healthy soils case study

DEEP DRAINAGE

Using Electromagnetic Maps to Track Down Deep Drainage

An Auscott Midkin case study

Good management of irrigated land is an important factor in ensuring sustainable and viable agricultural production. Inefficient irrigation practices can result in the creation of perched water tables, waterlogging, rising water tables and salt mobilisation in various cotton growing districts. A common cause of these problems can be deep drainage, which is defined as water that passes beyond the root-zone. With increasing pressures on water resources and expectations from the community regarding natural resource management, it is important that irrigators are able to identify if and where deep drainage may occur. This will assist in determining where improvements can be made in water delivery, application and storage.

Why act?

Auscott Midkin, a commercial cotton farm north-west of Moree, estimated that during a standard year the farm's dual cell reservoir was losing over 3570 megalitres per year, with 43 per cent of this due to deep drainage. These losses were the result of various combining factors:

- Firstly, the reservoir was positioned over gravel-based paleochannels which were once prior water channels located further down the soil profile; this was not identified during the reservoirs construction in 1981 due to technology limitations.
- Secondly, the reservoir had a relatively large surface area to volume ratio, resulting in high levels of evaporation.
- Finally, trees within the reservoir, which had once served as a windbreak to reduce evaporation, had died and their decayed roots have left deep channels through the soil profile.

What is science saying?

The Salt and Leaching Fraction (SaLF program) developed by the Queensland Department of Natural Resources, can provide deep drainage estimates from data routinely available from soil databases: for example, clay content and cation exchange capacity (CEC).

"Long term management is the way to resource preservation and economic rewards."

Terry Haynes at the new pumping station on the commercial cotton farm Auscott Midkin near Moree

In order to enhance the soil information which can be collected, electromagnetic (EM) induction instruments and maps can be used to measure bulk soil electrical conductivity (ECa), which is related to soil moisture, clay content, mineralogy and salinity. Because clay content and soil mineralogy are properties that greatly influence deep drainage, EM measurements can be calibrated against estimates of deep drainage (mm/annum).

Dr John Triantifilis, Senior Lecturer in Soil Science at the University of New South Wales, carried out an EM38 survey in the Ashley district in NSW across an area of approximately 55,000 hectares. As a result of the maps, soils samples and information collected, four irrigation simulations maps: 300, 600, 1,200 and 1,800 mm/annum were created. Varying scenarios were undertaken to simulate a wide range of possible deep drainage conditions. For example, irrigation = 600 and 1,200 mm were used to simulate the deep drainage characteristics of soil profiles in an irrigated cotton field, beneath a head ditch and a shallow supply channel. Similarly, irrigation = 1,800 mm of applied water was used to replicate the deep drainage anticipated in soil profiles located within a shallow water reservoir.

The first map (figure 3a) shows the probability of the risk that deep drainage will exceed 50 mm/annum if irrigation = 300 mm/annum was applied. This is equivalent to 3 Megalitres of applied water and a loss of 0.5 Megalitres per hectare. The white area indicates a low incidence of deep drainage (i.e. < 0.5) and where deep drainage is least expected to be greater than 50 mm/annum. The dark blue shaded area indicates where deep drainage is most likely to exceed 50 mm/annum. This map shows that all irrigated cotton-growing fields are located in areas of low probability. Areas where deep drainage is most likely to exceed 50 mm/annum are associated with Marshalls Ponds Creek, Caroale Creek and the Gwydir River. This suggests that crops requiring low water volumes or different methods of irrigation such as trickle or sprinkler may be the best option in these areas, due to their more permeable soils.

The next map (figure 3b) shows that deep drainage will exceed 50 mm/annum if irrigation of 600 mm/annum was applied. This is equivalent to 6 Megalitres of applied water per hectare. In considering future areas for irrigated cotton development, it is apparent that northeast of the Canarvon Highway would be the most suitable location.

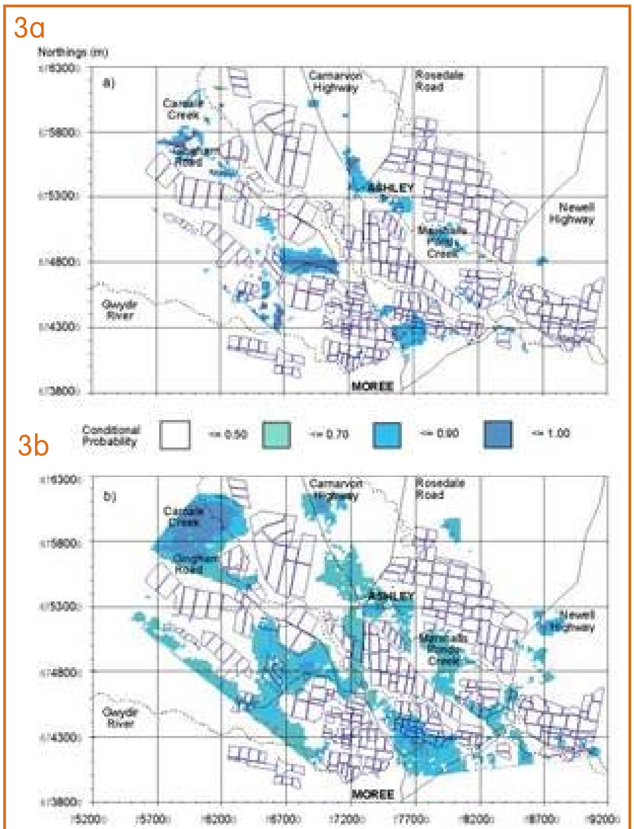


Figure 3. Map of probability that soil at a particular site will exceed an estimated deep drainage value of 50 mm/annum if a) 300, and b) 600 mm of irrigation water was applied and 584 mm of rainfall was assumed

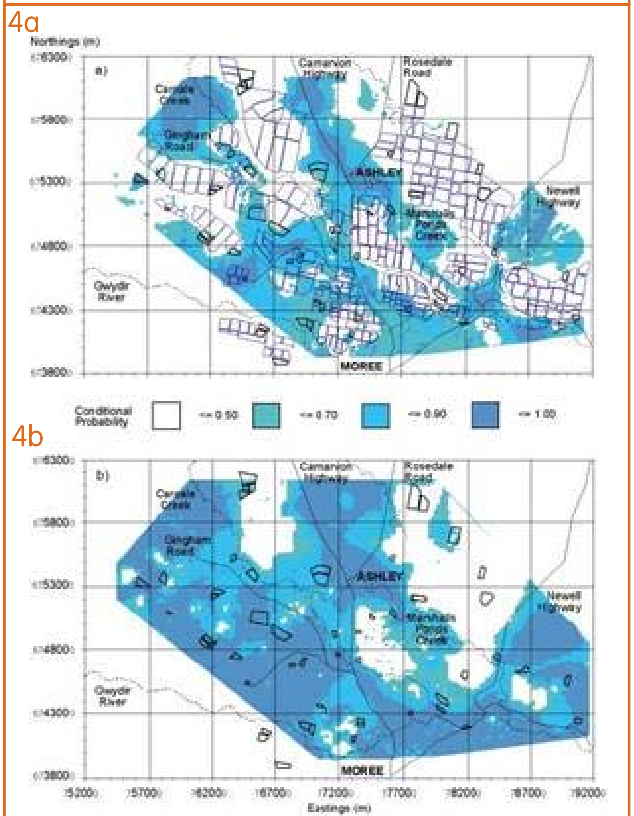


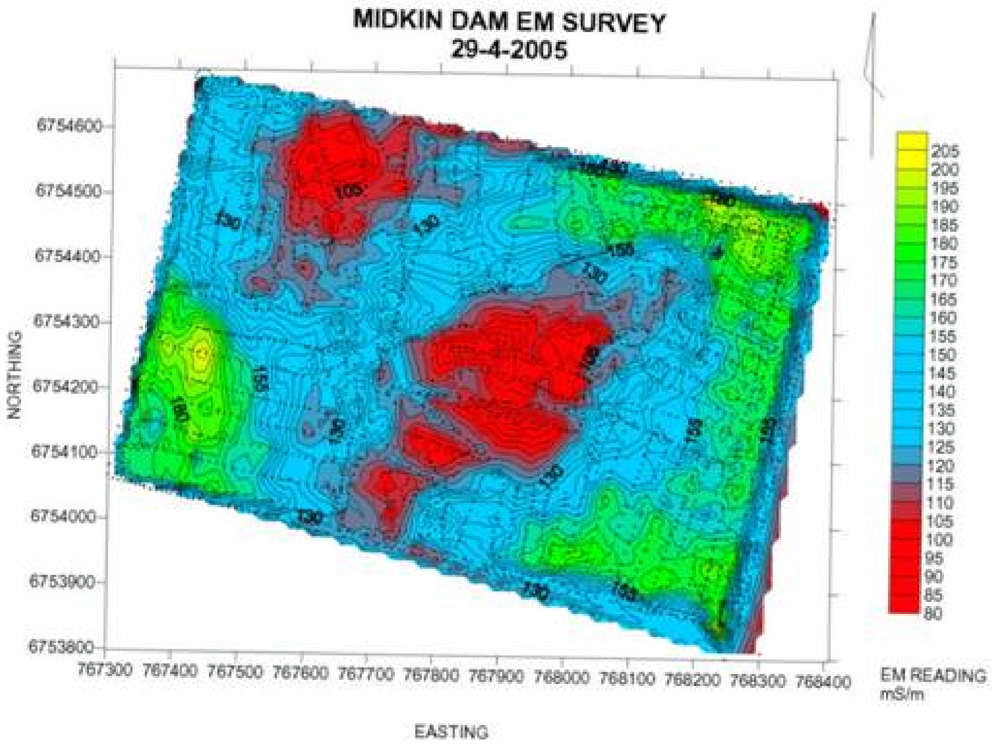
Figure 4. Map of probability that soil at a particular site will exceed an estimated deep drainage value of a) 75 mm/annum if 1,200 mm of irrigation water and b) 100 mm if 1,800 mm of irrigation water was applied and 584 mm of rainfall was assumed

The second set of maps (figure 4a) represents the probability that deep drainage exceeds 75 mm/year beneath infrastructure such as a shallow supply channel or head ditches (assuming irrigation = 1,200 mm of free standing water). Interestingly, many of the irrigated fields located north of Moree coincide with areas of higher risk, beneath supply channels and head ditches. It is reassuring, however, that the fields in this part of the district are generally smaller, have shorter irrigation runs and have been designed considering more their more permeable soil types and therefore reduce their contribution to deep drainage.

The final map (4b: irrigation = 1,800 mm) indicates the most unsuitable areas to locate a main supply channel and/or shallow earthen water reservoir. The map indicates a cutoff value of 100. Here, three areas stand out as being most suitable. However, it is also evident that some of the reservoirs are located in areas where water loss may be high and hence efficiency in water storage and delivery may need to be improved.

The Mobile Electromagnetic Sensing System (MESS) used to undertake electromagnetic (EM) surveys

The main irrigation channel at Auscott Midkin



EM survey of the new reservoir at Auscott Midkin

Auscott Midkin's new reservoir

The Solution

From the initial work undertaken on the district scale it was evident that the reservoir at Auscott Midkin was in a high risk zone; therefore, it was essential to identify deep drainage more closely to increase water use efficiency. This was done by exploring various options to relocate their reservoir to a more suitable location. An EM survey was conducted at several potential reservoir sites. Soil pits were dug to 'ground truth' the maps for higher precision and accuracy of the soils characteristics. Once all the parameters were assessed, a final EM survey was conducted at the preferred location.

Prior to the availability of EM technology, the entire reservoir would have been excavated to the same depth. However, with the aid of the survey vulnerable sites, marked in red on the Auscott Dam Survey, were only minimally disturbed so as not to expose the more vulnerable soils to deep drainage. The walls of the new reservoir were also raised five metres above the old reservoir's limits, reducing evaporation by over one third. The new reservoir also influenced the construction of the new pumping station. Together these changes, during a more typical year, will save Auscott over 2500 megalitres per year, which provides a substantial financial saving along with environmental benefits for the greater catchment.

Benefits for the Australian cotton industry

EM surveys have a great potential to improve farming systems, particularly when considering options to increase efficiency and suitability of a given site for irrigation fields, supply channels and water reservoirs. For example, the loss of water from a reservoir or conveyance structures could be improved by carrying out EM surveys to identify problem areas or to undertake appropriate action to minimise this loss. The results would also confirm management's queries regarding their properties reservoir and its water storage efficiency.

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