Precision technologies for drainage modelling

Department of Agriculture and Fisheries

Zerella Fresh, South Australia

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Key outcomes

- High resolution elevation mapping can be used to model drainage designs at the field or pivot scale to inform drainage activities.
- Orienting mounds to capitalise on natural drainage flow paths and constructing subsurface drainage will improve water movement and reduce crop losses.

Background

Located in the Mallee region in South Australia, Zerella Fresh is one of Australia's largest suppliers of carrots, potatoes and onions. Zerella Fresh has commenced implementation of various precision agriculture (PA) technologies, including GPS tractor guidance, yield monitors on carrot and potato harvesters and EM38 soil mapping for variable rate (VR) irrigation.

Surface elevation mapping is a new technology that is becoming readily available with service providers using drone, ATV or vehicle (ute or tractor) mounted sensors that can generate topographic maps at a suitable resolution. This information can be used to plan the most appropriate earthworks and field design (row orientation and length) to improve in-field drainage.

"One of the key benefits is better water management and reduced seepage impacts on crops."
– Jaco Pauer

Grower: Zerella Fresh *(pictured Jaco Pauer, Irrigation Manager)*

Location: Parilla, South Australia

Area: over 2000 ha

What they grow: carrots, onions, potatoes, broadacre dryland crop

Soils: sandy soils, with heavier loamy and clay flats

Topography: dune swale systems

Average annual rainfall: 365 mm

Precision technologies implemented: EM38 soil mapping, variable rate irrigation, drone imagery, yield monitoring

Objectives

- To explore technologies that assist decision making, use resources more efficiently and reduce crop losses.
- To determine if high resolution elevation technology can be used to map the land surface (topography) of the pivot irrigated production area and identify natural water flow paths.
- To use the maps generated to identify drainage issues and to test different solutions to assist decision making to improve the drainage of the production area.

The site

In the South Australian Murray Mallee, carrots, potatoes and onions are commonly grown in sandy soils in the dune swale landscapes. Paddocks typically have high dunes of deep free draining sandy soils, with heavier loamy and clay flats and hollows (swales) with impeded drainage inbetween.

This variation in elevation and soil type poses challenges when managing irrigation volume, timing and frequency. The swales often become waterlogged boggy hollows.

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Figure 1. Images of the Zerella Fresh case study site at Parilla, SA, showing areas prone to ponding and crop loss in carrots, equating to 2 ha, or 4 per cent of the pivot area.

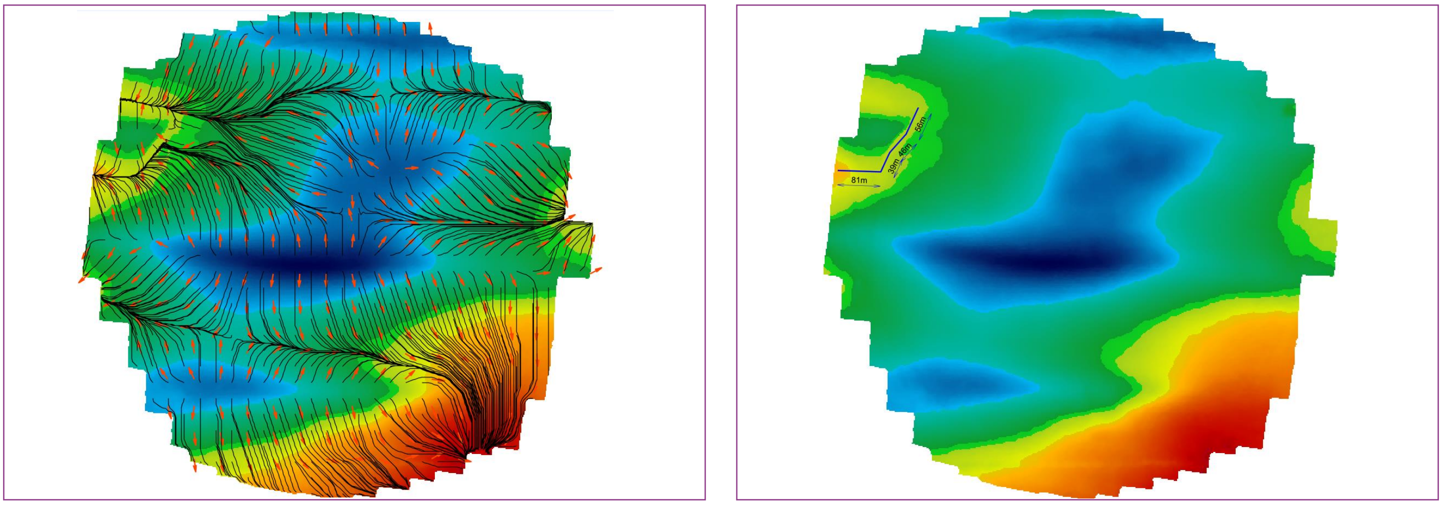

Figure 2. Left: Existing elevation (blue = high, red = low) and direction of natural water flow (red arrows). Right: The proposed alignment for a subsurface drain in the north-west quarter.

Overcoming these issues will enhance the productive potential of the soil, maintain crop yields, improve the resource condition and reduce adverse off-site impacts.

A case study was conducted on a 50 ha pivot irrigated production area at Parilla, SA. Within the study area there was a 2 ha area prone to waterlogging and crop losses (Figure 1).

Activities

Surface elevation data was collected at 2 cm/pixel resolution using a DJI Phantom quadcopter, in conjunction with ground control points. The quadcopter flew a grid pattern, following an automated flight path and using line spacing software. The images captured overlapped by 80 per cent, and were stitched together using Pix4d software and referenced against the ground control points.

This data was uploaded into Terra Design software, which generated ponding and flow path maps, as well as 3D cut and fill designs. AgTech Services (Laura, SA) were contracted to conduct the mapping and to design the drainage plans at a cost of $1450.

The cut and fill designs can be loaded into GPS-based levelling systems such as Trimble Field Level and John Deere iGrade.

Results

Elevation data was used to determine natural flow paths and ponding across the pivot (Figure 2, left). The red area in the south-east quarter shows enough fall in elevation to encourage water to flow off the production area. Aligning the beds and mounds to suit the fall in the landscape will enhance natural drainage and reduce crop losses in this area.

In contrast, the north-west quarter shows water flowing towards a relatively flat area (green in the image), with no natural relief to drain the surrounding area.

In this area, greater intervention is required. A cut and fill model was developed to show how the area might be re-levelled to enhance surface drainage, but this analysis showed limited opportunity for earthworks.

An alternative to surface re-levelling is to implement subsurface drainage. In this case, the analysis software was able to identify the best position for a subsurface

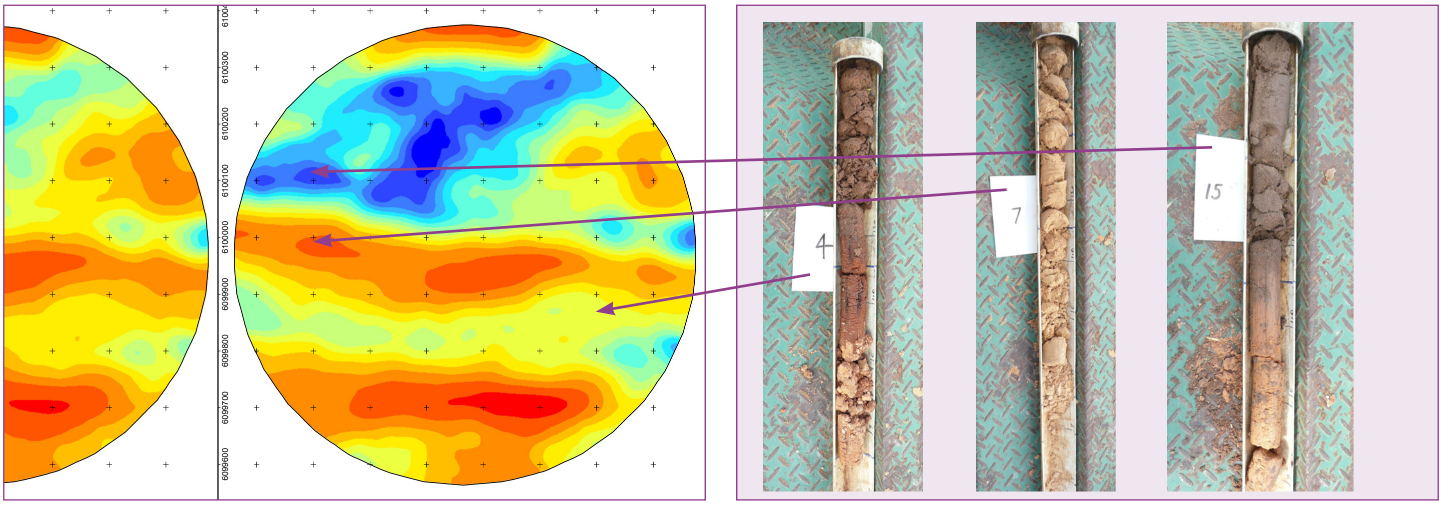

Figure 3. EM map of the Parilla site, identifying the deep sand on the dunes (red and orange) and the heavier clay loams in the swales (blue and aqua).

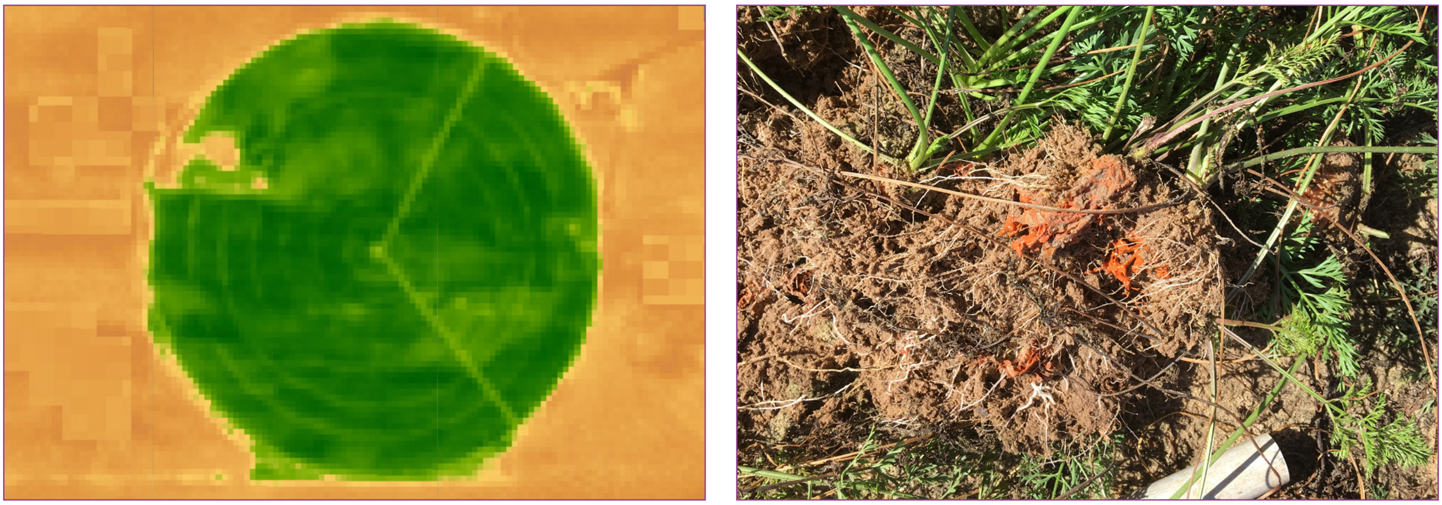

Figure 4. NDVI collected from satellite in early January 2018, showing the loss of carrot production in the north-west quarter (left) and carrots rotting due to water accumulation effects (right).

drain to capture water flowing across and through the soil (Figure 2, right), directing flow off the production area.

Strategic soil sampling is recommended to complement the topographical mapping, enabling the exact location and drain construction type to be confirmed. The soil type and presence of impermeable layers influences the system design. The drainage design includes determining how deep and how far apart pipes are to be placed, and whether a gravel drain or ag-pipe with nylon sock would be best.

In this scenario at Zerella Fresh, service provider, Aussie Drain estimated a short turnaround time of 1 to 2 weeks to install the drain.

Other soil sensing technologies

EM survey

Electromagnetic (EM) induction mapping is a useful tool that can map variability across paddocks (Figure 3, left). At a cost of approximately $15–40/ha (plus GST and travel costs), EM mapping is a quick and economical method to identify changes in soil type or soil properties at the surface and subsurface. This information can be used to identify zones for further soil sampling and devising variable rate application of fertilisers, irrigation and soil amendments.

Targetted soil analysis

In the Zerella Fresh study area soil analysis (Figure 3, right) confirmed differences in soil type with sand/clay loams showing as the blue zone and deep sands identified as the red zone. The blue areas are a seep with accumulation of water and nutrients with analysis showing a 300 fold higher concentration of P and a 2 fold concentration of K in the blue areas, compared with the red zones.

Normalised Difference Vegetation Index (NDVI)

NDVI, or greenness, imagery is freely available at low resolution from online platforms such as Irrisat (Figure 4, left), or from private service providers at high resolution. NDVI is useful for identifying crop establishment and growth variability, e.g. which areas are most productive, or the extent of crop losses. This information can be used to assess the effectiveness of zone based management, disease and insect incursions, crop maturity and irrigation efficiency. In this case the impact of waterlogging on crop biomass is clearly visible in the north-west quarter, and confirmed with field inspection (Figure 4, right).

Cost benefit analysis

This case study has shown the potential for elevation mapping to assist decision making in regards to drainage design. There are costs associated with implementing subsurface drainage, but substantial gains to be made once ponding issues are overcome and productive potential is restored. This mapping and modelling exercise has confirmed that subsurface drainage would be the best option in the affected area, saving costly earthworks to re-level the site.

Intensive field sampling estimated yield to average 74 t/ha across this field. Assuming average variable input costs to grow carrots of $12,000/ha (estimated from DAF carrot gross margin) and the almost complete loss of production on this 2 ha area, the cost of this mapping and modelling exercise ($1450 total) is relatively minor expenditure to identify possible management interventions to improve productivity.

The proposed subsurface drainage works requires 222 m of drainage pipe at a cost of $8/m. The possible return on this investment is outlined in the sensitivity analysis in Table 1.

The breakeven return on investment occurred at 30 per cent of the average field yield across this 2 ha area.

Next steps in precision agriculture

The next steps in precision agriculture for Zerella Fresh is to explore options for further variable rate applications.

"I am very excited about the future of Agtech and its use in horticulture. Trialling new ideas and implementing precision farming techniques will help to save resources and utilise them to the full potential.

We want to build a sustainable industry that we want to pass on to our children and their children."
– Jaco Pauer

Table 1. Sensitivity analysis for return on investment (ROI) for subsurface drainage.

Potential yield increase	ROI (%)
25% average yield	−18.51
50% average yield	63.00
75% average yield	144.50
100% average yield	226.00

Assumptions:

- Assuming average variable input costs of $12,000/ha and average carrot price of $12 per 20 kg carton.
- Assuming costs of $1450 for high resolution elevation mapping and cost of subsurface drainage of $1791 to drain the 2 ha area.
- Drainage works based on 100 mm diameter pipe and a cost of $8/m.
- This analysis does not include any packout data and assumes that all product is suitable for sale.
- This analysis does not include any machinery transport costs or earthworks costs.

Service providers: AgTech Services; FJ Turner; Aussie Drain

Authors: Claire Dennerley and Melissa Fraser, PIRSA Rural Solutions SA and Julie O'Halloran and Gaya Rajagopal, Queensland Department of Agriculture and Fisheries

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Costs presented in this document were accurate as of October 2019. These will change over time and between data processing service providers.

Funding and Project Partners

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