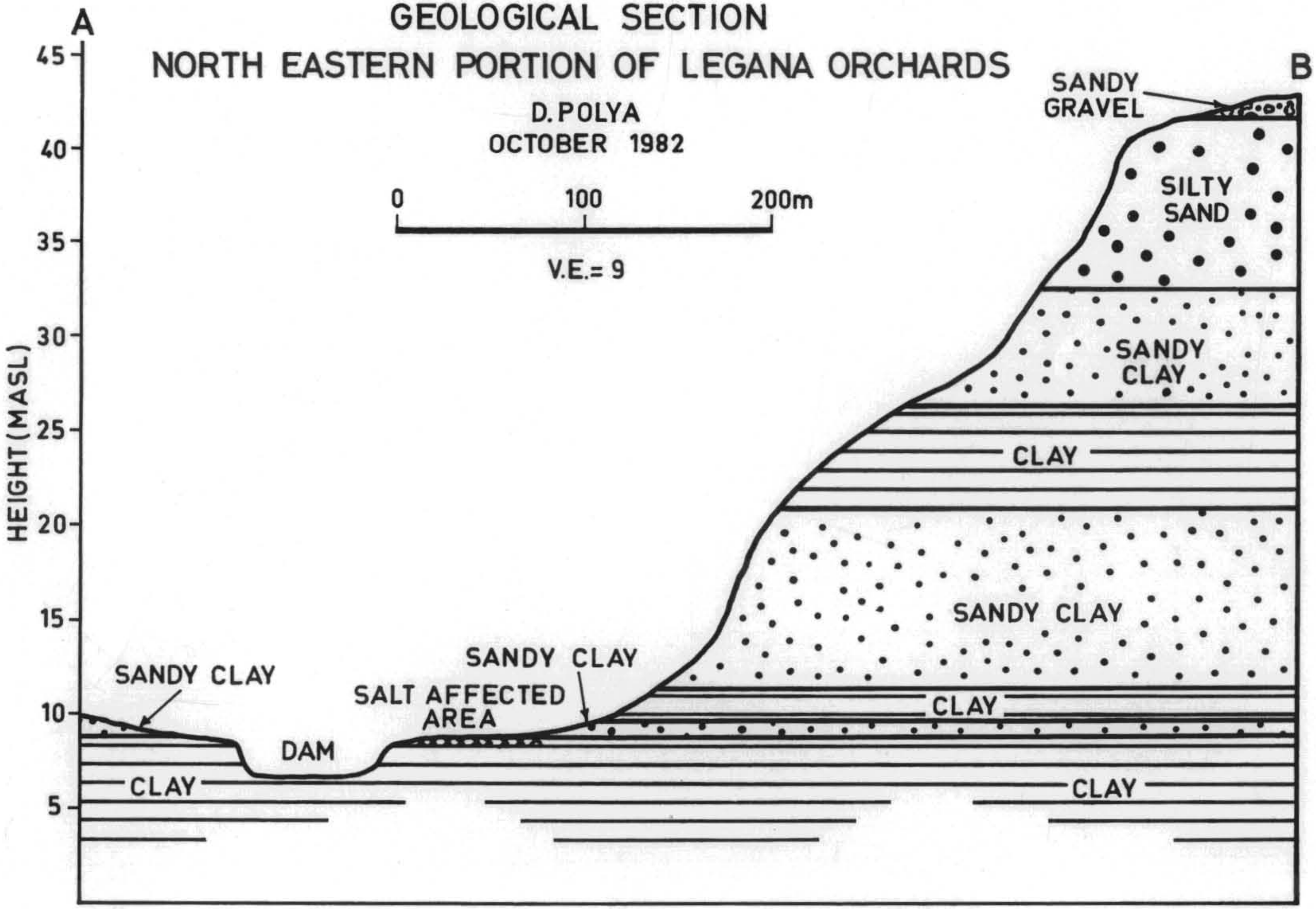
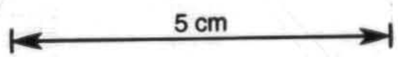


Figure 2.



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fragments of ancient iron-pans.

Most of the salt springs and wet patches (including the 0.4 ha area where trees have died) are found where a sandy clay layer overlies a compact blue-grey clay. This may be used as a guide to where further salt springs and wet patches might occur. Although there are lateral inhomogeneities within each clay layer, groundwater travels essentially in sheet-like aquifers not in underground streams of tubular form.

On the upper slopes of the orchard, boreholes (H2, H3, H7 and H8) were found to contain no free water. Brackish groundwater was struck in boreholes H4, H1, H11, H9, H10 and H5. During winter 1982, boreholes H1, H9, H10 and H11 were filled with water to the surface or overflowing, indicating a water table at about 10 m (a.s.l.). The occurrence of water in H4 indicates another water table at about 25 m (a.s.l.). That H6 is largely dry, suggests an impermeable clay layer somewhere between 15 m and 20 m (a.s.l.).

Water quality

The groundwater and 1982 dam water, with salinities well over 5000 ppm and 1000 ppm respectively are unsuitable for most irrigation purposes. It is understood that the dam salinity is abnormally high due to a lack of rain.

The groundwater is very brackish (5600 - 8500 ppm total dissolved solids) and acidic (pH < 4). The major constituents are sodium and chloride. Sodium adsorption ratios range from 13 to 23: at the salinities encountered, these values indicate an extremely high sodium hazard. Sodium causes a reduction of soil permeability and a hardening of the soil; this is caused by the exchange:

$$(Ca, Mg) - clay + 2Na^{+} \rightleftarrows Na - clay + (Ca, Mg)^{2+}$$

Dam water salinities ranged from 2100 ppm before winter to 1400 ppm after winter. Increasing Na/Cl ratios indicate that this is due to dilution by sea-water derived rainfall. A minimum in dam salinity would be expected after August and September rains. Dam water was found to have an SAR of 5: at a salinity of 1400 ppm this indicates only a moderate sodium hazard.

DISCUSSION

Dam water salinity

Dam water salinities between 400 ppm (21 August 1981, Department of Agriculture analysis) and 2100 ppm have been recorded. Several pairs of measurements have shown that, at any one time, the old dam is 5 - 10% more saline than the major north-flowing creek supplying it. This relationship indicates that the major direct control on dam water salinity is this creek: since the creek drains most of the dam's 1.8 km^2 catchment area, this is not surprising.

The ultimate major control on dam water salinity is the amount of precipitation. Because of the impermeability of the compact blue-grey clays, there is only a minimal increase in dam salinity due to the influx of brackish water from the north-eastern block.

Origin of salt in the groundwater

The major source of salt in brackish groundwaters in the orchard is the leaching of clays, with a high soluble salt content. It is difficult to assess the effect on groundwater salinity due to the application of potash, superphosphate, lime, ammonium nitrate, magnesium sulphate and calcium chloride.

Solubilisation of clay-salt has been increased by the presence of excess amounts of water, probably due to irrigation. High sodium in relation to the amount of calcium and magnesium present has caused a reduction of clay permeability and soil hardening.

Drainage

To recover the major salt-affected areas, drainage of the brackish groundwater to a depth of about 3 m would be required: drainage by either natural or artificial means will be either excessively slow or expensive. (Drainage of the surface alone is not sufficient to restore productivity unless shallow root stocks are planted).

Consider the 80 m x 50 m area where salt-affected and neighbouring trees have been recently grubbed. The underlying clays are saturated to within a few centimetres of the surface. The porosity of the clays is estimated to be 50%. The volume of water stored under this area to a depth of 3 m is equal to:

$$(\text{area})(\text{depth})(\text{porosity}) = (4000\ m^2)(3\ m)(0.50) = 6000\ m^3$$

or approximately 6 million litres (6 *Ml*).

Natural seepage rates would be of the order of 10^{-7} cm/s or 16 l/m^2/year (assuming a porosity of 50%).

The total area by which the block could be drained is (80 m x 50 m) + (80 m x 4 m) *i.e.* approximately 4300 m^2.

Therefore the natural seepage from the block is about 70 000 *l*/yr.

Thus approximately 70 years would be required to drain the brackish water (this is neglecting recharge).

Pumping rates from these clays could not be expected to be greater than 900 *l*/h (200 gal/h) (7.9 M*l*/yr).

Pumping would withdraw water from a much larger volume than the block being considered - possibly a volume over 20 times larger.

Therefore, it would still take over 10 years to remove the brackish water present. (Furthermore some expense would be entailed in this operation.).

Recharge

The best preventive measure against increasing salt-water problems is to cut down on the amount of water recharging the clays. Three sources of recharge are considered: natural, sprinkler irrigation and trickler irrigation.

Natural recharge in the 0.4 ha block is limited by the rainfall (average ∿ 0.8 m/yr) and the catchment area (16 000 m^2). Approximately 13 *Ml* of water would be expected to fall on the catchment area in an average year. Much of this will be lost in surface runoff and transpiration.

Sprinkler irrigation: for 14 years (1967 - 1980) water was applied to the orchard at volumes equivalent to 75 mm of rainfall over short periods of time, twice a year. This irrigation would total about 2.4 Ml/yr over the catchment area of the salt-affected block. Sprinkler irrigation water tends to cover the ground as a sheet resulting in high evaporative losses and a corresponding concentration of salts.

Trickler irrigation: over the past few years the orchard has been irrigated using a trickler system that provides each tree with 75 gal/week (340 *l*/week) over a 10 week period each year. Since there are approximately 4250 trees (135 trees/acre) in the catchment area, this corresponds to 3.2 M gal/yr, that is 14.4 *Ml*/yr. Assuming an uptake by each tree of between 70 gal/week and 200 gal/week, the maximum amount of water added to the block would be 1 *Ml*/yr - the actual value is probably much less.

It may be seen that sprinkler irrigation provides a much greater volume of water to the clays than trickler irrigation (at the cited rates of application). Uncertainty in the values of evaporation, transpiration, infiltration rates and surface runoff make a more detailed analysis of the recharge data difficult.

Further problems

Although the development of high levels of brackish water under the orchard may be being slowed down by the use of trickler irrigation, there are a number of areas in which fruit trees may be in danger of damage over the next few years. These areas occur at low levels in compact blue-grey clays at the feet of the larger and sharper gullies.

CONCLUSIONS AND RECOMMENDATIONS

(1) Brackish (5000 - 8000 ppm) acid water occurs at shallow depths under an area in the north-eastern portion of Legana Orchards where trees have been killed and stunted over recent years. Exchange of sodium for calcium and magnesium in clays has reduced the permeability of already quite impermeable clays. Sub-surface drainage in the lower parts of the orchard is extremely poor.

(2) The development of a salt-water drainage problem has been accelerated by the application of large amounts of water over short periods of time.

(3) Drainage of the salt-affected areas will be extremely slow. Any attempt to pump out the groundwater is considered impractical.

(4) This drainage problem is probably developing in other parts of the orchard. These parts are quite small in area and are indicated on Figure 3.

(5) Further development of the salt-water problem may be arrested by the careful use of irrigation. Although trickler irrigation is preferable to sprinkler irrigation, the large amount of water applied in the former

5 cm

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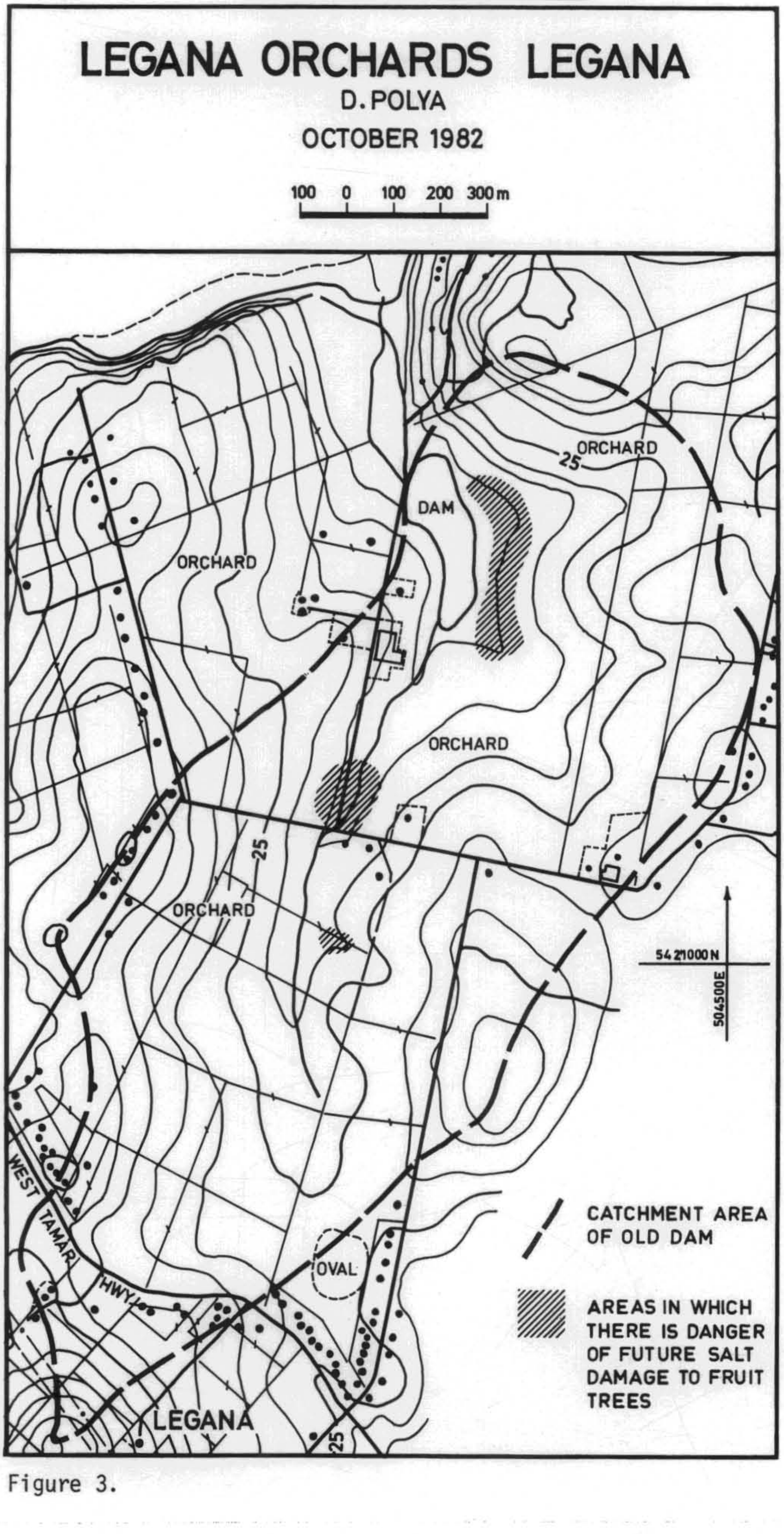


Figure 3.

system means that considerable care must be taken not to overwater.

(6) Monitoring of groundwater levels is advised. Boreholes H4, H9, H10, H11, H1, H6 and H5 have been cased and may be used for continued observation for some time.

[14 October 1982]

APPENDIX 1

EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration

No resistance
ranging to
refusal

Water

22 Jan, 80 Water level on date shown.

Water inflow.

Water outflow.

Notes - samples and tests

U50	Undistributed sample 50mm diameter.
D	Disturbed sample.
N	Standard penetrometer blow count for 300mm.
N*	SPT + sample.

Material classification

Based on Unified Soil Classification System.

In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

Moisture content

D	Dry, looks and feel dry.
M	Moist, no free water on hand when remoulding.
W	Wet, free water on hand when remoulding.
LL	Liquid limit.
PL	Plastic limit.
PI	Plasticity Index.

eg. M > PL – Moist, moisture content greater then the plastic limit.

Consistency

		hand penetrometer (kPa)
VS	Very soft.	< 25
S	Soft.	25 – 50
F	Firm.	50 – 100
St	Stiff.	100 – 200
VSt	Very stiff.	200 – 400
H	Hard.	> 400
Fb	Friable.	

Notes: X on log is test result
— is range of results.

Density index

		%
VL	Very loose.	0 – 15
L	Loose.	15 – 35
MD	Medium dense.	35 – 65
D	Dense.	65 – 85
VD	Very Dense	85 – 100

Cored borehole log

Case - lift

Casing used.

Barrel withdrawn.

Fluid loss

No loss

50% loss

100% loss.

Lugeons

Lugeon units (μL) are a measure of rock mass permeability. For a 46 to 74mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of 1×10^{-4} mm/sec.

Graphic log

No core.

Rock substances represented by clear, contrasting symbols consistent for each project.

Weathering

Fr	Fresh.
SW	Slightly weathered.
HW	Highly weathered.
EW	Extremely weathered.

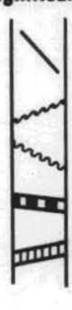
Strength

		point load strength index $I_{s(50)}$ (MPa)
EL	Extremely low.	< 0·03
VL	Very low.	0·03 – 0·1
L	Low.	0·1 – 0·3
M	Medium.	0·3 – 1
H	High	1 – 3
VH	Very high.	3 – 10
EH	Extremely high.	> 10

Note: X on log is test result.

Significant defects

Significant defects shown graphically.



Joint.

Sheared zone.

Crushed seam.

Infill seam.

Extremely weathered seam.

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. H1

sheet 1 of 1

project	LEGANA ORCHARDS	location	JETTY ROAD, LEGANA

co-ordinates	503940mE 5422220mN	drill type	Triefus	hole commenced	17.3.1982
		drill method	Auger	hole completed	17.3.1982
R.L.	8.8 m			drilled by	Barry Cox
inclination	Vertical	drill fluid	None	logged by	David Polya
bearing				checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
		▼	18.3			CL	Sandy CLAY, grey, plastic	M<PL			Permeable clay
				1		CH	CLAY with a trace of sand, plastic, grey, occasional salt grains	M<PL			Compact clay
		▼	17.3	2				W			
				3							

HOLE TERMINATED AT 3.0 m

REQUIRED DEPTH - 1 m BELOW WATER TABLE

Brackish water (8400 ppm) rose to surface overnight

Hole pumped out 25.3.1982 and packed with gravel and clay

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ENGINEERING LOG – BOREHOLE

borehole no. H2

sheet 1 of 1

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project	LEGANA ORCHARDS			location	JETTY ROAD, LEGANA
co-ordinates	503980mE 5422450mN	drill type	Triefus	hole commenced	17.3.1982
		drill method	Auger	hole completed	17.3.1982
R.L.	28 m			drilled by	Barry Cox
inclination	Vertical	drill fluid	None	logged by	David Polya
bearing				checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
				1		. . . . . .	CL	Sandy CLAY: orange/brown/grey hard, somewhat friable, plentiful ironstaining, occasional ironstone and quartz pebbles (∿ 3 mm)	D		x	> 400 Permeable Sand-sized pellets of clay
								HOLE TERMINATED AT 1.5 m BECAUSE NO COMPACT GREY CLAYS FOUND Hole remained dry 18.3, 25.3				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. H3
sheet 1 of 1

12/21

project	LEGANA ORCHARDS	location	JETTY ROAD, LEGANA

co-ordinates	504160mE 5422560mN	drill type	Triefus	hole commenced	17.3.1982
		drill method	Auger	hole completed	17.3.1982
R.L.	42 m			drilled by	Barry Cox
inclination	Vertical	drill fluid	None	logged by	David Polya
bearing				checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
		None				GM	Sandy GRAVEL, brown/orange, well rounded ironstone & angular quartz pebbles in coarse sand matrix, loose	D			
				1		SM	Silty SAND, brown/orange, friable, loose to medium density	D			
				2							
				3				D			
							HOLE TERMINATED AT 3.3 m REQUIRED DEPTH Purpose to determine thickness of gravel bank at N.E. end of orchard. Conclusion: thickness of gravel bank is at least 0.6 m but less than 4 m.				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. H4
sheet 1 of 1

13/21

project	LEGANA ORCHARDS	location	JETTY ROAD, LEGANA
co-ordinates	504220mE 5422350mN	drill type	Triefus
		drill method	Auger
R.L.	25 m	hole commenced	17.3.1982
inclination	Vertical	hole completed	17.3.1982
bearing		drilled by	Barry Cox
drill fluid	None	logged by	David Polya
		checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
		▼	18.3				CH	CLAY with some sand, plastic, very stiff, grey with fine brown sand Salt grains present	H< PL		×	220 Compact
					1		CH	CLAY with some gravel, plastic, hard grey with fine brown sand, angular milky quartz fragments, ironstone plates, mottled	H< PL		×	Compact ironstained 400+ fissures
							CH	CLAY with some sand, plastic, very stiff, grey with fine brown sand	H< PL			Compact
					2		CH	CLAY with some gravel (as for 0.6 - 1.2 m)	H< PL		×	Compact ironstained fissures 200
		▼	17.3		3, 4		CH	CLAY with some sand, plastic, mottled purple/brown/grey, stiff some flat angular ironstone fragments with well rounded nodules near top rare small quartz pebbles	H> PL W		× ×	120 100

HOLE TERMINATED AT 4.3 m
MAXIMUM AUGER LENGTHS

Hole drilled adjacent to brackish pool that had been noted for several decades

Hole pumped out 25.3.1982 and packed with gravel and clay

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. H5
sheet 1 of 1

project	LEGANA ORCHARDS	location	JETTY ROAD, LEGANA
co-ordinates	503750mE 5421740mN	drill type	Triefus
		drill method	Auger
R.L.	13 m	hole commenced	17.3.1982
inclination	Vertical	hole completed	17.3.1982
bearing		drill fluid	None
drilled by	Barry Cox	logged by	David Polya
checked by			

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
		▼	25.3		1		CL	Sandy CLAY with some gravel brown, plastic, stiff	D		x x, x	Gravel-sized aggregates of clay particles
		▼	18.3		2, 3, 4		CH	CLAY grey, plastic, hard angular quartz pebbles common ironstaining increases towards the base	M< PL; M> PL		x; x, x x	Compact Some iron-staining 450++
								REFUSAL, POSSIBLY BY IRON PAN AT 4.2 m Water not reached 17.3.1982 Salinity 19.3.1982 6370 ppm 5.5.1982 6190 ppm				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. H6

sheet 1 of 1

15/21

project	LEGANA ORCHARDS	location	JETTY ROAD, LEGANA
co-ordinates	504040mE 5422220mN	drill type	Triefus
		drill method	Auger
R.L.	13 m	drill fluid	None
inclination	Vertical	hole commenced	18.3.1982
bearing		hole completed	18.3.1982
		drilled by	Barry Cox
		logged by	David Polya
		checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
					1		CL	Sandy CLAY, plastic, brown, very stiff, some charcoal fragments	D			Sand-sized aggregates of clay
					2 3		CH	CLAY with some sand plastic, grey, stiff (+ brown, fine sand)	M> PL		×	200-230 Compact
		▽	25.3		4		CL	Sandy CLAY, plastic brown firm/stiff.	M> PL			Sand-sized aggregates of clay
								HOLE TERMINATED AT 4.3 m MAXIMUM AUGER LENGTHS Water not reached 18.3.1982				

TASMANIA DEPARTMENT OF MINES

5 cm

16/21

borehole no. H7

sheet 1 of 1

ENGINEERING LOG – BOREHOLE

project	LEGANA ORCHARDS	location	JETTY ROAD, LEGANA
co-ordinates	504080mE 5422380mN	drill type	Triefus
		drill method	Auger
R.L.	25 m	hole commenced	18.3.1982
inclination	Vertical	hole completed	18.3.1982
bearing		drilled by	Barry Cox
drill fluid	None	logged by	David Polya
		checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
				0–2.8		CH	CLAY, plastic, pale-grey, very stiff	M< PL		×	300-400 Compact
				3		CL	Sandy CLAY, plastic, brown/grey very stiff	M> PL		×	300 Somewhat permeable
						CH	CLAY with some gravel and sand plastic dark brown, stiff	M< PL		×	200 Compact
				4		CL	Sandy CLAY	M> PL		×	300 Somewhat permeable

HOLE TERMINATED AT 4.3 m

MAXIMUM AGUER LENGTHS

Hole remained dry 25.3.1982

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. H8 | sheet 1 of 1

17/21

project	LEGANA ORCHARDS	location	JETTY ROAD, LEGANA
co-ordinates	504150mE 5422360mN	drill type	Triefus
		drill method	Auger
R.L.	26.5 m	drill fluid	None
inclination	Vertical	hole commenced	18.3.1982
bearing		hole completed	18.3.1982
		drilled by	Barry Cox
		logged by	David Polya
		checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
				0–4.3 (1, 2, 3, 4)		CH	CLAY with a trace of sand light grey plastic, very stiff	D		×	300 Compact
				4.3				D		×	300
							HOLE TERMINATED AT 4.3 m MAXIMUM AUGER LENGTHS Hole remained dry				

TASMANIA DEPARTMENT OF MINES

5 cm

borehole no. H9

sheet 1 of 1

18/21

ENGINEERING LOG – BOREHOLE

project	LEGANA ORCHARDS	location	JETTY ROAD, LEGANA

co-ordinates	503930mE 5422060mN	drill type	Triefus	hole commenced	18.3.1982
R.L.	9.8 m	drill method	Auger	hole completed	18.3.1982
inclination	Vertical			drilled by	Barry Cox
bearing		drill fluid	None	logged by	David Polya
				checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
							CL	Sandy CLAY, plastic, brown/grey, stiff	H< PL		×	200
							CH	CLAY with a trace of sand, grey, plastic, very stiff numerous salt crystals increased iron-staining to the base	H> PL		×	250-350
					1							
					2							
		▼	18.3		3						×	250-350
					4				M> PL		×	150
								REFUSAL, POSSIBLY BY IRON PAN AT 4.2 m Salinity (19.3.1982) 5630 ppm				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. H10

sheet 1 of 1

19/21

project	LEGANA ORCHARDS	location	JETTY ROAD, LEGANA

co-ordinates	503910mE 5422070mN	drill type	Triefus	hole commenced	18.3.1982
R.L.	8.6 m	drill method	Auger	hole completed	18.3.1982
inclination	Vertical	drill fluid	None	drilled by	Barry Cox
bearing				logged by	David Polya
				checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
							CH	CLAY, grey, plastic very stiff	D			Compact
					1							
								Thin ironstone-rich layer ↓				
					2			some silt and ironstaining towards the base	H> PL			
		▼	18.3		3							
									W			
					4							
								HOLE TERMINATED AT 4.3 m				
								MAXIMUM AUGER LENGTHS				

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. H11

sheet 1 of 1

20/21

project	LEGANA ORCHARDS	location	JETTY ROAD, LEGANA
co-ordinates	503990mE 5422220mN	drill type	Triefus
		drill method	Auger
R.L.	9.8 m	hole commenced	18.3.1982
inclination	Vertical	hole completed	18.3.1982
bearing		drilled by	Barry Cox
drill fluid	None	logged by	David Polya
		checked by	

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
					0–1		CL	Sandy CLAY, plastic, grey very stiff iron stained			×	300
					1–3.3		CH	CLAY, plastic, blue-grey, very stiff minor ironstaining			×	Compact 250
		▼	18.3		2						×	250-300
					3						×	200

HOLE TERMINATED AT 3.3 m

REQUIRED DEPTH

Salinity (19.3.1982) 8230 ppm

APPENDIX 2. Chemical analyses of dam, drill hole and surface waters

		820370	820722	821114	820369	820367	820368	820401	820400	820403	820402	820399	820404	820721
		Dam	Dam	Dam	Pool	Drain	Drain	H1	H11	Surface	H4	H9	H5	H5
pH		6.8	6.3	n.a.	6.8	6.2	3.2	3.7	3.8	6.3	3.9	3.8	3.6	4.3
CO_3	(ppm)	nil	nil	n.a.	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
HCO_3	(ppm)	22	23	n.a.	150	36	nil	nil	nil	28	nil	nil	nil	nil
Cl	(ppm)	1100	800	780	3000	30	3600	4350	4350	4350	4000	2950	3500	3650
SO_4	(ppm)	86	42	33	57	13	49	35	14	30	21	75	41	42
SiO_2	(ppm)	n.a.	5	n.a.	n.a.	n.a.	n.a.	100	90	25	48	83	65	49
Ca	(ppm)	87	61	63	210	8.3	170	200	115	230	175	74	67	79
Mg	(ppm)	80	84	77	340	3.0	340	550	530	405	390	255	360	365
Fe	(ppm)	n.d.	n.d.	n.a.	n.d.	0.1	0.8	0.6	0.1	n.d.	0.5	0.1	0.6	n.d.
Al	(ppm)	n.a.	n.d.	n.a.	n.a.	n.a.	n.a.	8.4	3.0	n.d.	2.9	1.8	6.8	2.9
K	(ppm)	22	15	9.8	29	5.7	18	4.6	2.5	12	9.3	3.5	6.0	13
Na	(ppm)	300	250	270	1400	13	890	1380	1480	1620	1430	1380	1320	1300
TDS	(ppm)	2100*	1560	1400	5700*	n.a.	6900*	8410	8230	8390	7310	5630	6370	6190
Cond.	(µS/cm)	3400	2200	n.a.	8400	190	10000	10200	10100	10200	9300	7600	8350	8650
SAR		6	5	5	14	1	9	23	13	15	14	17	14	14
Na/Cl		0.42	0.48	0.53	0.72	0.67	0.38	0.49	0.52	0.57	0.55	0.72	0.58	0.55

n.a. - not analysed, n.d. - not detected (< 0.1 ppm Fe, < 0.2 ppm Al)

$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$: Na, Ca, Mg in meg/*l*   Na/Cl : elemental ratio

*TDS estimated from conductivity and chloride analysis

820370 - Dam water (collected 9.3.1982); 820722 - Dam water (5.5.1982); 821114 - Dam water (12.8.1982); 820369 - Saline pool adjacent to dam (9.3.1982); 820367 - Open drain near H1 (9.3.1982); 820368 - Outlet of agricultural dam near H1 (9.3.1982); 820401 (19.3.1982); 820400 - (19.3.1982); 820403 - Surface water from pool near H4 (19.3.1982); 820402 - (19.3.1982); 820399 - (19.3.1982); 820404 - (19.3.1982); 820721 - (5.5.1982).