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Don McFarlane
Richard Engel
Arjen Ryder
Maurice Eales

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McFarlane, Don; Engel, Richard; Ryder, Arjen; and Eales, Maurice (1990) "Level banks used to decrease waterlogging can increase salinity," *Journal of the Department of Agriculture, Western Australia, Series 4*: Vol. 31 : No. 2 , Article 11. Available at: http://researchlibrary.agric.wa.gov.au/journal_agriculture4/vol31/iss2/11
level banks used to decrease waterlogging can increase salinity

By Don McFarlane¹, Ric Engel², Arjen Ryder¹ and Maurice Eales²

¹ Research and Technical Officer respectively, Division of Resource Management, Albany
² Adviser and Technical Officer respectively, Division of Horticulture, South Perth

Some farmers have used level WISALTS banks to control surface waters above areas affected by waterlogging and salinity.

Because the amount of waterlogging has been reduced, crop yields have increased downslope of some banks. However, the banks divert fresh surface water into deeper salty groundwater and, in the long term, worsen salinity.

This article details an investigation of the effect of level WISALTS banks on saline groundwaters and discusses alternative methods of preventing the waterlogging of saline areas.

Level and absorption banks recommended by the Department of Agriculture and used for water erosion and flood control may also increase groundwater recharge.

The use of level banks to decrease waterlogging and salinity

Some farmers installed level banks above saline areas when they found that crop yields improved after these areas had dried out. We now know that the improved yields resulted from decreased waterlogging rather than from decreased salinity (Negus 1987). Most plants can withstand some salinity in the absence of waterlogging but fail rapidly when they occur together (see ‘Plant growth and survival in saline, waterlogged soils’ on page 56).

We were concerned about what happens to the fresh water that collects in the channels of level banks.

If it evaporates then it may slightly increase soil salinity in the bank channel.

If it leaks through the bank spoil at more permeable sections it may exacerbate waterlogging downslope of these sections.

If it seeps downwards into the soil profile then it may increase the level of deep groundwaters and worsen salinity.

Site investigation

A hillslope on Mr Lex Hardie’s farm near Narrogin was chosen for the investigation.

The water levels in five level WISALTS banks were monitored for five years. Evaporation was measured using floating pan evaporimeters and the seepage above and below the banks was monitored with shallow wells. Dye was used to trace the water that was stored in the bank channels. Deep groundwater levels under the banks were monitored with nests of bores (Figure 1).

A cross section through the hillslope shows the banks in relation to the underlying groundwaters and the saline area at the bottom of the hill where groundwater pressures are at or above the ground surface (Figure 2).

How much water entered the banks?

The average amount of water entering the banks from the top of the hill to the lower midslope over the five years is shown in Table 1.
There is a progressive increase in the amount of runoff (and seepage on top of the subsoil clay) from the top of the hill to the bottom. The last bank monitored (in the lower mid slope) was constructed in shallow pipe clay and was close to another upslope bank, which explains why such a high percentage of rainfall entered its channel.

Averaged over the whole hillslope, about 7.5 per cent of rainfall ended up in the bank channels over the five years.

Where does the water in the bank channels go?

Dye tracing of water in one channel showed that water leaked vertically. The shallow wells immediately downslope of the banks were dry, indicating no water leaked through the bank spoil in these areas.

Almost all of the water that entered the sandy bank channels in the upper parts of the hillslope drained vertically from the channel whereas about half of the water in the most impermeable bank channel evaporated. On average, about three-quarters of the water in the banks drained vertically and about one-quarter evaporated over the five years.

The recharge from the bank channels, averaged over the hillslope and the five years, was equivalent to 21 mm of rain (Table 2). Replacing native vegetation with crops and pastures, which is the cause of secondary salinity, is thought to contribute between 20 and 70 mm of recharge. Therefore the addition of 21 mm from the channel of level banks to recharge will almost certainly worsen salinity.

Table 1. Average amounts of water entering the banks (1984 - 1988) expressed as a percentage of annual rainfall and as an equivalent depth of rainfall (mm)

<table>
<thead>
<tr>
<th>Bank location</th>
<th>Water entered (%)</th>
<th>Water entered (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top of hill</td>
<td>1.9</td>
<td>7</td>
</tr>
<tr>
<td>Upper slope</td>
<td>4.0</td>
<td>15</td>
</tr>
<tr>
<td>Midslope</td>
<td>5.1</td>
<td>19</td>
</tr>
<tr>
<td>Lower midslope</td>
<td>14.2</td>
<td>53</td>
</tr>
<tr>
<td>Lower midslope</td>
<td>29.0</td>
<td>110</td>
</tr>
<tr>
<td>Average for hillslope</td>
<td>7.5</td>
<td>28</td>
</tr>
</tbody>
</table>

Figure 1. Diagrammatic cross-section of a level bank showing instrumentation and water flow. (Not to scale.)

Figure 2. Diagrammatic cross-section through the hillside showing the banks, underlying groundwater, basement rocks and the chloride (Cl) concentration of water. Bore numbers are in circles.
Some of the fresh water that is diverted by the banks may have become recharge further down the hillslope anyway. However, the rapidity with which the water levels rose in the banks suggested that the water was moving rapidly down slope and may not have had time to soak in had the banks not been there.

The amount of recharge caused by the banks was most related to rainfall in June and July (Figure 3). Winters need not be wet for significant recharge to occur from the channels.

The high rainfall in 1985 occurred when the hillslope was cropped to oats. Crops are known to use more water than pastures and this may have reduced the amount of runoff and seepage in this year (Figure 3).

<table>
<thead>
<tr>
<th>Bank location</th>
<th>Water becoming recharge (% of rainfall)</th>
<th>Water becoming recharge (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top of hill</td>
<td>1.8</td>
<td>7</td>
</tr>
<tr>
<td>Upper slope</td>
<td>3.7</td>
<td>14</td>
</tr>
<tr>
<td>Midslope</td>
<td>4.4</td>
<td>16</td>
</tr>
<tr>
<td>Lower midslope</td>
<td>11.1</td>
<td>41</td>
</tr>
<tr>
<td>Lower midslope</td>
<td>11.6</td>
<td>45</td>
</tr>
<tr>
<td>Average for the hillslope</td>
<td>5.7</td>
<td>21</td>
</tr>
</tbody>
</table>

### Groundwater levels

If the banks are contributing additional recharge then the groundwater levels under the hillslope would be expected to be rising rapidly.

The water levels in many bores have been rising by about 30 cm per year, while the average rise has been about 20 cm. Over the same period, groundwater levels under a nearby hillside with bulldozer-built drains on a gradient have recorded no net rise (Photo 1). The removal of water in the drains may be lessening recharge on this hillslope while the hillslope with level banks has enhanced recharge.

When groundwater levels are deep beneath the soil surface (that is, at the top of hillslopes), groundwater levels rise fairly uniformly (Figure 4). When groundwater levels are closer than about eight metres from the soil surface they undergo a strong seasonal rise and fall. In wetter years the levels rise rapidly (for example, 1985 and 1988).

### Salinities

The salinity of rainfall and of water on different parts of the hillslope was measured to see where the main increases occurred (Figure 2).

The chloride (Cl) concentration (a measure of salinity) of rainfall was 4 mg/L.

Seepage waters on top of the subsoil clay had chloride concentrations of about 100 mg/L. This increase from 4 mg/L is caused by evaporation from the soil and plants concentrating the salts in the soil profile. However, this water is still fresh (the recommended upper limit for drinking water for humans is 400 mg/L chloride).

The salinity of the water held in the bank channels was highest in autumn and spring because of increased evaporation and less runoff of fresh water. The average chloride

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*An artificial waterway.*

*Figure 3. Relationship between recharge and June and July rainfall.*

*A level WISALTS bank storing runoff and seepage water. Note the recorder for monitoring water levels.*
concentration in the banks was 26 mg/L which was fresher than the seepage water (1,000 mg/L) due to the fresh runoff.

The groundwaters under the banks had high chloride concentrations of 3,650 mg/L. This results from the infiltrating waters passing through large amounts of salt stored deep in the soil profile. From bore samples it was calculated that there was an average of 700 tonnes of salt stored under each hectare of the hillslope.

The highest chloride concentrations were in the saline discharge zone (7,000 mg/L chloride). Here the groundwaters become more saline as they flow through the aquifer and the salts are concentrated by evaporation at the discharge site.

What alternatives are available?

To prevent the water in the channels from causing recharge the channels can be on a grade and the water discharged at a grassed waterway or uneroded creekline (Photo 1).

If the water is being discharged rather than stored then there is no need for such a large channel. Therefore drains constructed with a grader can be used. Provided the channel is cut into the clay subsoil, grader-built drains should be effective. A grader-built drain costs about a fifth of a bulldozer-built drain and removes only about a third of the land from production.

Some farmers don’t like grader-built drains as they need maintenance to clear the channel and to maintain freeboard.

A study has shown that the cost of losing land from production is much more important than the cost of construction, which in turn is much more important than the cost of maintenance (Salerian and McFarlane 1987).

As the channels of bulldozer-built drains are highly prone to silting, maintenance is needed to prevent ponding in the channel, even if it is not needed for maintaining the freeboard.

Mr Lex Hardie prefers to use deeper banks built with a bulldozer because he believes they intercept more water moving downslope. He also has found that the only way to seal sand seams is with a bulldozer.

There are cases where level banks are necessary; for example where there are no areas in a paddock to safely dispose of the water from the drains.

Where salinity is already apparent in downslope areas some farmers have installed pipes through the bank walls. These pipes slowly discharge the stored water between storms. This reduces recharge and enables the bank to empty before subsequent runoff.

Another method adopted by farmers to overcome the lack of a natural waterway is to construct an artificial waterway. This involves fencing both sides of the waterway, seeding it to grasses and in some cases grading a channel with side banks to ensure that the water is retained within the waterway.

Figure 4. Changes in groundwater levels for bores at the top of the hillslope (18) to those in the valley (1) where deep groundwater pressures are above the ground surface. For bore locations see Figure 2.

Acknowledgements

The cooperation and advice of Mr Lex Hardie is gratefully acknowledged.

Further reading


