Using EMI in farm planning and management

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Traditional methods for collecting accurate and reliable soil information from the farm paddock or across a whole property have involved detailed field soil sampling and laboratory analysis of soil characteristics. But this can be very time consuming and expensive due to the variability in soil properties that can occur across one field.

Electromagnetic Induction (EMI) surveying used in combination with field soil sampling has been shown to be a rapid and cost efficient method for providing accurate maps of soil type differences and distribution. Used in association with other layers of information such as aerial photographs, satellite imagery and yield mapping, EM surveys can also be used to identify production and management zones on your property.

WHAT IS ELECTROMAGNETIC INDUCTION (EMI)?

Electromagnetic surveying measures the soil's apparent electrical conductivity. The technology works on the basis that within an electromagnetic field, any conductive body carries a current.

The instrument measures the apparent flow of electrical conductivity through the soil, called the soil's apparent electrical conductivity (ECa) measured in milliSiemens/metre (mS/m).

Readings are affected by the soil's salt content and type, clay content and type, mineralogy, depth to bedrock, soil moisture, organic matter and temperature. The maps produced can be used to identify trends within the survey area and to target locations for further soil investigations to determine the nature of any variability — in particular, which variable listed above is actually influencing the ECa readings.

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A number of different types of EMI instruments are available on the market. The four most common types are the EM38, EM31, EM34 and EM39. Although they all operate in the same way, they vary in the depth to which they read within the soil profile.

All operate in both the vertical and horizontal mode (this determines the depth to which they read). A summary of this is given in Table 1.

EMI instruments are generally mounted on a vehicle, such as a 4WD or ATV to allow for rapid data collection.

TABLE 1: Configuration and nominal depths for Geonics EMI meters (McNeill 1980)

			Depth (m) for a uniform halfspace	
Instrument	**Frequency**	**Coil spacing (m)**	**Horizontal dipole (Emh)**	**Vertical dipole (EMv)**
EM 38	14.6kHz	1.0	0.75	1.5
EM 31	9.8kHz	3.70	3.0	6.0
EM 34	6.4kHz	10.0	7.5	15.0
	1.6kHz	20.0	15.0	30.0
	0.4kHz	40.0	30.0	60.0
EM 39	39.0kHz	0.50	Lowered down bore holes for continuous reading, radial distance = 0.9m.	

These depths are only indicative, as the depth of penetration of the electrical signal will be determined by how uniform, or non-uniform the soil is. If the soil is very conductive near the surface then the signal will be dissipated and will not read to a greater depth.

HOW CAN EMI TECHNOLOGY BE APPLIED?

Infrastructure planning and assessment

EMI technology is a useful tool for planning infrastructure layout and for investigating water losses from existing infrastructure such as channels and storages. Underlying many of our alluvial plains are prior streams or paleo-channels that consist of sands and gravels.

Construction of water storages, channels and other infrastructure above these lighter soil types can result in significant water losses. Water loss from storages and channels can also be caused by salt in the soil profile as salt aggregates clays, increasing permeability.

Figure 1 shows the output from an EM survey undertaken on a leaking storage in the Namoi valley. It shows that there is significant variation across the site, ranging from relatively highly conductive material (shown in pink) to areas of lower conductivity (shown in blue).

As outlined previously, a number of factors influence ECa readings. Salt and clays are highly conductive whereas sand and gravels tend to have a much lower conductivity.

To determine which factor was influencing conductivity at the site, a series of soil pits was dug and the soil analysed. The soil pits, shown on Figure 1 by the crosses, were dug across the range of ECa readings at the site.

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An EM31 mounted on a ATV and connected to a GPS system.

FIGURE 1: EM31 survey of a leaking storage

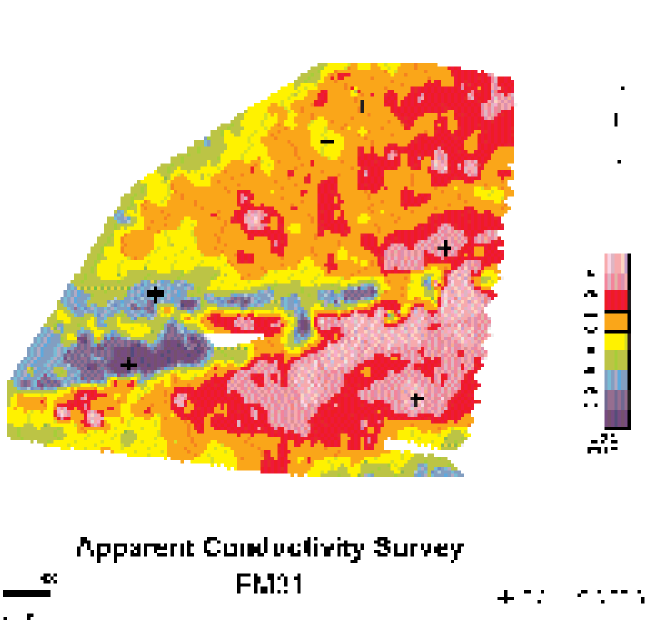
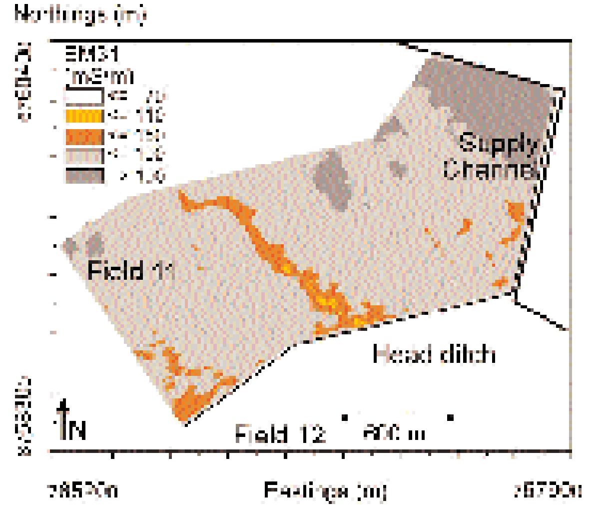
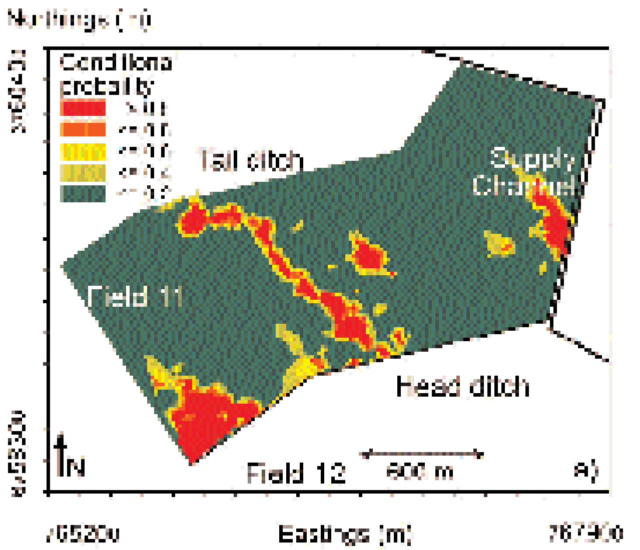


FIGURE 2: EM31 survey of a field (Triantafilis et al)



Field validation found the higher ECa readings in the top right of the map corresponded to heavy grey cracking clays whereas the lower conductivity readings shown in orange corresponded to sandy loam soil profiles.

FIGURE 3: Conditional probability that a soil will exceed an estimated DD value of 75 mm/year if 1200 mm of irrigation water applied and 584 mm of rainfall was assumed (Triantafilis et al 2002)



The green areas which correlated with heavier soil textures had a much lower probability of DD and higher chance of perched water tables, whereas the red areas had a much higher chance of DD owing to the sandy loams associated with a prior stream.

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In this particular survey, soil analysis showed that the EM31 readings were responding to soil type, not salt. A prior stream consisting of sands and gravel which underlay the storage was close to the surface and excavation during construction had removed much of the thin surface clay layer resulting in the high water losses from the storage.

Water use efficiency

With increasing pressures on the availability of water in irrigation areas, there is a need to ensure that water is used efficiently. EM data can provide information on the variation in soil types and assist in identifying deep drainage risk across a field.

As a pre-development tool, this information can help to design the layout of fields so that soils of similar characteristics are within similar fields, allowing for uniform irrigation. In existing fields it may assist in the scheduling of irrigation across a field. Limiting the amount of water that is lost through deep drainage (DD) is important, not only in economic terms but also in terms of its impact on potential salinity and waterlogging.

Research by the Cotton CRC and the University of Sydney in the lower Gwydir valley found that the clay alluvial plains showed a potential susceptibility to shallow perched water tables leading to waterlogging and, in isolated cases, causing soil salinisation. A perched water table forms when excess water in a soil profile can't drain beyond an impermeable layer, such as a very sodic layer or the existence of heavier plastic clays.

Using EM technology in combination with the model SaLF (salt and leaching fraction) and field validation they were able to produce maps of conditional probability of DD exceeding a critical cut-off value for different rates of irrigation.

The areas of highest risk (conditional probability <=2) were consistent with areas where water-use efficiency was problematic — leading to the creation of perched water tables. Information such as this can assist land managers to be more strategic in their management when considering options to improve irrigation efficiencies.

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