Draining a saline seep

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Earlier trials

Before 1979, sub-surface drainage had not been tried in Western Australia's agricultural area outside the coastal irrigation zone. The exception was a drain installed in 1977 on CSIRO's property 'Yalanbee' at Bakers Hill to drain a saline hillside seepage. The drain worked successfully at first and allowed subterranean clover to be grown on previously scalded land. Later, an iron precipitate blocked the pipe, and since 1984 the drain has not been maintained.

Tambellup

In 1979, staff at the Department of Agriculture's Katanning office co-operated with a farmer 20 kilometres west of Tambellup to drain a small salty seep. About 200 metres of 65 millimetre diameter black slotted plastic pipe was installed. When the pipe was set in the ground in May 1979, the eye of the seep was too wet to walk across, with water filling foot pug marks left by cattle. By the end of that year, the ground was firm and there was no water lying on the surface. The drain, which discharges water at a rate of six litres a minute, was installed with no detailed site investigation nor observation wells to monitor drawdown.

Punchmirup Siding

As a result of these early successes, a drainage trial was planned for 1980 for a saline seep on a property at Punchmirup Siding on the closed
Katanning-Donnybrook railway line. Advice was sought from CSIRO and from officers of the Irrigation and Water Resources Branch of the Department's Division of Resource Management.

The aims were to examine the effects of sub-surface drains on groundwater and soil salt levels; to measure the quantity and salt content of effluent and to assess changes in the composition of pastures. The trial would also provide experience in laying sub-surface drains and in assessing installation costs.

The seep is typical of many hillside seeps in the district. It is located towards the foot of the south-facing slope that runs down from Punchmirup to a creek more than a kilometre away. The eye of the seep is 160 m from the creek which is part of the headwaters of the Carlecatup River that flows into the Blackwood River system.

The site to be drained was surveyed and a contour map drawn up. Three nests of observation wells were installed. Each nest consisted of three drill holes: a shallow hole sunk one metre deep, an intermediate hole sunk to 2.5 m and a deep hole drilled to basement rock. Rock was encountered at four to 10 m.

All holes were lined with 40 mm plastic pipe, capped at the lower end and suitably slotted. In the deep and intermediate holes, the slotting was confined to the bottom 1 to 1.5 m, and the space around the slotting back-filled with washed sand. A bentonite clay plug was placed above the sand to complete the wells as piezometers. The piezometers measure the pressure of the groundwater at the depth of the slots.

In the shallow holes the pipe was slotted over the full length of the buried portion of pipe, and sand only was used for back-filling. These wells measure the depth to the watertable.

Information gained from drilling logs and the water levels in the wells suggested that the salty seepage was caused by groundwater being 'dammed' up behind a rock bar. Water was leaking upwards through preferred channels, forming seepage eyes or 'mound springs'. Piezometer readings also showed that the groundwater up-slope of the rock bar was under considerable pressure.

Using this information, the layout for the drains was planned and three drains each 200 m long and 30 m apart constructed. Two lines of watertable observation wells were placed across and at right angles to the drains. The figure shows the layout of the drains and wells relative to the seepage eye and the creek.

The drains were set two metres below the surface to intercept groundwater as it leaked upwards. Where the line of observation wells intersected the proposed line of the drain, a piezometer was sunk to basement rock.

The water levels in these wells were first measured on March 28, 1980. Drains were excavated during the first week in May.

**Laying the drains**

Trenches were dug with a back-hoe fitted with a 46 centimetre wide bucket. Work started from the outfall end of each line in turn. The trench floor was trimmed with a spade with a curved blade to create a groove in which to bed the pipe. The pipe was laid as soon as a section was excavated and covered with local pit gravel to a depth of 20 cm. The trench was then back-filled using a blade on the front of a wheeled tractor.

Grade was maintained using a line and boning rod. The line was set at pre-determined heights on posts located to the side of the trench every 20 m. Levels were taken with a dumpy level.

Rock above the planned drain floor caused excavation difficulties in several places and it was not always possible to achieve design depth. At such points the drain was 'jumped up' and a new flatter grade adopted above that point to achieve design depth higher along the drain.

This problem was most severe in drain No. 3 which discharged into the highest point of the creek. The amount of water in this line above the point at which rock intruded made it difficult to form a firm base on which to lay the pipe, to maintain grade, and to secure the pipe under the gravel. The latter problem was caused by the pipe floating and the gravel tending to creep under it.

These problems were exacerbated by slumping of the trench walls where the trench crossed the eye of the seep. The saturated soil was unable to support the spoil dumped from the trench.

Flow meters used for metering household water supplies were fitted to the outfall of each drain. Iron precipitates frequently blocked the meters.
vegetative cover (%)

<table>
<thead>
<tr>
<th></th>
<th>1980</th>
<th>1982</th>
<th>1984</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare scald</td>
<td>17</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Barley grass</td>
<td>64</td>
<td>33</td>
<td>9</td>
</tr>
<tr>
<td>Capeweed (and other)</td>
<td>19</td>
<td>61</td>
<td>87</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2. Changes in salt content of surface soil samples at the Punchmirup seep (% total soluble salts)

<table>
<thead>
<tr>
<th>Sampling date</th>
<th>Above drains</th>
<th>10 m from drain</th>
<th>20 m from drain</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>28/3/1980</td>
<td>0.34</td>
<td>0.22</td>
<td>0.24</td>
<td>0.27</td>
</tr>
<tr>
<td>11/3/1981</td>
<td>0.03</td>
<td>0.08</td>
<td>0.10</td>
<td>0.07</td>
</tr>
<tr>
<td>22/12/1981</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>31/3/1982</td>
<td>0.07</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>15/10/1982</td>
<td>0.03</td>
<td>0.04</td>
<td>0.05</td>
<td>0.04</td>
</tr>
</tbody>
</table>

and they were soon discarded. Estimates of flow were thereafter made by measuring flow into a graduated container over a given time.

The site was seeded with six-row barley with a combine in a once-over operation. Cultivation was at right angles to the drains (across the slope) to obliterate the erosion channels caused by the earlier outflow from the seep and to level the ground disturbed by the back-hoe.

**Monitoring and measurement**

Water levels, outflows and salinities of both effluent water and water in the wells were measured. During installation, water levels were checked daily, then weekly to the end of 1980. For the next two years recordings were done monthly, followed by three monthly recording, since 1983.

Topsoil samples were taken before installation and twice yearly during 1981 and 1982. Pasture cover which was mapped at the time of installation was monitored again in 1982 and 1984.

**Results**

The most dramatic effects of the drains are evident in the general appearance of the site. When the drains were installed the seepage eye was a quagmire in which a four-wheel-drive vehicle had been firmly bogged. A car can now be driven across that area.

The area around the eye was mainly bare and eroded, with steady trickles of water flowing downslope causing rills and minor gullies.

Since the drains were installed surface flows of water from the eye have stopped. Capeweed and grasses are growing on three-quarters of the previously bare area and clovers are invading the areas that previously only carried sea barley grass. Erosion is no longer a problem. Table 1 shows the percentage changes in pasture cover.

The salinity of the surface soil was substantially reduced over the first year and has remained at that lower level (Table 2).

Water levels in the wells adjacent to the drains fell rapidly (up to 70 cm) within 24 hours of the drains being installed. Further falls occurred subsequently. Despite seasonal fluctuations, the water levels have not dropped by as much as predicted or desired.

Blockages have caused problems in drain No. 3 which cuts through the eye of the seep. When this drain blocks, as it did within a year of its installation, water levels in the wells across the eye of the seep rose to their original level. In 1982, drain No. 3 was opened and relaid over 130 m of its length. This line was excavated to the original design depth. An attempt to blast the rock in the bottom of the trench failed and it had to be chipped out with a jack hammer.

After the drain was relaid, well water levels fell by up to a metre, but by early 1984 there were again signs of this drain being partially blocked.

The amount of effluent water and its salt content has fluctuated with season and rainfall. After the unseasonal cyclonic rain in January 1982, flow rates more than doubled and salinity decreased by 14 per cent in drain No. 2 and by 47 per cent in drain No. 1 on the previous readings.

The combined discharge from the three drains has been as high as 26.5 litres a minute in mid-winter to a low of six litres a minute in summer.

**Blockages and maintenance**

Iron precipitate is common in sub-surface drains. It has caused severe problems in drains installed in 1981 on a property at Jingalup, and was a problem encountered by CSIRO workers in their drains at Bakers Hill.

CSIRO researchers also reported clogging of pipes with an amorphous hydrated iron precipitate containing substantial amounts of aluminium and silica. They showed that the iron precipitate would dissolve in an acidic solution. They developed a practical method of creating acidic conditions in the Bakers Hill drains by releasing sulphur dioxide gas into the upper end of the drain. Sulphur dioxide combines with water to produce sulphurous acid. Sulphur dioxide is available commercially, but it is highly poisonous and must be handled with care. The technique was successfully demonstrated by CSIRO at the Punchmirup site in 1983.

**Costs**

Sub-surface drains are expensive. The original drains cost $5.54 per metre installed, excluding the cost of a labourer, but including the cost of pipe, back-hoe hire and the carting of gravel. This expenditure cannot be justified on the grounds of the extra pasture production gained from the reclaimed land. However, where the effluent water is of a quality suitable for stock then a useful watering point can be developed at the same time as the land is being reclaimed.