

PRELIMINARY SOIL SALINITY ASSESSMENT IN THE LOWER NAMOI VALLEY

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Introduction

In the arid and semi-arid regions of the world, irrigation has enabled previously unarable tracts of land to be used for a wide variety of agricultural activities. Unfortunately many of these areas have associated with them stores of soluble salts which, with time and rising water tables, accumulate in the surface of soil profiles causing widespread, crop-damaging salinisation and waterlogging. In such areas where irrigation is considered appropriate, baseline data is required to monitor the changes in the water balance and salt status of the soil profiles. In this note the current methods available for salinity investigations are discussed as well as geostatistical methods which can assist in the collection and interpretation of the data collected. Using these techniques the results of recent exploratory investigations of salinity in the lower Namoi valley are presented.

Salinity assessment

Globally the standard measure of soil salinity in the laboratory is the *electrical conductivity of a saturated soil paste*, called the EC_e , which reflects the salt content available for plant uptake at field capacity. Due to the time-consuming nature of this analysis and the subjectivity of the criteria for saturation, methods such as the $EC_{1:5}$ and $EC_{1:2}$ which use *smaller ratios of soil to water in the extract* are commonly used in preference to the saturation extract. $EC_{1:5}$ is one part oven-dry soil to five parts water and $EC_{1:2}$ is one part oven-dry soil to two parts water. These water extracts give an indication of the total soluble salt content. The different methods are comparable with a number of conversion factors based on soil textural properties used to estimate EC_e from $EC_{1:5}$ (see SOILPak β Manual 1992).

Although these laboratory methods are accurate they are time-consuming and labour intensive involving much field sampling and laboratory preparation and analysis. Over the last decade significant advances in soil salinity assessment have been made with the application of *electromagnetic techniques (EM)*. Field-measuring EM devices have replaced these laboratory methods for field salinity assessment. Their ease of use, rapid assessment of a particular soil profile *in situ*, and portability, save time and money and have allowed users worldwide (including Australia) to implement these devices for large scale reconnaissance salinity surveys for mapping and monitoring of salinised areas (Corwin and Rhoades, 1982).

EM38

The most commonly used EM instrument for salinity assessment is the EM38. Although not the only device of its kind, the EM38 indicates the *average apparent soil electrical conductivity, EC_a* , of the rooting zone of a soil profile. An indication of the location of the salt can be obtained by using the

instrument in two different orientations. Theoretically, the maximum depth of measurement is 2.0 m when the instrument is held in the vertical mode of operation. In the horizontal orientation the average depth of reading is approximately 1.0 m.

The principle of operation of the **EM38** involves the use of a transmitter and receiver coils located at either end of the device. An electrical current is supplied to the transmitter which produces a magnetic field in the soil directly beneath it. Secondary magnetic fields are then induced around the primary field which conducts a current detected by the receiver coil. The conductivity measured is then a indication of the amount of salt present within the profile. Simply, the instrument acts as a large-scale remotely sensing electrode.

Salinity assessment with the EM38

Recently, such a device was utilised within the lower Macquarie valley to survey fields where incipient traces of rootzone soil salinity have become apparent in areas currently irrigated for the production of cotton (Hall *et al.*, 1992). Reduction in yields have resulted from the failure of seedlings to establish at germination. The **EM38** was found to adequately delineate areas which were most severely affected and indicated which areas require immediate remedial action.

Similar research is in progress within the lower Namoi valley (CRDC project US05C). The reduction in yields apparent in some areas within the lower Macquarie Valley are due to significant rises in water tables within the area which have brought soluble salts to the surface. The watertables within the lower Namoi valley are thought to be as deep as 30 to 40 m. Nevertheless, the techniques established to calibrate the **EM38** device on these heavy grey cracking clay soil profiles is of relevance to other cotton-growing areas where similar soil profiles are irrigated extensively, and have a greater risk of water tables interacting with such salts, bringing them to the surface.

The current research focuses on the extent and dynamics of a previously identified **BELAR** soil profile class identified during a preliminary investigation of the baseline data set of the area (Triantafilis and McBratney, 1992). These profiles have a prominent salt bulge at 1.30 m and are associated with the subsoil, *Boolcarrol* soil layers, characterised by large amounts of salts including sodium and chloride. Although baseline soil profile data was used to identify these salt layers they exist at a grid spacing of up to 2.8 km (McGarry *et al.*, 1989). It is necessary is to use the **EM38** device to map in much more detail the location of these *Boolcarrol* soil layers in the **BELAR** soil mapping unit.

Geostatistical analysis of EC_{1:5} data

Although the current data set (McGarry *et al.*, 1989) is of limited use in terms of field interpretation of salinity much can be made of the sparse data with a geostatistical procedure known as *kriging*. Kriging can be used to interpolate or estimate the value of an unsampled site based on the values nearby. Kriging can also be used to optimise field sampling procedures. The existing EC_{1:5} data for each soil profile on the 2.8 km grid was used in this way so that a field sampling strategy could be devised to enable calibration of the **EM38** for the **BELAR** soil profile types; an essential step in the field salinity assessment. The resultant kriged map for the soil depth of 1.30 m is illustrated in Figure 1 (where EC_{1:5} was converted to EC_e). The larger values of EC_e reflect in general the

presence of the salt-rich *Boolcarrol* soil layers. The more saline layers were found in the north-western areas.

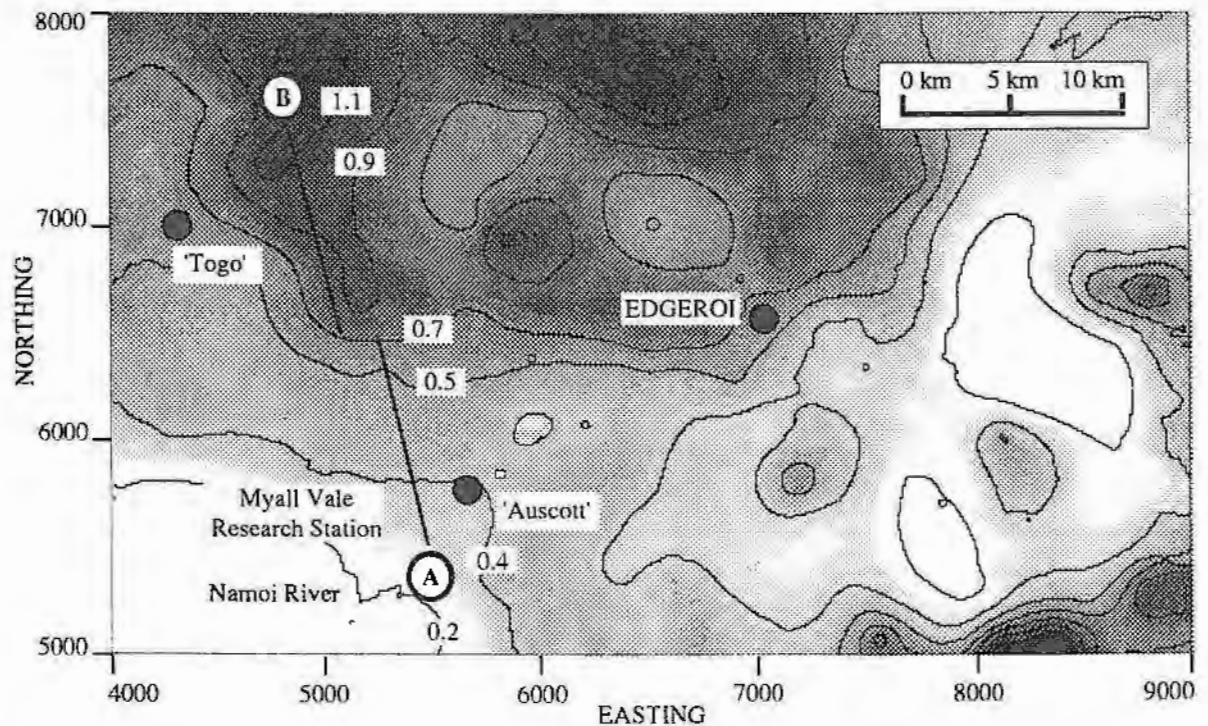


Figure 1. Map of EC_e at 1.30 m indicating the transect across Auscott and Togo used for calibration. Values above 0.7 (S/m) would be harmful to cotton plants if they occurred near the surface

Calibration of the EM38

Prior to use in a broadscale salinity investigation the EM devices require calibration. The apparent gradient evident in Figure 1, from point A to point B, was used to calibrate the EM38 with the use of two transects. This entails sampling soil profiles for $EC_{1:5}$ and comparing this with the EC_a obtained at the same site with the EM38. This assists in the interpretation of each EM reading made at every unsampled site. To date, 12 soil profiles have been used for the preliminary calibration with further sites to be included at a later stage.

Calibration involved sampling every 10 cm to a depth of 2 m for analysis of $EC_{1:5}$. Over each prospective hole the EM38 device was used in both orientations to obtain measures of the EC_a of the soil profiles. The $EC_{1:5}$ data obtained for each hole was then used to compare it with its respective EC_a value obtained by the EM38. The response of the device is different for each orientation and can be accounted for by weighting the value of the $EC_{1:5}$ soil samples at each depth according to the manufacturer's specifications. In the calibration presented, an equal weighting of the $EC_{1:5}$ of the whole soil profile provided a similar calibration result.

The calibration of the EM38 in both orientations is shown in Figure 2. The vertical orientation produces the larger readings due to the presence of the *Boolcarrol* soil layers at depths below 1 m

which is beyond the theoretical response of the horizontal mode of operation. The average EC_e in some profiles are approaching saline levels at which cotton will not grow (EC_e of 0.77 S/m). So that some layers as evidenced in the preliminary analysis of the data contain EC_e values large enough to cause problems if they accumulated at the surface.

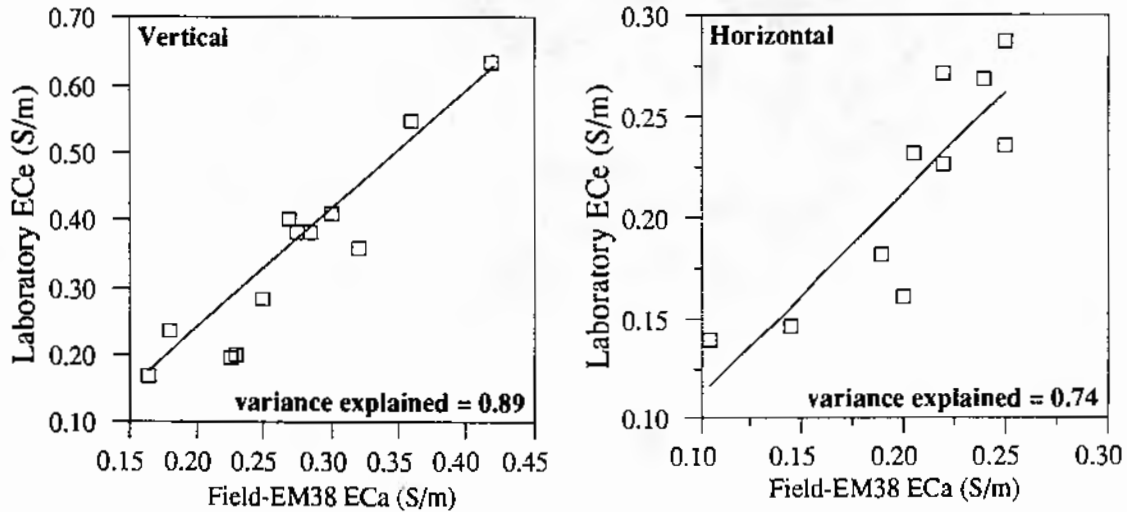


Figure 2. Calibration of EM38 in the horizontal and vertical modes of operation

Other instruments

The ability of the EM38 instrument to detect the *Boolcarrol* soil layer has led to the extension of this project to investigate the potential of other similar EM devices, including the EM31 and EM34, which are capable of detecting deeper stores of salt and water. Both operate in a similar way to the EM38 with their respective depths of penetration and applications presented in Table 1. Another device commonly used in association with the EM31 and EM34 is the EM39 (down-the-hole probe) which can assist in the calibration of these devices when bore holes are dug for sampling and at a later stage can be used to monitor the bore holes drilled. These deeper-penetrating devices along with the EM38 will be used to survey the lower Namoi valley study area and provide baseline data for future researchers as well as techniques that will be applicable to other cotton-growing areas.

EM Model	Depth of EC_a reading (m)	Use
EM38	1.0 - 2.0	Rootzone salinity assessment
EM31	3.5 - 7.0	Shallow aquifer assessment
EM34-3	7.5 - 30	Groundwater salinity assessment
EM39	Depth of bore hole	Calibration of other EM devices. Monitor saline sites.

Table 1. EM models, penetration depth (horizontal - vertical) and their use

Salinity surveying using geostatistics

As with any survey the number of sites required to identify the field variation is an important consideration prior to sampling and for later mapping. As mentioned previously the technique of *kriging* can assist in optimising the sampling scheme required to account for most of the variation in the field. The EM31 has recently been used in preliminary investigations to determine the spatial variability of EC_a in two adjacent fields within the study area. Two transects running east-west across two adjoining fields and toward a large storage dam were sampled at a spacing of 10m. The data are presented in Figures 3a and 3b.

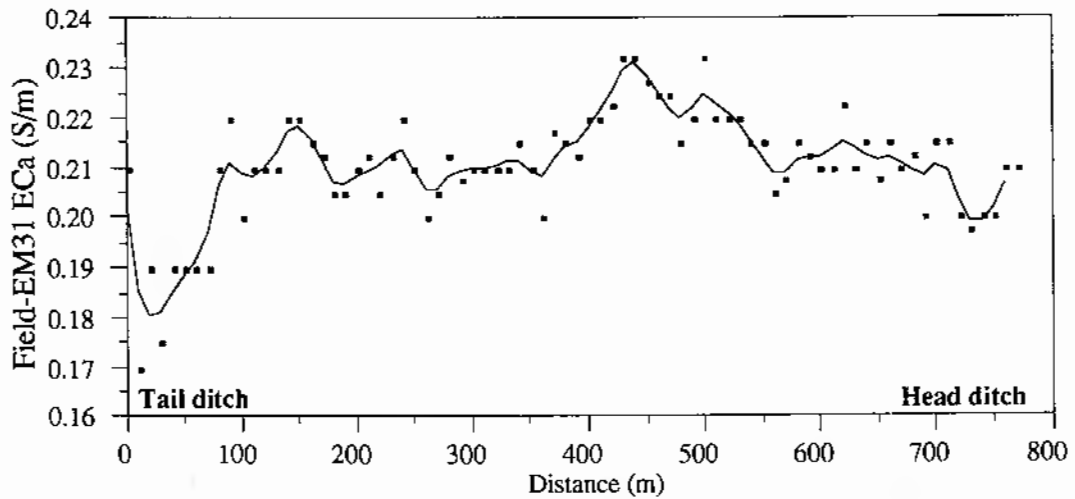


Figure 3a. EC_a transect data across Auscott Field 20 using an EM31

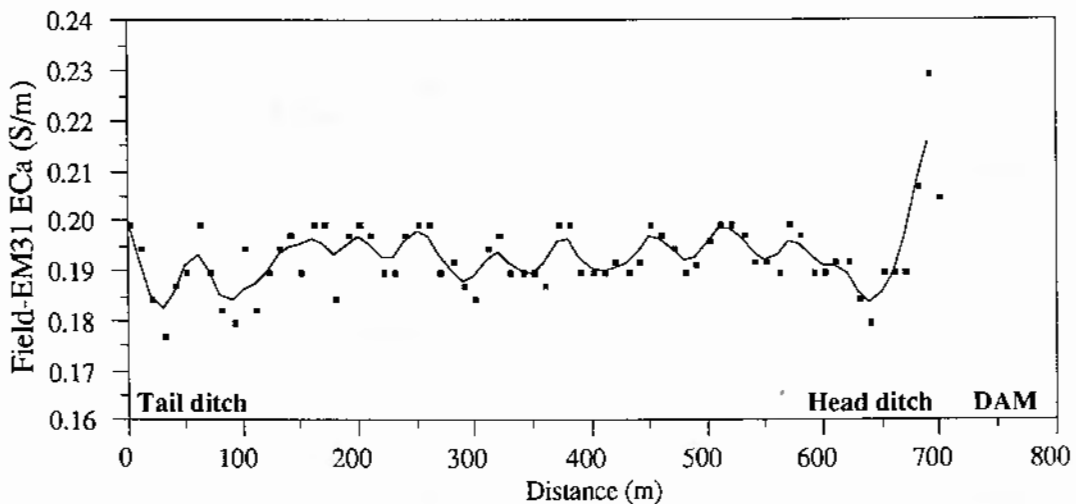


Figure 3b. EC_a transect data across Auscott Field 19 using an EM31

The values obtained by the EM31, illustrated in Figures 3a and 3b, tends to indicate that, other than the salt associated with the *Boolcarrol* soil layer, no other salt store is readily identifiable at this stage. It must be remembered that the instruments depth of penetration is 6 m and the EC_a is an average to that depth, so that the instrument should be calibrated first before any interpretations should be made. These transects and many others will be conducted in order to determine the effect

of large storage dams. In these two transects there did not appear to be any obvious effect unlike in the lower Macquarie valley (Hall, *et al.*, 1992). The patterns evident in the two fields are worthy of further investigation, however. Field 20 shows relatively larger values in the middle of the field while Field 19 has a rather cyclical pattern with larger values obtained at the head ditch which is the point closest to the dam.

Geostatistics can assist us in the interpretation of these transects as mentioned previously. The fundamental concept of geostatistics is the *variogram*. It indicates the distance the soil is spatially related and therefore the distance a particular point is eligible for predicting an unsampled point, as used for the production of Figure 1. It also indicates the sampling distance required to account for a given amount of variation in a field. The two components of the variogram are the *variance* and the *lag*. When the variance, which is simply a measure of variation of sample points a certain distance apart, e.g. at 10m, 20m, 30m, etc., remains constant after a particular distance, the soil within that distance is said to be spatially related.

The variogram of Field 20 illustrates this (Figure 4). At a distance of 120 m the variance stabilises therefore the soil within 120m of any other point along this transect is spatially dependant and can be use to predict the value of an unsampled point. To map the variation in this particular field the EM31 should be used at least every 120 m in the east-west direction. A north-south tract is required to calculate the maximum observation distance required in that direction.

The variogram of Field 19 (Figure 4) reflects the cyclical pattern in the transect (Figure 3b). At distances of approximately 60 to 80 m the sample data and variation is periodic so that at double these distances the variation is again quite small. This possibly indicates gilgai with amplitudes of 60-80 m. Further sampling is required to verify this and the sampling distance required to account for it.

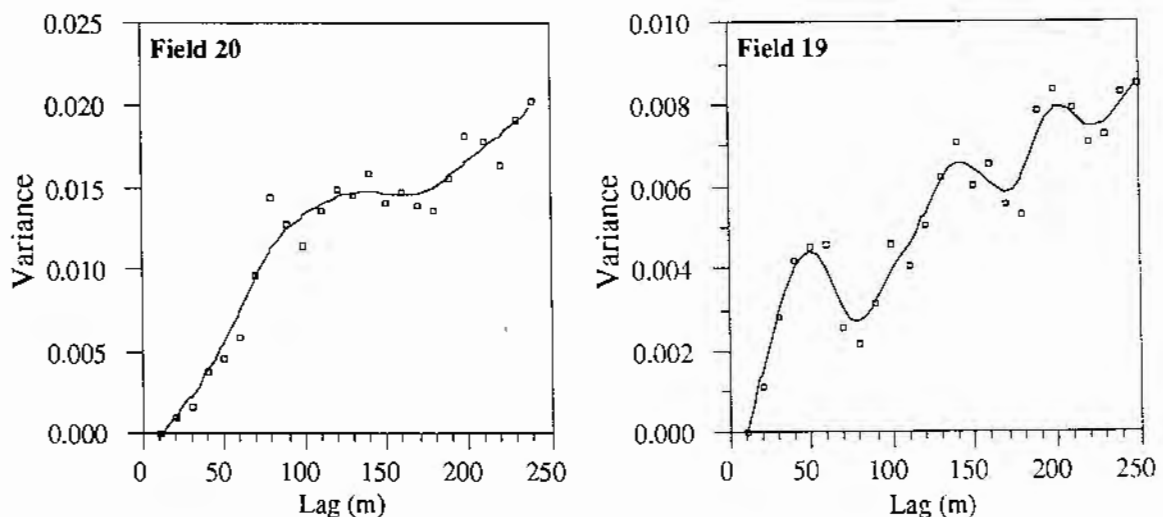


Figure 4. Variogram of Auscott Fields 20 and 19

Future work

The three field-assessment devices (EM38, EM31 and EM34) will be calibrated for the lower Namoi valley study area and then be utilised on a field-by-field basis for mapping using kriging and other geostatistical techniques. Data collection during the mapping exercise will be assisted by the use of a satellite Ground Positioning System, which has an accuracy of up to 5 m. The EM39 down-the-hole probe will assist in the calibration of these instruments and may be used to monitor boreholes sampled for chemical analysis. The data generated by this survey will act as baseline data for the study area with the techniques developed applicable to other cotton-growing areas. Further reports will relate the results of subsequent investigations and from these management strategies will be devised.

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1. The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that this is crucial for the company's financial health and for providing transparency to stakeholders.

2. The second part of the document outlines the specific procedures for recording transactions. It details the steps from initial entry to final review, ensuring that all necessary information is captured and verified.

3. The third part of the document addresses the role of the accounting department in this process. It highlights the need for clear communication and collaboration between different departments to ensure that all transactions are properly recorded.

4. The fourth part of the document discusses the importance of regular audits and reviews. It explains how these processes help to identify any discrepancies or errors in the records and ensure that the company's financial statements are accurate.

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