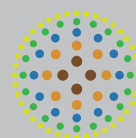


# PRECISION AGRICULTURE IN **RICE** PRODUCTION

Implementation  
&  
Grower Insights



precision  
agriculture



**RURAL INDUSTRIES**  
Research & Development Corporation

This book is the final part of the project *Implementing precision agriculture in the Australian rice industry* conducted by Precision Agriculture Pty Ltd and supported by the Rural Industries Research and Development Corporation and Rice Research Australia. This document includes two previous publications *Precision Agriculture in Rice Production: Grower experiences and insights* (2014) and *Precision Agriculture in Rice Production: GPS & GNSS technology in layouts and levelling* (2015).

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# PRECISION AGRICULTURE IN RICE PRODUCTION

Implementation  
&  
Grower Insights



**Australian Government**  
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precision  
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# GLOSSARY OF TERMS

## GLOSSARY OF TERMS

**Active Sensing Systems** Remote sensing systems which measure the characteristics of a reflected signal generated from an object bombarded with a signal from the sensor. e.g. radar.

**Aerial Photography** Remote sensing technique in which either an orbital satellite or aircraft/drone records a photograph of a portion of the Earth's surface.

**Archive** The storage of historical records and data collected over a number of years. e.g. The Landsat data archive stored since the 1980s.

**Contour Line** A line drawn on a map connecting a set of points which have the same value.

**Decision Support System (DSS)** A system that is capable of integrating diverse data sources with expert knowledge and decision models to aid in strategic decision making.

**Differential Correction** The correction of the GPS signal to make it more accurate. This requires a secondary GPS receiver, called a base station, placed at a point of known position. The base station then measures bias errors that are used to correct bias errors at the location of interest. There are three common ways to access a correction signal from a base station:

1. A marine beacon
2. A commercial FM radio station frequency supplied by AUSNAV.
3. A satellite provided by a specialised GPS operator.

**Extrapolation** The prediction of the value of a variable outside the measured range or an inference of the value of a variable.

**Geographic Data** Data which records the shape and location of a feature as well as associated characteristics which define and describe the feature.

**Geographic Information Systems (GIS)** A computerised database designed to efficiently capture, store, update, manipulate, analyse, and display all forms of geographically referenced information.

**Global Positioning System (GPS)** A network of 24 radio-transmitting satellites developed by the US Department of Defence to provide accurate geographical position fixing.

**Grid** A data structure that uses a set of grid cells forming a regular, or nearly regular, tessellation of a surface to represent an area such as a field.

**Ground Truth** The collection of information on the Earth's surface at the same place and time as a remote sensor gathers data. This permits the interpretation and calibration of remotely sensed data sources such as a yield maps.

**Guidance System** A system of equipment for automatically guiding the path of a vehicle.

**Hyperspectral Sensor** A sensor capable of simultaneously measuring hundreds of individual wavelengths of the electromagnetic spectrum.

**Landsat (Land Satellite)** A series of unmanned earth-orbiting satellites used to study the earth's surface.

**Latitude/Longitude** A polar coordinate system that specifically describes a position on the earth. Latitude is the north to south position. Longitude is the east to west position. Locations are described in units of degrees, minutes and seconds.

**Mean** The average of a set of data in which the values of all observations are added together and divided by the number of observations.

**Multispectral Sensor** A sensor that obtains imagery from several different portions of the electromagnetic spectrum at one time.

**Near Infrared (NIR)** Portion of the electromagnetic spectrum lying near the red end of the visible spectrum. Wavelengths around 700–3000 nm.

**Normalised Difference Vegetation Index (NDVI)** An index of vegetation biomass commonly used to estimate the potential yield of a crop.

**PCMCIA Card** A removable card that is able to hold large quantities of data and able to withstand the harsh environmental conditions used by most yield monitors.

**Pixel** An abbreviation for "picture element", a pixel is simply the smallest picture element of a digital image. The smaller the pixels, the higher the resolution of an image.

**Polygon** A multisided figure or shape that represents area on a map such as a similar yield, land use or soil type.

**Real-Time Correction** The practice of correcting the GPS signal by immediately sending the differential correction information to the mobile receiver in use.

**Real-Time Kinematic (RTK)** A procedure where carrier-phase corrections are transmitted in real-time from a reference receiver to a user's receiver(s). RTK enhances the precision of position data derived from satellite-based positioning systems. In agricultural applications it provides  $\pm 2$  cm accuracy.

**Remote Sensing** The collection of information about an object, series of objects or landscape without being in physical contact with the object or event.

**Scale** The ratio or fraction between the distance on a map, chart, or photograph and the corresponding distance on the ground.

**Sensor-Based Variable-Rate Application Systems** Systems which create applications maps by processing field data collected from real-time sensors as the implement moves through the field, altering the input application rate on-the-go.

**Site-Specific Crop Management (SSCM)** A management system that takes into account the variability of crop and soil parameters to make decisions on the application of production inputs.

**Spatial Prediction** Any prediction method that incorporates spatial dependence.

**Spatial Resolution** Refers to the size of the smallest object on the ground that an imaging system, such as a satellite sensor, can distinguish.

**Spatial Variability** The difference in field conditions from one location to another in the same field.

**Spectral Resolution** The capability of a sensing system to distinguish between electromagnetic radiations of different wavelengths.

**Standard Deviation** A statistical term that indicates how spread numbers are from the average, calculated by taking the square root of the average of the squares of the deviations from the mean.

**Temporal** Pertaining to time, such as temporal variation (variation over time).

**Temporal Resolution** The time taken for a satellite to revisit the same location.

**Variable-Rate Application (VRA)** The adjustment of crop production inputs such as fertiliser to match conditions within a field.

**Variable-Rate Technology (VRT)** Instrumentation used for varying the rates of application of fertiliser, pesticides and seed as it is applied across a field.

**Variance** A measure of dispersion of a set of data points around their mean value. The square root of the variance is the standard deviation.

**Yield Monitor** A system that gathers georeferenced yield data by measuring the mass or volume of a harvested crop per unit area, by location, within a field.

**Zone Management** A management system in which a field is divided into different zones, based on production potential, for the application of agricultural input.

# PRECISION AGRICULTURE

## BACKGROUND

Precision agriculture (PA) is a broad term used to describe the rapidly developing practices using spatial technologies to measure and strategically manage farming systems from the whole farm to within paddock perspective. The ultimate aim is to deliver economic, management and environmental benefits.

PA provides growers with enormous, and sometimes overwhelming, quantities of information which enables them to:

- ⊕ develop a history of farm records;
- ⊕ improve decision-making;
- ⊕ target farm input use and improve efficacy;
- ⊕ unlock yield potential;
- ⊕ foster greater traceability; and
- ⊕ enhance marketing of farm products.

## PA IN RICE

There has been a considerable amount of PA work conducted in the rice industry, in particular:

- ⊕ aerial crop imaging;
- ⊕ managing crop effects from laser guided land-levelling; and
- ⊕ variable rate nitrogen application.

PA in rice production in Australia is on the verge of rapid adoption and now is the time to consolidate past experiences and build a framework for the successful implementation of PA by the wider industry.

## DEFINITION

Precision Agriculture (PA) is a farming management concept based on observing, measuring and responding to inter- and intra-field variability in crops.

PA aims to optimise field-level management with regard to:

- ⊕ crop science: by matching farming practices more closely to crop needs;
- ⊕ environmental protection: by reducing environmental risks and footprint of farming;
- ⊕ economics: by boosting competitiveness through more efficient practices

PA integrates spatial technologies with the management processes of cropping systems, and enables growers to strategically respond to the challenges of crop production relative to space and time.

Implementation of PA in the rice industry introduces some additional challenges to those seen in broad-acre crop production, however PA can lead to enormous opportunities.

## CHALLENGES

- ⊕ Permanent infrastructure in irrigation layouts.
- ⊕ Use of aerial seeding and fertiliser application.



Permanent infrastructure such as roads and channels need to be considered in order to get the most benefit when developing rice paddocks to utilise PA.



## OPPORTUNITIES

- ⊕ Address within-field variability resulting from cut and fill when land-forming irrigation bays.
- ⊕ Utilise RTK satellite navigation systems to collect accurate elevation data across paddocks in order to assess which bays would benefit from re-grading.
- ⊕ Reduce the incidence of overlap due to part-width passes at the end of a bay. Overlaps add agronomic challenges and input costs.
- ⊕ Increase returns by matching crop management more closely with crop needs within each rice bay.

## CONTROLLED TRAFFIC FARMING

Controlled traffic farming (CTF) is a system of crop production where wheels are driven on hard permanent tracks. CTF relies on RTK autosteer to attain operation to operation and year to year repeatability. In grain production the wheel spacing and 'lap' width are determined by the header, which cannot be easily modified. Other implements are then modified to be multiples of the header width. Common systems are 9 m and 12 m, with 3 m wheel spacing. The key is to research machinery options, decide on a width and stick to it. A 9 m CTF system may work with a 9 m wide seeder and header front, and a 27 m wide boomspray. Spreading could then be 18 m or 27 m depending on the implement capabilities.

Use of CTF in rice production is complicated by the presence of irrigation structures, and where beds are used the widths have to be adjusted to suit.

## THE PROJECT

### IMPLEMENTING PA IN THE AUSTRALIAN RICE INDUSTRY

Many rice growers have made significant investment into PA equipment such as auto-steer, yield mapping and variable rate application technology. The project, *Implementing PA in the Australian Rice Industry*, aims to deliver knowledge to growers on ways to maximise returns on their investment.

The project focused on engaging growers and agronomists, and working with them to develop skills and knowledge across the industry. It aimed to simultaneously:

- ⊕ build awareness of the capabilities of PA in rice production and the economic benefits;



Poor establishment (top) on cut areas and good establishment (bottom) elsewhere in direct drilled rice results in differences in yield. PA is highlighting how closely correlated rice yield is to cut & fill, and also offers an opportunity to effectively ground truth and begin to address the issues.

*Rice Research Australia, Sun Rice, 'Old Coree' Jerilderie, NSW.*

- ⊕ use focus farms to identify yield limiting factors across the industry and develop guidelines for implementing PA in rice;
- ⊕ up-skill the rice industry (growers, agronomists and others) to enable implementation of PA;
- ⊕ deliver innovative crop management solutions addressing within paddock variability through on-farm trials; and
- ⊕ identify crop production knowledge gaps and integrate these into future research.

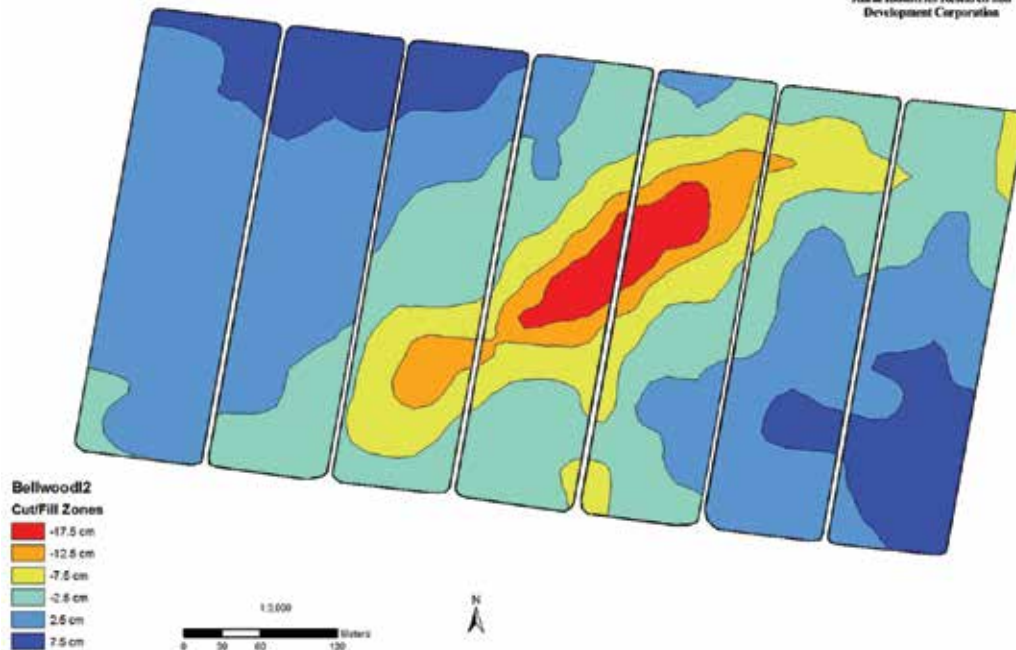
This publication captures the key outcomes with guidelines for growers adopting PA and direction for future research and development within the rice industry.

# PRECISION AGRICULTURE

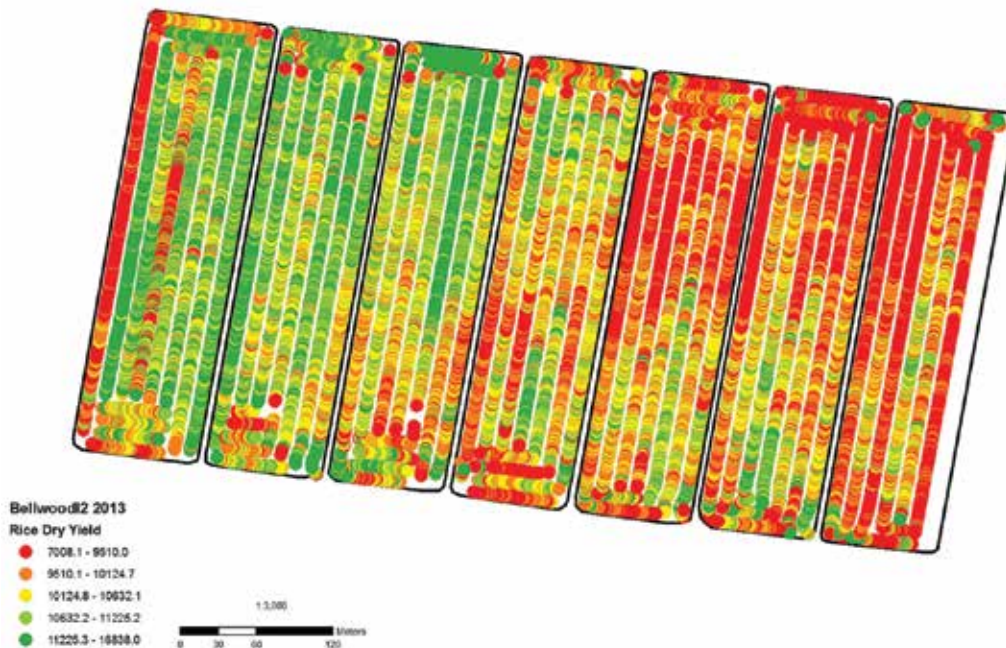
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## CUT AND FILL ZONES

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## RICE YIELD 2013



These maps illustrate the strong relationship between rice yield (bottom) and cut & fill (top). Most yield maps reflect cut & fill as seen in this example, however this is not always the case. This is probably due to a combination of factors such as multiple regrading effects and improved levelling techniques (topsoiling).

Grower: Mick Agosta, Paddock: Bellwood I2



## TOP FIVE RECOMMENDATIONS FOR GETTING STARTED

- 1 Develop a Precision Agriculture plan for your farm – focus on unlocking yield potential first; many farms will have simple solutions which can deliver significant benefits, especially within the poorer yielding areas of the paddock. Secondly look for opportunities to reduce input costs.
- 2 Invest in regular field levelling as variable water depth can dramatically impact rice production and water use efficiency.
- 3 Analyse your rice yield maps, which are essentially a profit map, enabling you to measure the economic impacts of key yield constraints and act accordingly to increase farm profitability. Every farms' actions will be unique to their specific situation.
- 4 Cut & fill maps often correlate with yield maps (caution: this relationship may vary between paddocks). If so, utilise land-forming maps and paddock knowledge to define management zones and soil sampling plans in order to ultimately develop an agronomic management package for each management zone.
- 5 Do not begin variable rate crop nutrition unless you are confident with the accuracy of your management strategy. Use on-farm trials to test fertiliser use efficiency.

## WHY CONSIDER VARIABLE RATE MANAGEMENT IN RICE?

- ⊕ A typical rice crop varies by greater than \$1000/ha (3–4t/ha), costing the Australian industry up to \$150million per annum – variable rate fertiliser has proven to close this yield gap between high and low yielding areas, unlocking the potential to increase productivity by 10–15%.
- ⊕ Intensive agriculture such as rice production favours variable rate management as poor performing areas in a high cost of production system can dramatically reduce farm profitability.
- ⊕ Many paddocks have predictable yield zones associated with cut & fill maps, offering growers the ability to develop a variable rate nutrition and soil conditioning programs.

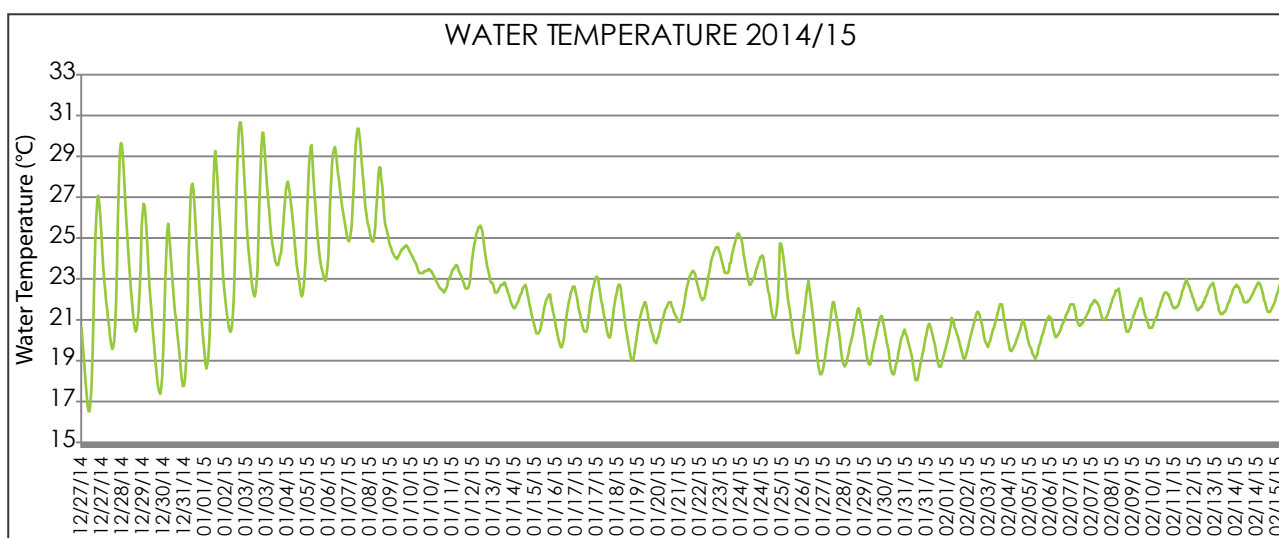


# SOIL CONDITIONING

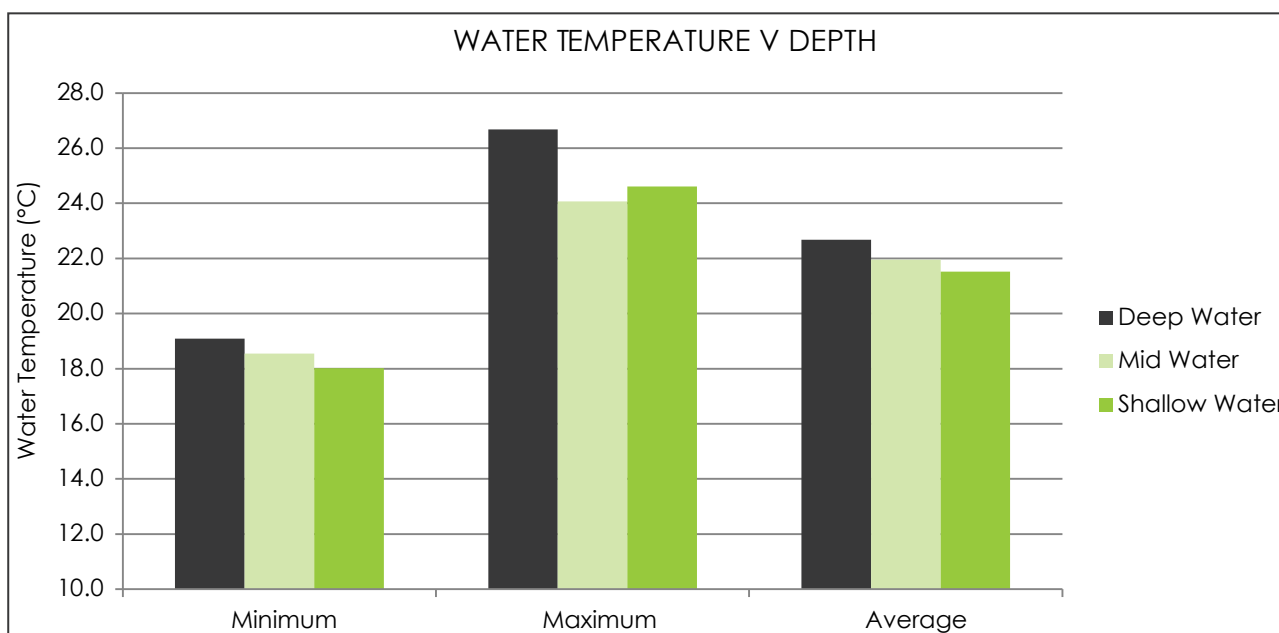
## SOIL CONDITIONING AND MANAGING WATER DEPTH

The variability in water depth across many bays was a surprising finding and reinforced the concept that growers need to focus on getting the basics right before focussing too closely on the more advanced variable rate management strategies. Further work is required to better understand the interaction of water depth, water supply and irrigation design on the variability of water temperature across each bay. Our preliminary findings found water temperatures

(measured 20mm above soil level) varied by up to 3°C within a bay. This variation was mainly attributed to change in water depth and the proximity of the sensor to the water supply. There was an inconsistent relationship between water depth and rice yields between paddocks and seasons.



Example of a typical water temperature pattern in rice (between 27 December 2014 and 14 February 2015), showing both daily and seasonal movement



A common trend was observed where deeper water buffered against the cooler air temperatures, maintaining a higher average water temperature by at least 1 °C

## RECOMMENDED MANAGEMENT ACTIONS

- ⊕ Regular levelling of paddocks to ensure minimum grades on each bay will limit the effect of inconsistent water depth, thus offering superior water management ability.
- ⊕ RTK autosteer systems on grower's tractors can collect accurate elevation data (ideally sowing application map) which can be used to prioritise which bays may benefit from a regrade. Do not use elevation data associated with yield data as tyre compression and paddock sinkage can change as the header fills with grain, influencing the elevation maps.
- ⊕ Topsoiling is an extremely valuable process when levelling new country as it has the ability to eliminate the detrimental effects of cut.
- ⊕ Strategic GPS-referenced (0–10 cm) soil tests based on previous years' rice yield map and/or cut & fill map are essential to monitor nutrient levels and soil health.
- ⊕ Actively manage soil sodicity and acidity (more important for non-rice crops) with targeted lime and gypsum applications based on grid soil pH maps (lime), yield maps and/or cut & fill maps (gypsum).



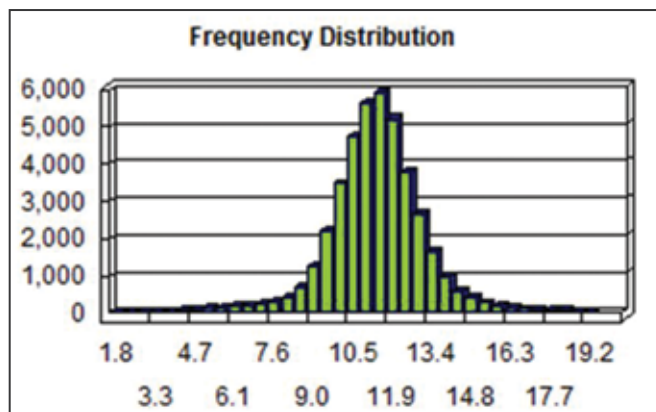


# MEASURE TO MANAGE

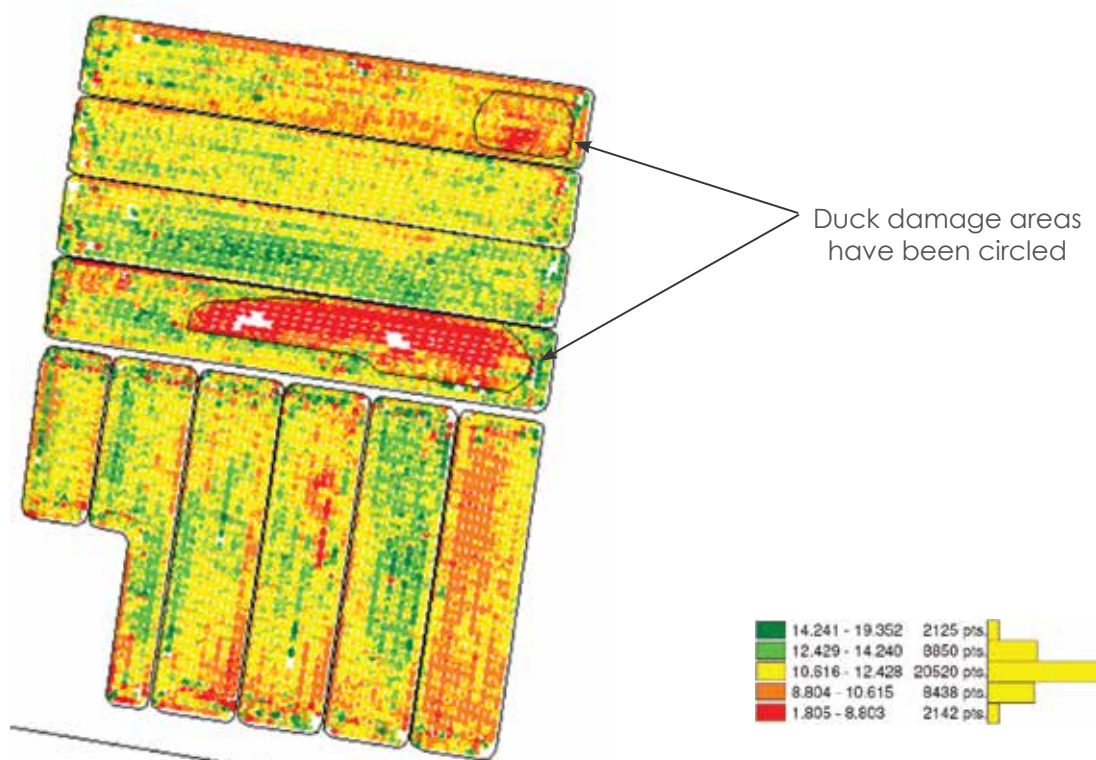
## MEASURE TO MANAGE

- ⊕ Even if you are not thinking about implementing variable rate management in the near future, there is still value in collecting and reviewing yield maps as it may help identify strategies to increase production. There are numerous service providers who prepare growers and contractors for yield data collection, and process the data for viewing.
- ⊕ Utilise yield data to quantify the extent of variability (yield and economic) across each paddock in order to determine if this can be managed economically.
- ⊕ Yield data should also be used to measure variations and responses to management practice changes (i.e. levelling, fertiliser applications), to justify completed tasks and to see if a positive (yield and economic) response has been achieved. These management practices do not necessarily need to have a site specific crop management focus.
- ⊕ For example: determine the economic impact of ducks by analysing a yield map. Use the data to quantify the exact area effected by ducks

and compare the duck damaged area with the average yield immediately surrounding this area. In 2013, ducks effected 4ha out of a 52ha paddock, reducing yield by 3.13t/ha costing \$3756.



Classic distribution of yield data for a rice paddock with a 3–4t/ha variation. The aim is to tighten this spread of yield and shift the average across the to the right or higher.

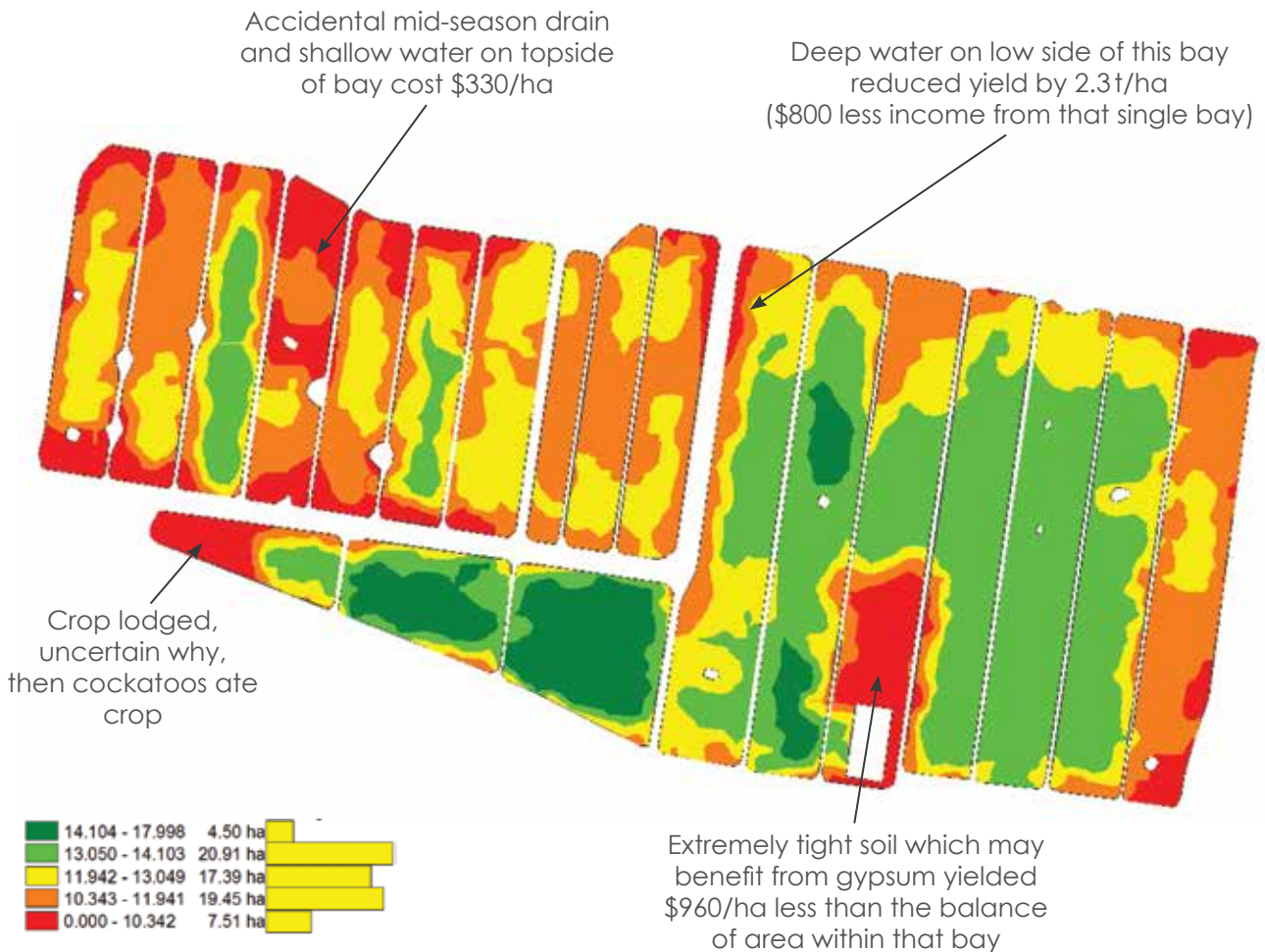


Rice yield map (2013) illustrated in its raw data (point) format with associated legend indicating yields varying from <8.8t/ha to 14.2t/ha

# MEASURE TO MANAGE

Another example of how the combination of a yield map and the grower's paddock knowledge can deliver valuable insights for future management decisions. It is a good idea to review yield maps each year and record observations, such as those listed below, as it is invaluable

when a grower is ready to begin variable rate management and is looking back over multiple years of data.



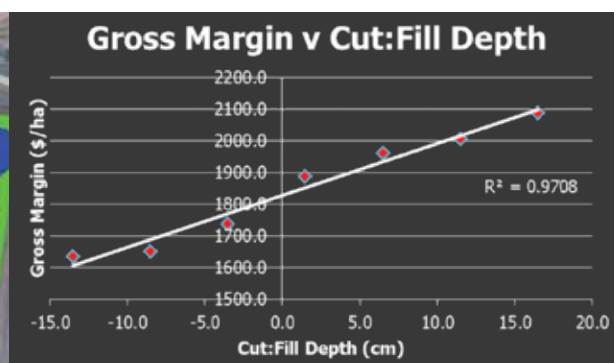
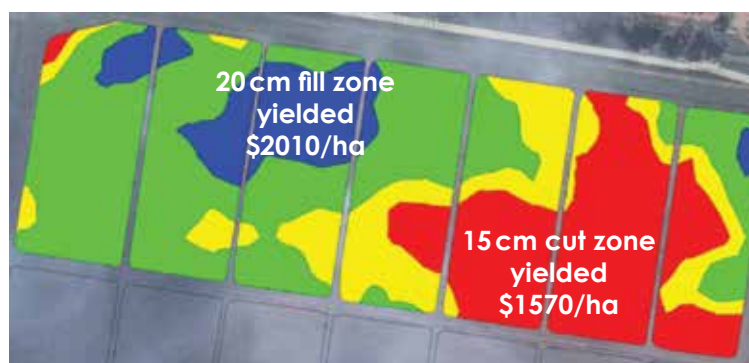
Rice yield map (2014) illustrated as a smoothed surface (five zones) format with associated legend indicating yields varying from <10.3t/ha to >14.1t/ha

# MANAGEMENT ZONES

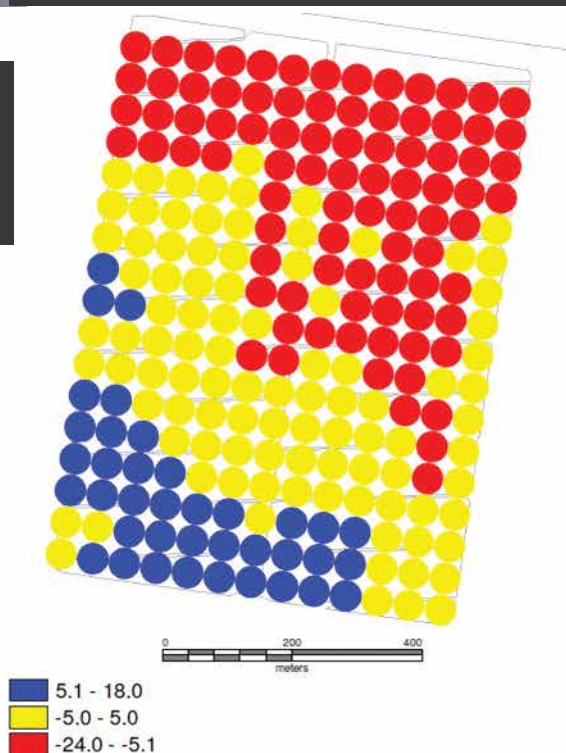
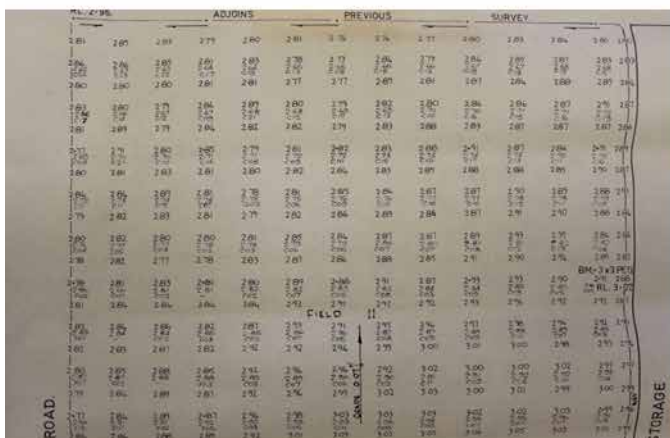
## DEFINING Paddock MANAGEMENT ZONES

⊕ If a strong correlation between rice yields and cut & fill can be identified, then it would be worthwhile integrating (digitising) the cut & fill maps into the precision ag mapping program. Cut & fill zones can be defined from a data set, typically two to four zones per paddock (5–10 cm increments).

⊕ Below is an example of a farm where every paddock which was analysed for yield versus cut & fill zones resulted in an extremely strong relationship, therefore offering confidence for this grower to design variable fertiliser programs (at sowing) based upon cut & fill zone maps.



Example of digitising a hardcopy land forming map (below) into a precision agriculture mapping program (right). The blue dots represent points with 5-18 cm fill depth and red dots are 5-24 cm cut depth.



⊕ Growers with multiple years of yield data should review all maps and look for consistent trends. However, it is likely the maps will vary between seasons due to factors such as temperature, wind, water management, ducks and weeds. If clear production zones cannot be found, then there would be little value in pursuing a variable rate management program.

⊕ Do not use yield data from non-rice crops in an attempt to define rice management zones as other crops respond differently to soil/water influences.

⊕ Multiple seasons crop imagery (UAV, aerial or satellite) may also help define areas of high and low production, however these data sets are highly sensitive to water depth and can be influenced by weed pressure (i.e. high biomass may in fact be high weed pressure). These

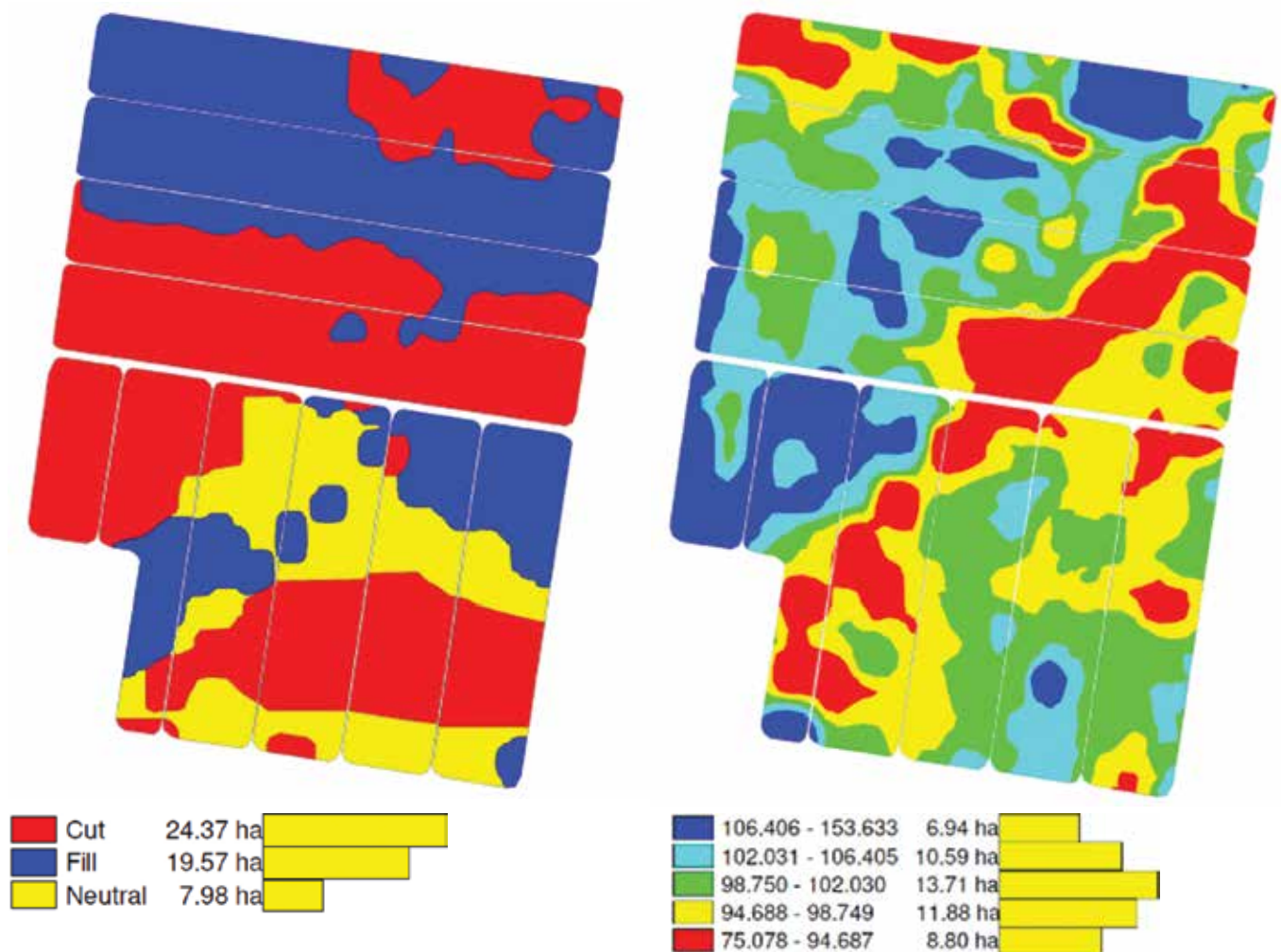


# MANAGEMENT ZONES

maps must be interpreted by the grower who has a good memory! It is a good idea to keep a record of paddock performance with simple comments such as, 'southern end effected by wind resulting in poor crop establishment'.

- ⊕ EM38 maps are effective for defining soil variability associated with water holding capacity. This is valuable for winter crops but not for defining rice management zones.
- ⊕ EM31 maps are good for identifying soil types suited for rice production but the maps are not particularly useful for defining paddock level management zones as they obtain their readings well below the root zone.

- ⊕ Local paddock knowledge should always be integrated into the paddock zoning process. The best approach is to find a precision agriculture consultant who can help pull all the relevant data sets together and then work with the grower to define the finalised management zones for each paddock.



Above is an example of a paddock where the cut & fill map (LHS) is the primary data set used to build a variable rate fertiliser map. The EM38 map (RHS) does not correlate to the cut & fill map and is not used for developing rice management zones.

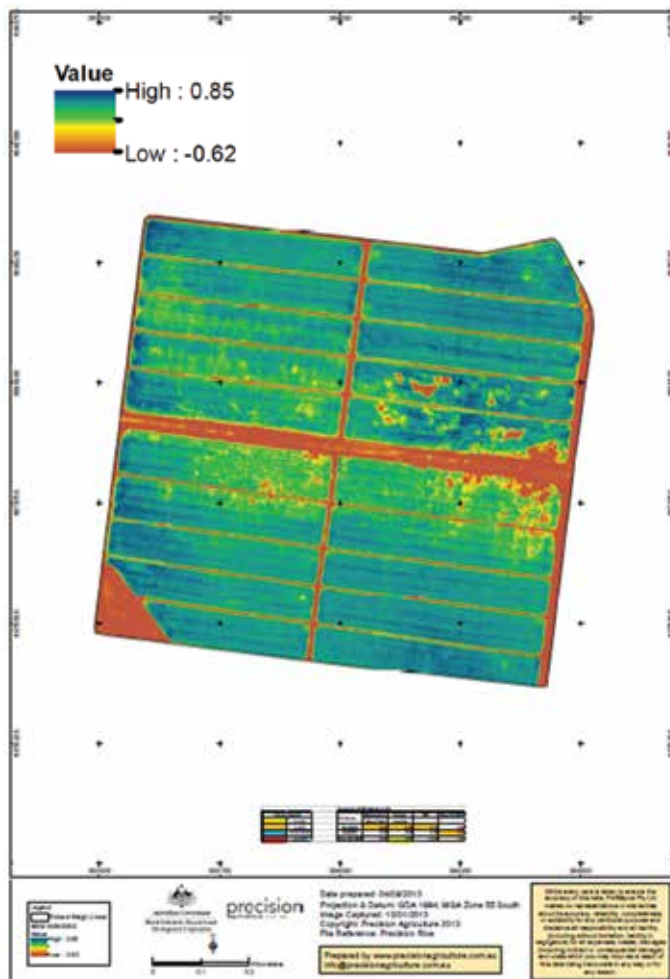
# TOOLS FOR NITROGEN

## CROP SURVEILLANCE TOOLS FOR NITROGEN APPLICATIONS

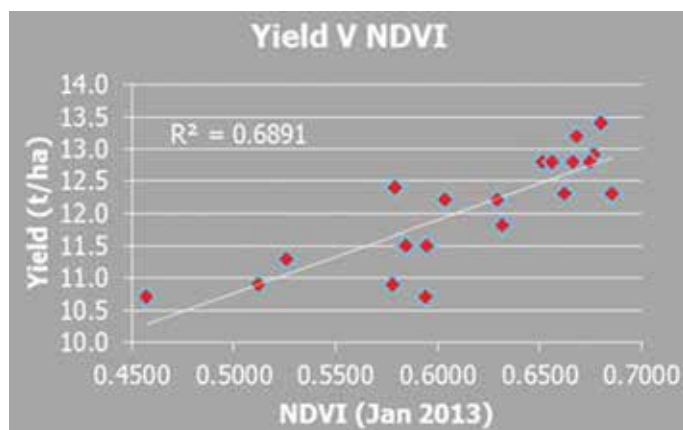
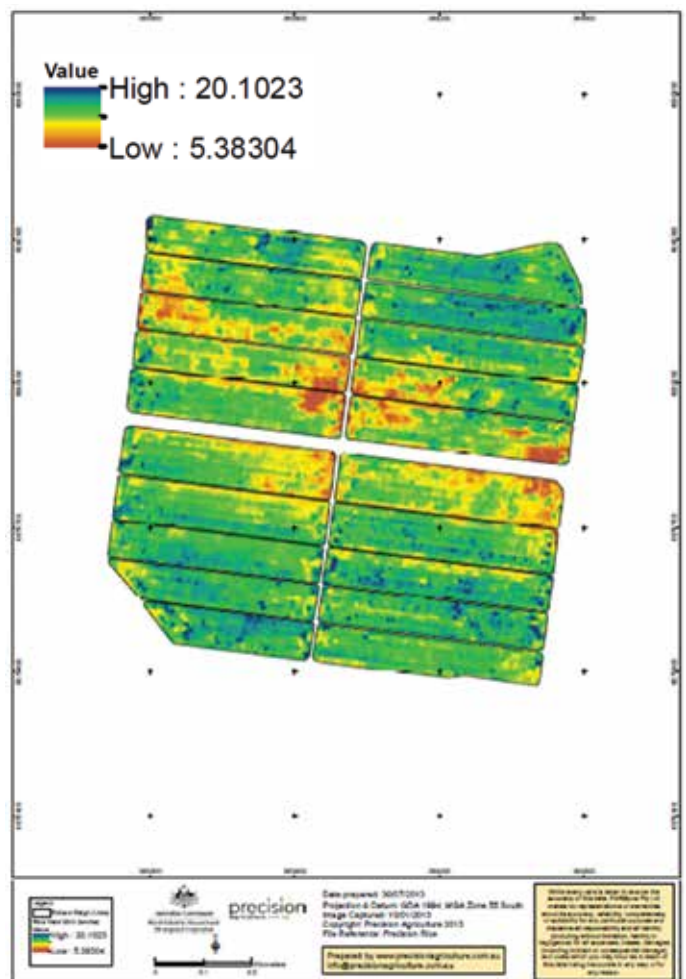
⊕ Normalised Difference Vegetation Index (NDVI) is a relatively good indicator for predicting spatial yield patterns, thus a yield potential index. NDVI does not identify what is limiting yield potential, however it should be used as a guide for crop scouting and plant nitrogen uptake sampling.

⊕ When ordering a satellite, aerial or UAV image of a crop it is advantageous to know when the capture is likely to occur; this is so the grower can note the water depth for each bay. Higher water levels equate to less crop being visible for crop vigour/greenness assessment.

NDVI January 2013



Rice Yield 2013

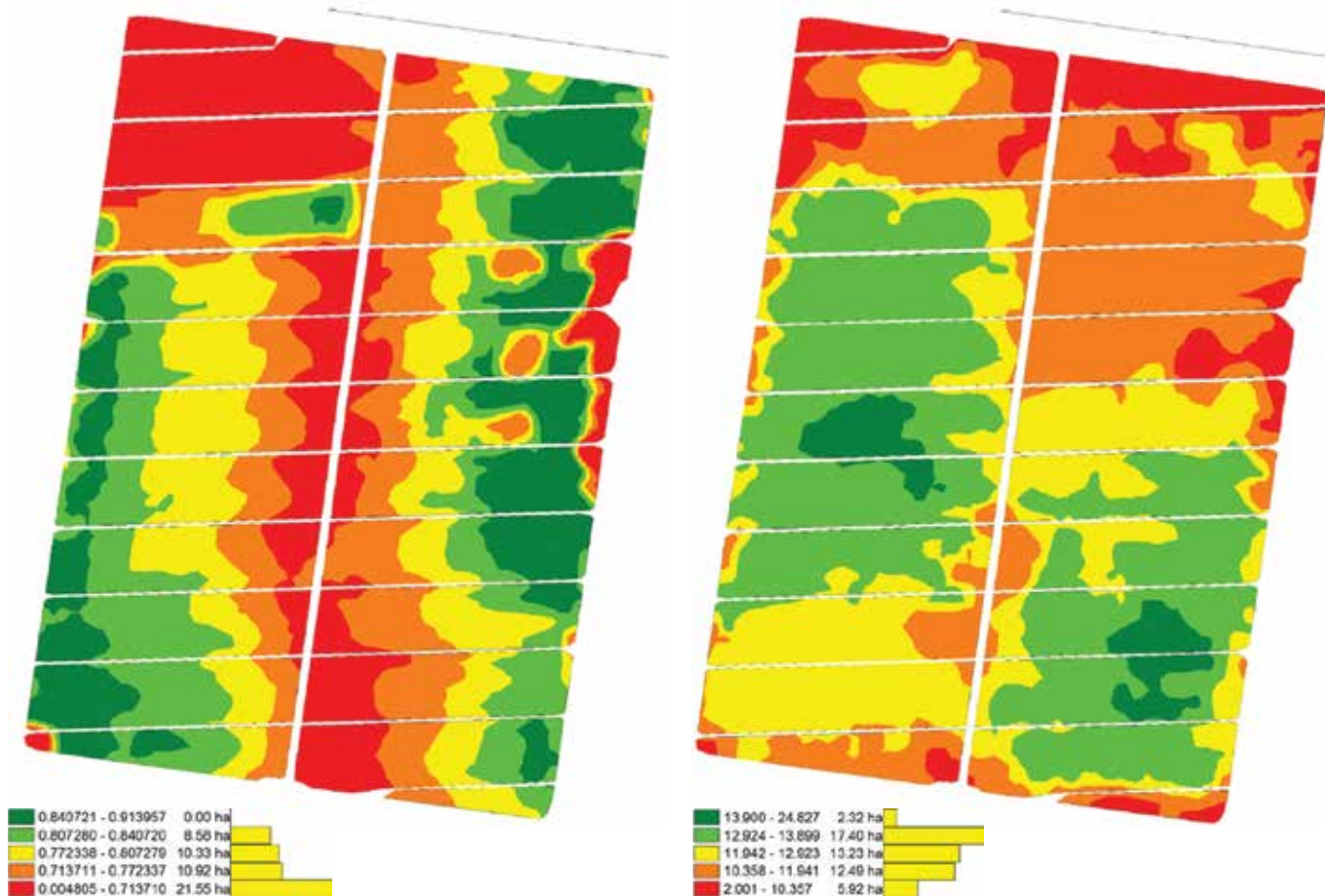


Example of a paddock which had a good correlation between NDVI (around PI, above left) and final yield (above). The next step in this example would be for the grower to intervene to increase production in the low NDVI areas, typically with nitrogen. If it is not a nitrogen limitation, then the grower may need to wait until the next crop before implementing a strategy to increase yield potential in this area of the paddock.

# TOOLS FOR NITROGEN

NDVI January 2013

Rice Yield 2013



Above is an example of a paddock where the NDVI map of the rice crop, captured 14 January 2013 did not reflect the final yield map, which can be explained by variable water depth across the paddock. The low NDVI (red) areas spreading out from the central division of the paddock is a consequence of increasing water depth across this paddock.



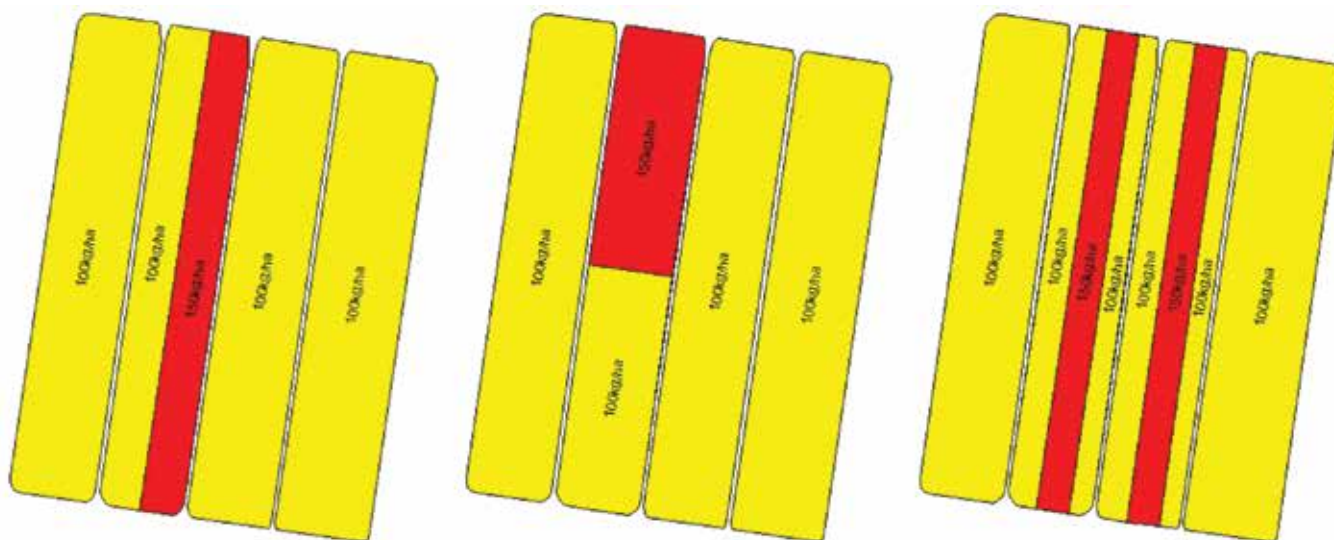
# ON-FARM TRIALS

## ON-FARM TRIALS

The most valuable trial for any grower is the one run on their own farm. Simple on-farm trials complement the traditional 'scientific' research methods. It is critical to make sure the trial is designed so the treatments can be fairly compared against each other, without the effect of inherent paddock variability or historical management. Results from these trials are another layer of information to inform the growers' management decision.

- ⊕ Simple test strips within the same bay should be used to quantify crop/economic response to a management factor, primarily fertiliser and soil conditioning (lime and gypsum, if cultivated in).
- ⊕ Trial design and location holds the key to success – viewing historical yield maps and land forming maps offers insights into paddock and bay selection that are consistent in their yield performance.
- ⊕ These data sets can also help design trials to deliberately run through areas of high and low performance.

- ⊕ Select bays which are wide enough for each treatment to include three passes of the header and avoid bays with significant variation in water depth as this may confound your trial results.
- ⊕ Where possible run each trial strip the entire length of the paddock. At a minimum, trials should be no less than 100m long.
- ⊕ An option for minimising water depth influence is to split the bay in half across the bay (see design below, centre) rather than a split along the centre run-line (see design below, left).
- ⊕ Certain trials will be more suited to bay level comparisons (i.e. water management), however multiple replicates would be required in order to obtain confidence in results from these trials as more confounding factors are introduced to the trial when comparing different bays.



Example of three simple trial designs which can offer a grower valuable insights into how a product or change in management may influence rice production.

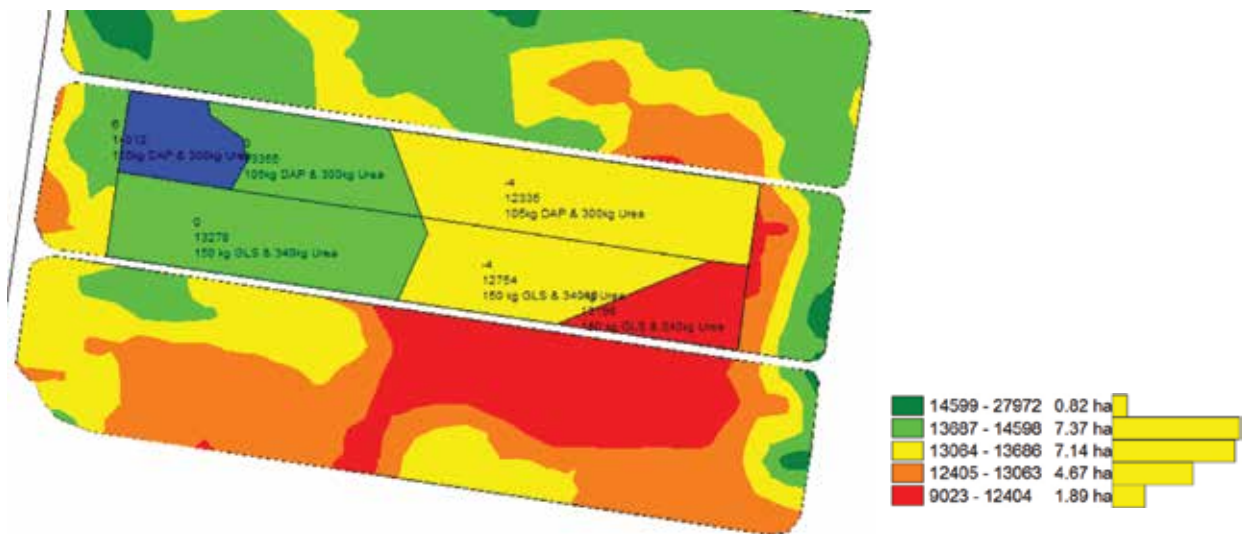
# ON-FARM TRIALS

## TRIAL EXAMPLE 1 – GRAIN LEGUME SUPER

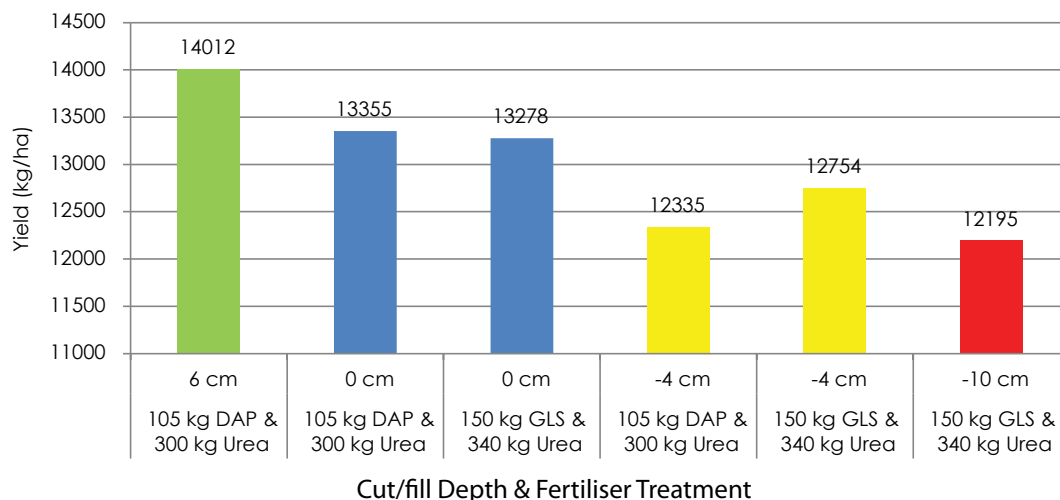
Grain legume super (7% sulphur) trial was implemented as a simple split-bay design (half bay with and half bay without). It is important to only conduct this style of trial within bays that are relatively flat, in order to minimise the effect of variable water depth from one side of the bay to the other.

We were able to overlay the cut & fill map as indicated by the different colours within each trial strip and then extract the relevant yield data from

within each area. Whilst this extra analysis adds complexity, it is critical for understanding the crop response to the trial. Trials which are not being analysed by a precision agriculture consultant who has the ability to conduct this level of analysis should be conducted in bays with minimal influence of cut & fill zones.



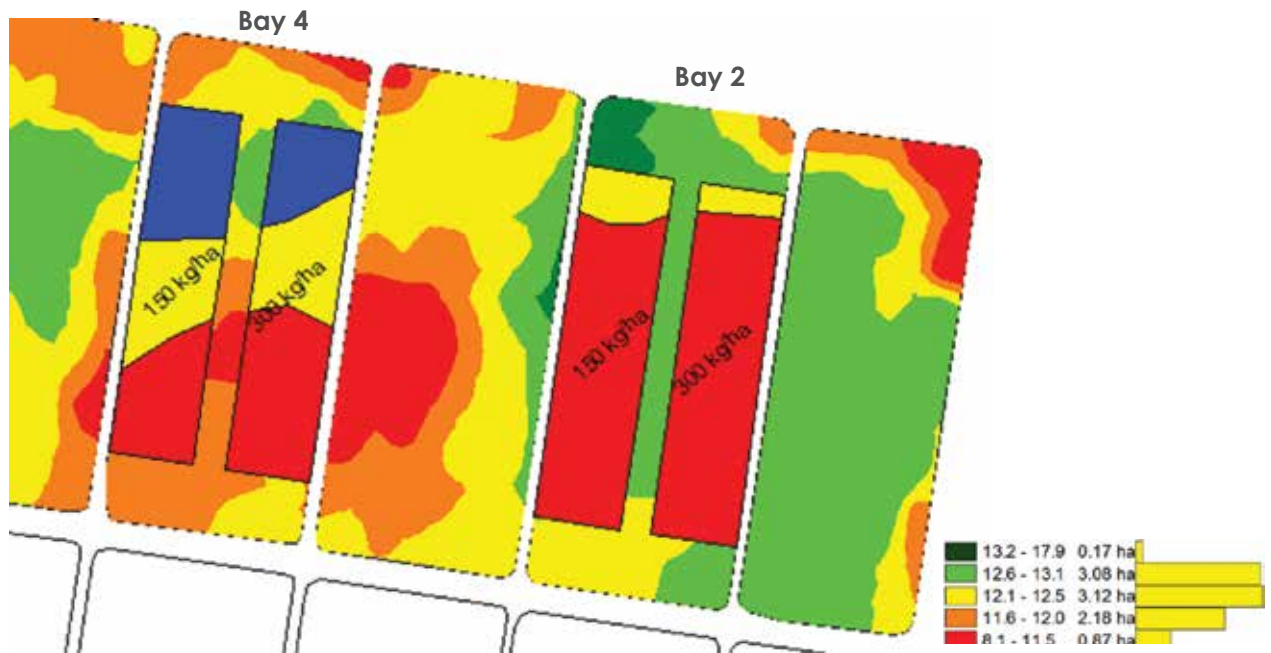
Trial design (above) and rice yield (below): top half of bay = 105 kg/ha DAP + 300 kg/ha urea; bottom half of bay = 150 kg/ha grain legume super (GLS) + 340 kg/ha urea  
 Colour-coded by cut & fill depth (blue = 6 cm fill, green = untouched, yellow = 4 cm cut, red = 10 cm cut) with rice yield map in the background



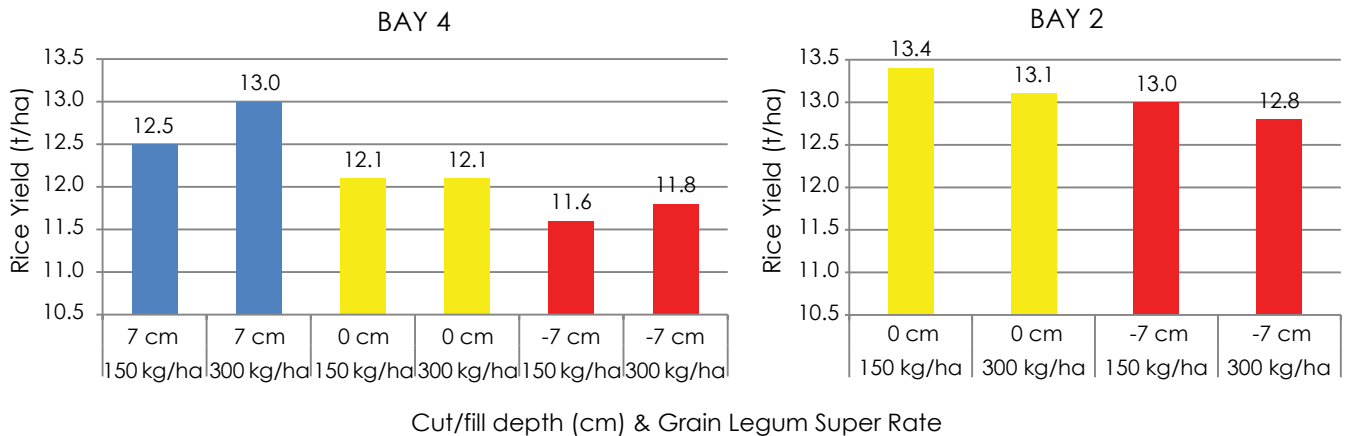
The first observation from this trial is that yield declines from fill to cut zones. The grain legume super which delivered 10.5 kg/ha sulphur increased yield in the 4 cm cut zone by 419 kg/ha (approximately \$140/ha) but did not influence

yield in the untouched zone. This trial response is consistent with the grower and agronomist's expectation and supports the concept of applying sulphur to all cut zones across the paddock.

# ON-FARM TRIALS



Trial design (above) and rice yield (below): grain legume super rates (LHS strips = 150 kg/ha; RHS strips = 300 kg/ha). Colour-coded by cut & fill depth (blue = 7 cm fill, yellow = untouched, red = 7 cm cut) with rice yield map in the background.



It is important to understand that the two most eastern bays (RHS) out-yielded all other bays, despite being predominantly cut zones. This was due to the application of 125 kg/ha of urea, which in hindsight should have been applied to the entire paddock. The grain legume super did not increase yield in Bay 2. The extra 150 kg/ha grain legume super in Bay 4 increased yield, in both the 7 cm cut & 7 cm fill zones, but not in the untouched

zone. Further analysis is required to determine both the nitrogen and sulphur responses across the paddock.



# ON-FARM TRIALS

## TRIAL EXAMPLE 2 – GYPSUM

Several gypsum trials were conducted through the duration of the project and consistently found encouraging results with increased rice yields in areas which had received 1–2 t/ha. We can appreciate the concern many people have

with gypsum increasing water use, however we wanted to explore the potential to improve crop establishment in sodic soils.



Photos (taken the same day) of drill-sown rice emerging in different bays within the same paddock at 'Old Coree'. This illustrates surface sodicity (right) and associated poor crop establishment which can easily be assessed and identified visually.

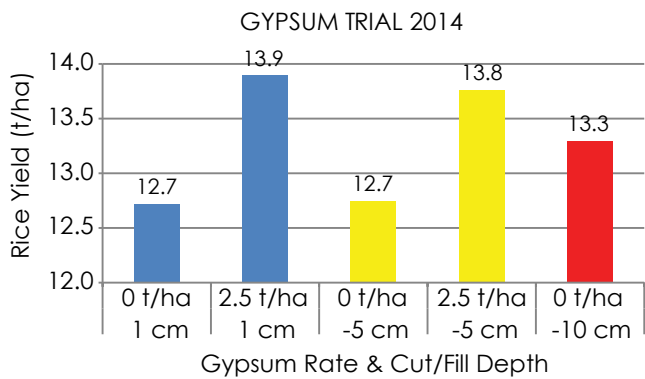
There is enormous potential for targeted gypsum applications in zones with surface sodicity (whole bays or portions within a bay) to greatly improve crop establishment and early crop vigour.

A gypsum trial was conducted near Finley with half a bay receiving 2.5 t/ha. As seen here, the design was for 1 t/ha but a higher rate was accidentally applied.

Two examples of gypsum trials conducted during the project. In the top trial gypsum was incorporated by tillage, whereas the bottom trial gypsum was not incorporated. It is recommended to incorporate the gypsum to enable a more accurate comparison, otherwise the gypsum will be more available to enter into water solution across the entire bay.



# ON-FARM TRIALS

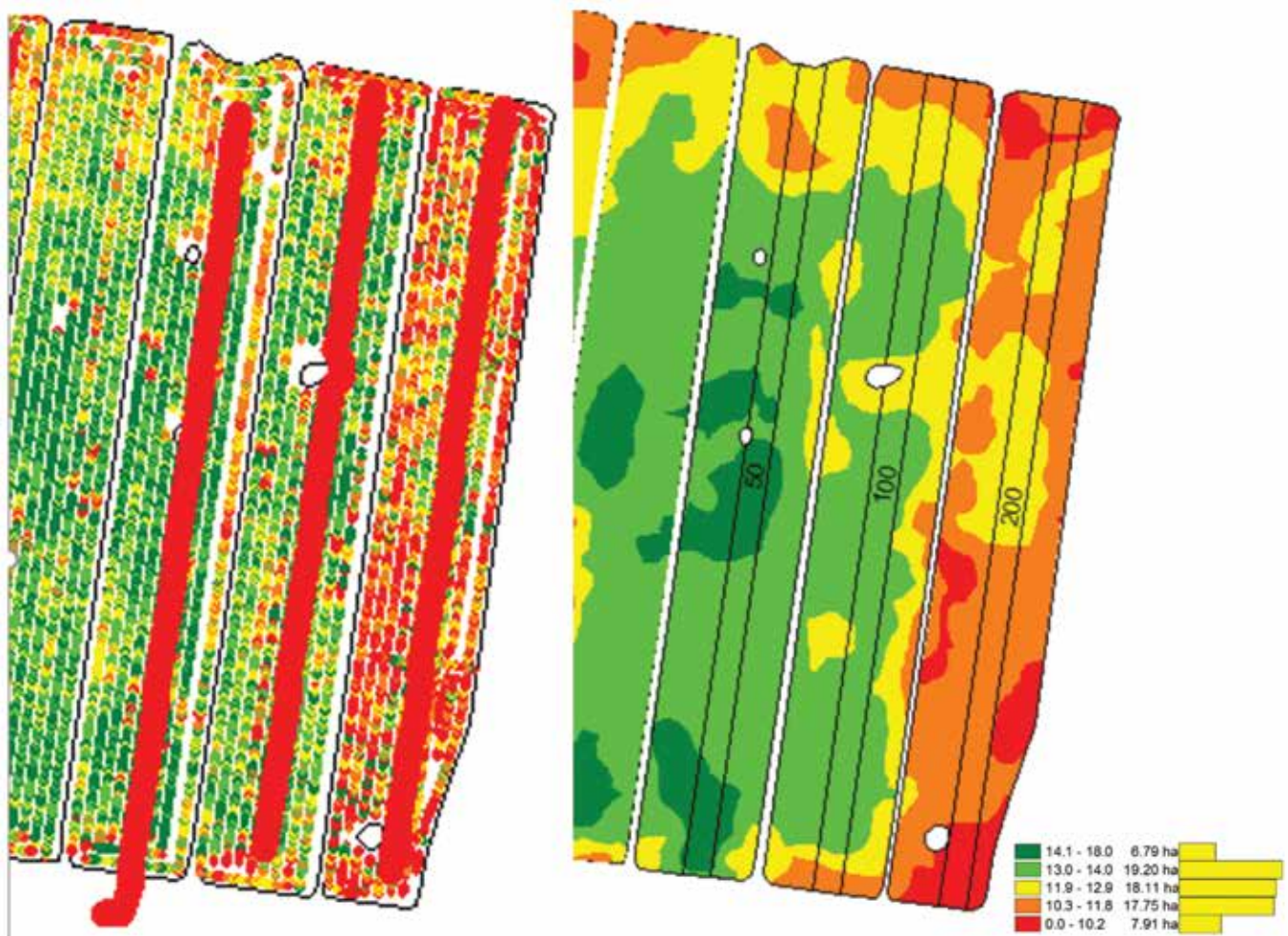


Results from this gypsum trial were reported against the different cut & fill zones with a strong response in the 1 cm fill and 5 cm cut zones. Further testing will be conducted across the farm to better understand the crop response to gypsum, especially to determine whether the crop is responding to improved soil condition, clearer water quality or extra sulphur supply.

## TRIAL EXAMPLE 3 – SULPHUR

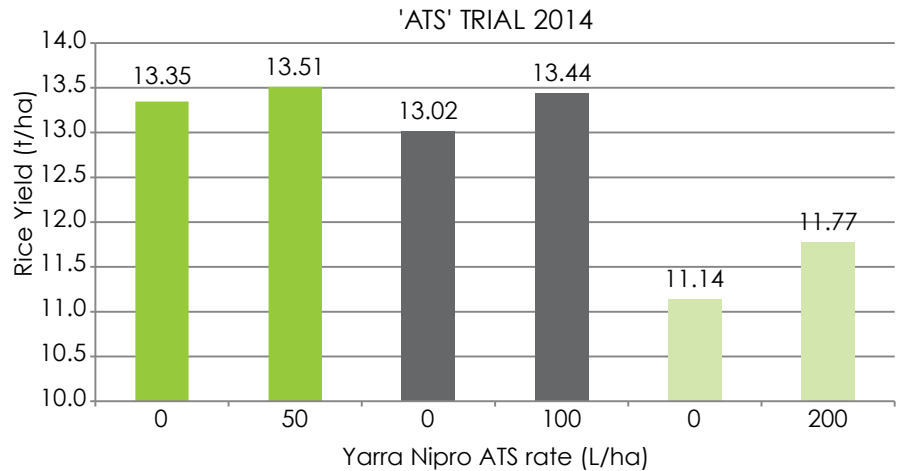
Yarra Nipro 'ATS' (16% nitrogen and 34% sulphur) was applied as a bare-earth spray prior to pre-drilling granular fertiliser. The red strips show the

coverage recorded by the sprayer, eliminating the need for physical markers in the paddock to locate trial locations.



Point data rice yield map (left) with spray coverage strips (red lines) and smoothed surface rice yield map (right) with trial design including Nipro 'ATS' rates (L/ha).

There was a consistent yield increase where the product was applied in all three bays with an increasing rate response. The results from this basic trial offers confidence for the grower to conduct more extensive trials across larger areas.



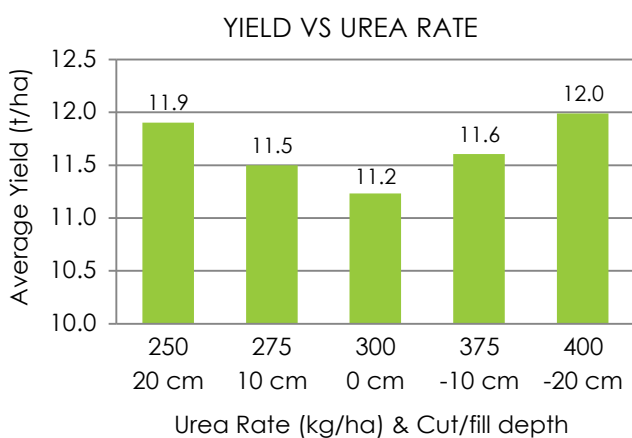
## IMPLEMENTING VARIABLE RATE FERTILISER

Assuming management zones have been defined and there is a clear need for Variable Rate (VR), all the research and grower experiences suggest variable rate applications are best implemented prior to, or at sowing. Nitrogen is the most common nutrient to be applied post sowing and while crop imagery can be used to refine nitrogen application maps, increased nitrogen application in poor performing zones (mainly cut zones) is best pre-drilled.

The most common VR program is based around increasing yield potential in poor performing (typically 'cut') zones which usually involves increased fertiliser rates (and/or addition of extra nutrients, i.e. sulphur and zinc) in these zones. This project found multiple examples where increased

phosphorus and nitrogen in these zones closed the traditional yield gap between high and low performing zones.

The adoption of VR management within the rice industry remains low, despite the fact that many growers have the ability to vary inputs with their spreaders, sprayers and seeders. Lack of understanding the benefits and know-how for developing a VR strategy continue to inhibit widespread adoption.



Example of a paddock where VR pre-drilled nitrogen application closed the yield gap between cut and fill zones. The 20cm cut zone was the highest yielding area within that paddock proving the value of VR for that paddock.

### PROJECT FINDINGS TO SUPPORT INCREASED USE OF VR MANAGEMENT

- ⊕ Production variability within each paddock is significant (approximately \$1200/ha variation between high and low yielding areas).
- ⊕ VR fertiliser programs have proven to close this yield gap and offer a 10–15% increase in productivity.
- ⊕ The combination of yield maps, local paddock knowledge, cut & fill maps and targeted soil sampling can help define management zones and strategies to unlock yield potential.
- ⊕ There is an increasing number of service providers able to help growers manage their data and build VR application maps.



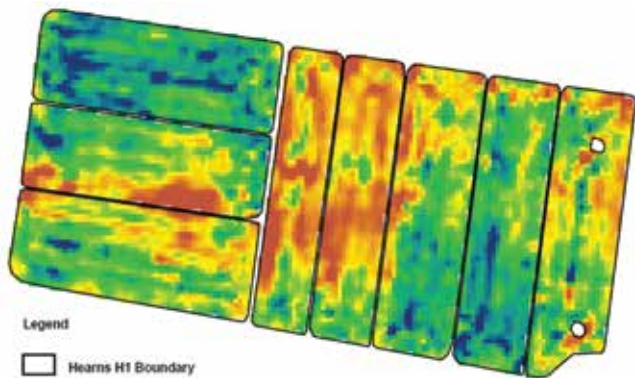
# YIELD DATA

## COLLECTING YIELD DATA

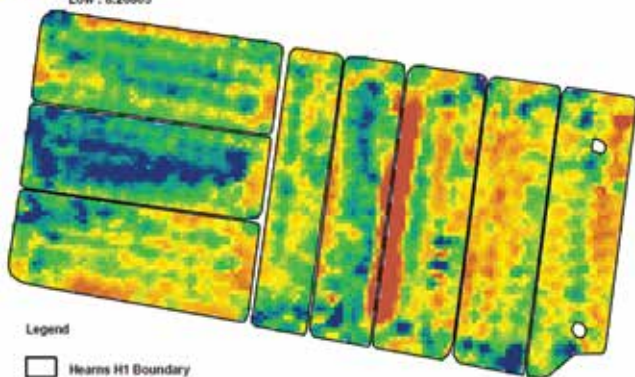
Being prepared, valuing the data and know-how of hardware setup holds the key to collecting high quality yield data. Speak with your local machinery dealer if you are uncertain about operating and maintaining the hardware associated with yield monitoring.

This project, like many growers, experienced the typical pains associated with collection of yield data. Issues included:

- ⊕ Multiple harvesters used in a focus paddock which resulted in only partial yield data collection which proved to be of very little value.
- ⊕ Complete loss of yield data when a computer malfunctioned. Always try to back up your yield data.



Legend  
□ Herans H1 Boundary  
Herans H1 Rice Yield 2006  
Value  
High : 20.6682  
Low : 8.26805



Legend  
□ Herans H1 Boundary  
Herans H1 Rice Yield 2012  
Value  
High : 16.9656  
Low : 7.38195

Illustration of yield variability from season to season (top 2006, bottom 2012). This highlights the need for seasonal records to explain this between season variation.

- ⊕ Grain moisture monitor problem. The grain moisture monitor is critical for the accuracy of a yield map and thus this data could not be used for paddock analyses.
- ⊕ Contractors arriving without yield mapping capability. Communication with your contractor is critical and if possible have a formatted data card (card or USB stick formatted using PA software with pre-loaded paddock list) ready.

## YIELD MAPPING CHECKLIST

- ▶ Have a new FORMATTED DATACARD or USB with paddock list, boundaries and/or guidance lines for each season.
- ▶ TEST YIELD MONITOR. Download and check data at start of harvest to ensure all is working.
- ▶ Calibrate FLOW SENSOR for each crop type and when changing between high and low yielding crops (but not halfway through a paddock) – read manual for proper method for each machine.
- ▶ Calibrate MOISTURE SENSOR against reliable moisture meter – otherwise yield maps can be completely irrelevant or have large errors.
- ▶ Make sure the HEIGHT SWITCH is set up and working correctly.
- ▶ Ensure the correct HEADER FRONT WIDTH is in the monitor.
- ▶ Ensure the correct CROP TYPE is entered into the machine. There are normally different calibration settings for each crop type.
- ▶ Where possible avoid using MULTIPLE HEADERS to harvest the same paddock.
- ▶ Try to keep a FULL FRONT and use GPS guidance if available.
- ▶ Record harvested TONNES for each paddock to enable post-harvest calibration, if required

# CASE STUDY

## PATE FARMING TOCUMWAL

### ADOPTING PA TECHNOLOGY

Nathan Pate farms with his wife, Leah and his workman Jono (known as Pate Farming in this study). They run a 1000ha controlled traffic farming (CTF) enterprise based on dryland and irrigated winter crops and rice.

The move into a full CTF system was a gradual process which started in 2000, although at that stage Pate Farming was not really heading towards a CTF system. It all started with the purchase of a new header with yield mapping capabilities. This presented an opportunity, and so began a planned program of machinery replacement, with the end goal a CTF system and the use of variable rate application technology.

A local machinery dealer and friend was one of the key sources of information on, what was then, cutting edge technology. In 2002 Pate Farming invested in an airseeder that had the ability to apply seed and fertiliser using prescription maps and variable rate technology. In 2004 they added sub-metre autosteer.

After a number of years using sub-metre autosteer Pate Farming felt that there would be benefits in more accurate steering with year-to-year repeatability. This would enable greater efficiency of operations, simply by setting up rice bays to remove half-width laps and avoid, where possible, dry runs to get out of the bay.

### MACHINERY

In 2010 Pate Farming made some simple machinery modifications to move to a 9 m wide CTF system with 3m wheel-track centres, using  $\pm 2$ cm RTK autosteer. All modifications were done on farm and included:

- ⊕ removing a tyre from the airseeder to bring it back to 9 m;
- ⊕ purchasing cotton reels for the front axles and spreading the rear wheels on the existing axles of his FWA sowing tractor and spray tractor; and
- ⊕ adjusting his boom spray axle to the 3m wheel spacing (it was purchased in 2009 with this option as part of the plan to move to a 9m CTF system).

Pate Farming use a community base station, paying an annual subscription. This decision has meant that there is no initial financial outlay and the cost of ongoing maintenance and upgrades is taken care of with the subscription fees.

<b>LOCATION</b>	Tocumwal Murray Valley NSW
<b>KEY ENTERPRISES</b>	Wheat, barley, canola, rice
<b>TOTAL AREA</b>	1300ha
<b>CROPPED AREA</b>	1000ha
<b>IRRIGATED AREA</b>	250ha
<b>RICE AREA</b>	200–250ha
<b>CURRENT PA SYSTEM</b>	9m CTF with 3m wheel centres; variable rate seed/ MAP/urea at sowing; variable rate topdressing; variable rate lime and gypsum application; yield mapping

### IRRIGATION LAYOUT

In parallel with the machinery modifications there has been some planning with the layout of three paddocks most recently set up for rice. The bays were planned with the machinery movement from one bay to the next in mind (see diagram on following page). The ideal is to run bays with even multiples of nine metres. This ensures the start and finish of sowing and harvest operations is at the same end of the paddock. Pate Farming's paddock setup is based primarily upon



Cotton reels were fitted to the front axle and wheels spread on the rear axle of the tractors to move to 3m wheel centres for the CTF system.

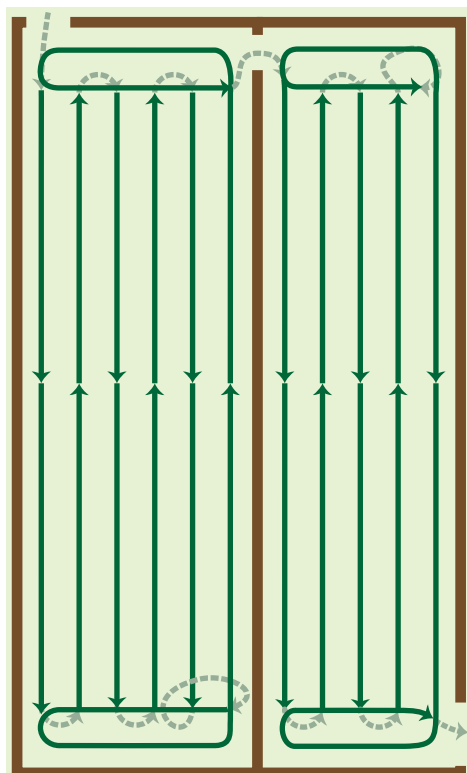
# PATE FARMING TOCUMWAL



The boom spray was purchased so that the axle width could be easily modified to 3m wheel centres.

compatibility with the airseeder and harvester. The boom spray compatibility is not a primary concern as the rice banks are sprayed as part of the paddock hygiene, to stop weeds 'creeping' into the crop zone from the banks.

The aim is to have each bay the same width (where practical), and the last bay becomes 'what's left'. This depends on the location of permanent obstacles, such as drains and channels. Sometimes due to the location of the



Rice bay layouts are designed to be compatible with the airseeder and harvester, and aim to avoid part-width and dry runs.

paddock entrance the pattern is a little more complex, using cross-overs from bay-to-bay to avoid running dry back to the starting end, and to facilitate efficiencies. But the goal is to have a continuous track moving from bay to bay within each paddock.

This optimal layout will be dependent on water movement, and some compromise may have to be made due to slope, bay size or the presence of permanent infrastructure.

## TECHNOLOGY HARDWARE

When investing in the hardware to enable autosteer and variable rate Pate Farming has been keen to make sure that the implement controllers will 'talk' to each other. Using one system for all operations helps reduce problems in the paddock.

Pate Farming uses the John Deere Greenstar™ system, some of which comes with the machinery. When Pate Farming was investing in a spreader they went with a Bogballe, which has its own controller, but is easily operated with the John Deere variable rate system. A few manufacturers now use an ISO (International Organisation for Standardisation) standard which improves compatibility.

### TECHNOLOGY HARDWARE

<b>GPS AUTOSTEER</b>	John Deere Starfire™ 3 with corrections from community base station (RTK)
<b>SOWING</b>	John Deere 9800 air-cart with GS2630 display
<b>SPRAYING</b>	John Deere rate controller (liquid) with GS2630 display
<b>HARVEST</b>	GS2630 display
<b>UREA SPREADING</b>	Bogballe monitor with an RS232 connection to the GS2630 display
<b>LIME/GYPSUM SPREADING</b>	Marshall spreader (10t) with John Deere rate controller (dry) with GS2630 display
<b>GPS LEVELLING</b>	John Deere iGrade with a portable base (hired) set up in the paddock





Compatibility of implement controllers is essential for PA and variable rate applications. The Bogballe spreader controller is easily operated with the John Deere system.

## SOFTWARE AND DATA ANALYSIS

Pate Farming uses Apex™ (John Deere farm management software) to manage yield maps and prepare prescription maps for variable rate applications. They use:

- ⊕ yield maps predominantly to develop prescription maps for winter cereal inputs;
- ⊕ EM38 for gypsum and lime application; and
- ⊕ cut and fill maps for rice inputs (mainly fertiliser).

Pate Farming would consider using another software program to better analyse the data, especially as they have sets of data from a number of years. At this stage the data is looked at in-house, but it can be time consuming and it is becoming hard to allocate the necessary time. They are considering using a specialist PA consultant to help get the most out of the data being collected.

## LESSONS LEARNT

Pate Farming's move to CTF has been rewarding and although it has provided numerous benefits it is not all straight forward. A few key lessons have been learnt along the way and are highlighted in the table at the bottom of this page.

## BENEFITS TO DATE

The key benefits identified by Pate Farming during the adoption of PA and CTF are:

- ⊕ CTF set up well in rice bays makes operations simple and greatly improves efficiency.
- ⊕ Cost savings on inputs. For example lime and gypsum applied to the areas of the paddock where they are needed, rather than using a blanket application. In addition there is no overlap when applying products and the improved layout removes double sowing of half laps which reduces input and operation costs.
- ⊕ CTF enables easy conduct of large-scale, in-paddock trials.
- ⊕ Yield. Pate Farming has observed a gradual improvement in yield and reduced variability, both within paddock and from season to season, since adopting CTF and targeted seed and fertiliser application using variable rate.

## THE FUTURE

Pate Farming sees the future of PA in rice production and other cropping programs is filled with opportunity but also some challenges.

## VARIABLE RATE APPLICATIONS

One of the biggest dilemmas for Pate Farming and his colleagues using PA technologies is deciding the optimum use of variable rate:

- ⊕ Should the focus be on improving the highest yielding zones of a paddock or trying to improve the poorer areas?

### Lessons learnt during the adoption of PA

Lesson	Description	Solution
Issues with equipment compatibility	Can be frustrating and time consuming; problems always occur at a busy time	Use one system to minimise problems and down time
Operator ability to use the system and trouble shoot	When things don't quite go to plan; hard to get trained operators on a casual basis	Need ability to talk an operator through task over the phone
Time and skills to analyse data	Seems to be hard to allocate time	Consider using a PA consultant

# PATE FARMING TOCUMWAL

⊕ How do growers determine what input/operation to variable rate and which areas to target?

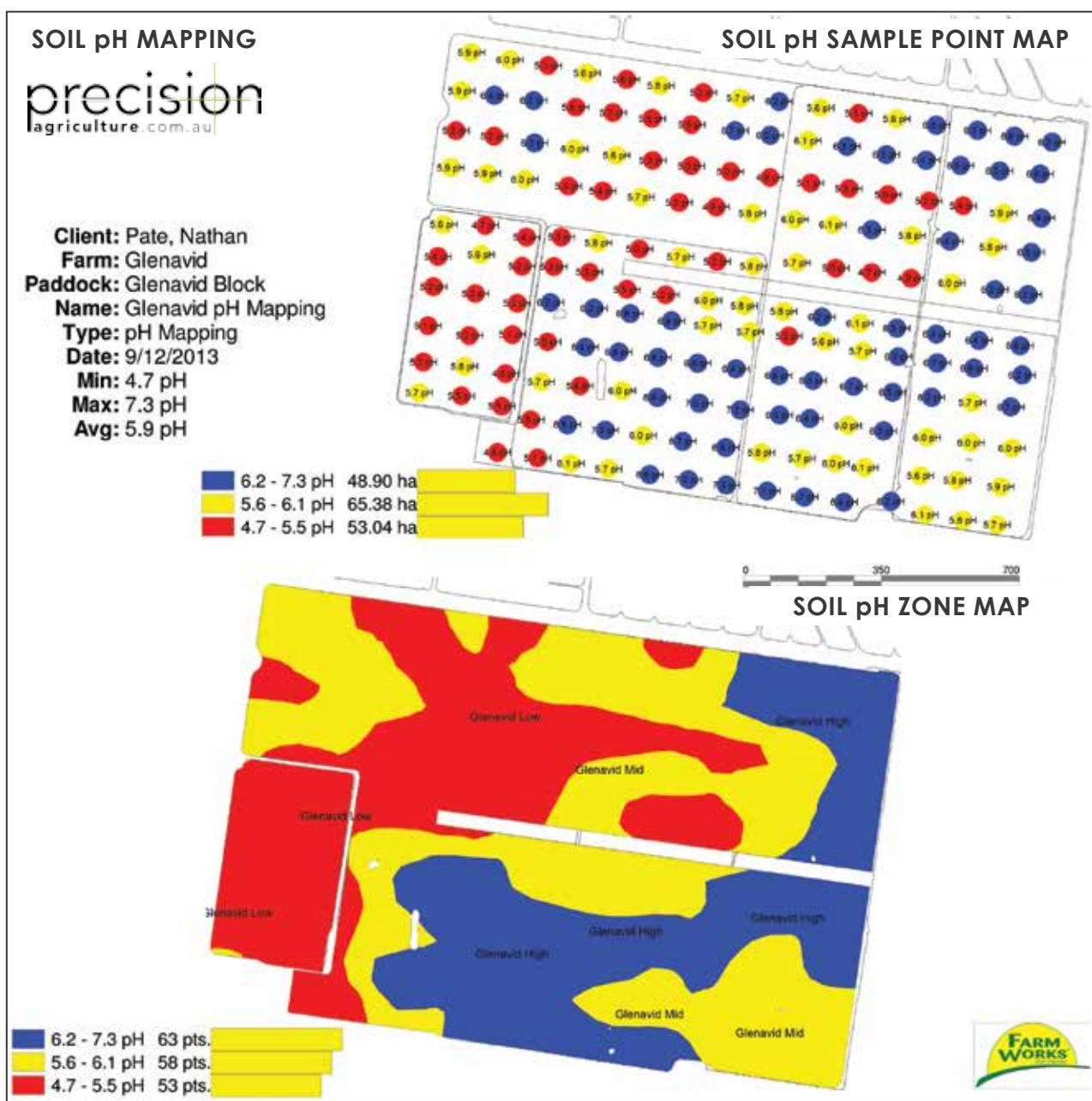
The use of trials and nutrient rich strips will hopefully make it clearer as the years go by.

Employing consultants is integral to the way forward. Pate Farming recently employed Precision Agriculture.com.au to conduct soil pH mapping on paddocks due for lime application. The soil pH maps (see example below) were then used to create prescription maps for variable rate lime application. Pate Farming found this to be very good value for money.

## CHALLENGES

Pate Farming is finding the further they get down the PA road and the more data that is collected, the more questions are raised.

The biggest challenge is to answer some of the questions and confidently set future directions. This issue faces many growers who have invested time, energy and money into PA and can result in a slump in motivation. Pate Farming is confident the Rice PA Project will help answer some of the questions and reinvigorate them and other growers heading down the PA path. ■



Pate Farming employed consultants to conduct soil pH mapping, a rapid and effective way to produce zone maps for variable rate lime application.

# CASE STUDY

## SLEIGH FARMING JERILDERIE

### ADOPTING PA TECHNOLOGY

Richard Sleigh farms in a family business west of Jerilderie with his brothers Andrew and David (known as Sleigh Farming in this study), with Richard managing all the cropping. Sleigh Farming has been using  $\pm 10$ cm autosteer for five years and mapping operations for the same time. Two years ago they began yield mapping when they purchased a new header with mapping capabilities.

The move to autosteer was initially driven by the desire for efficiency gains (reduced overlap, inputs and fatigue) and as Richard openly admits, he likes innovations. He had been reading about GPS technology in many agricultural publications and machinery brochures and talking about it with other growers. When the cost of implementation came down after the initial release period Sleigh Farming committed, although they were only partially convinced autosteer and PA would really deliver significant benefits. It hasn't taken long to be fully convinced. This year Sleigh Farming has moved to an RTK GPS system ( $\pm 2$ cm) using a community base station on the home block and a loaned mobile base station this season on a remote farm.

### MACHINERY

Sleigh Farming does not run a fully controlled traffic system in rice but matches the in-crop operations of spraying and spreading, both on 21 m. They don't feel it is overly important to match up the airseeder to these operations, nor the header.

### IRRIGATION LAYOUT

Working with various layouts (rice bays and border check winter crop bays), variations in paddock slope and limitations imposed by permanent infrastructure, Sleigh Farming is focused on the airseeder. Where possible bays are being set up in multiples of the airseeder to minimise overlap. This will be an ongoing process as bays are rejuvenated.

### TECHNOLOGY HARDWARE

Investment in technology has been limited to purchasing machinery with autosteer capability and then purchasing the John Deere Greenstar™ controller screen. Sleigh Farming uses this to map and record each in-paddock operation.

<b>LOCATION</b>	Jerilderie, NSW
<b>KEY ENTERPRISES</b>	Wheat, barley, canola, rice, seed sorghum, Merino sheep and beef cattle
<b>TOTAL AREA</b>	4000 ha
<b>CROPPED AREA</b>	1000 ha
<b>IRRIGATED AREA</b>	800 ha
<b>RICE AREA</b>	200 ha
<b>CURRENT PA SYSTEM</b>	RTK autosteer, mapping all operations, matched in-crop operations, yield mapping

The availability of a community base station means Sleigh Farming doesn't have to worry about base station maintenance and there is not a large up-front capital cost, but an annual licence fee which covers usage, upgrades and maintenance.

### SOFTWARE AND DATA ANALYSIS

Sleigh Farming is starting to collect quite a bit of data and is now trying to put the yield maps to use. Visual appraisal of the printed maps is used to identify areas within a rice field to conduct targeted in-field testing, particularly of nitrogen top-dressing. Then the yield map from the subsequent harvest is used as a simple way to determine how the crop responded to the treatment.

#### TECHNOLOGY HARDWARE

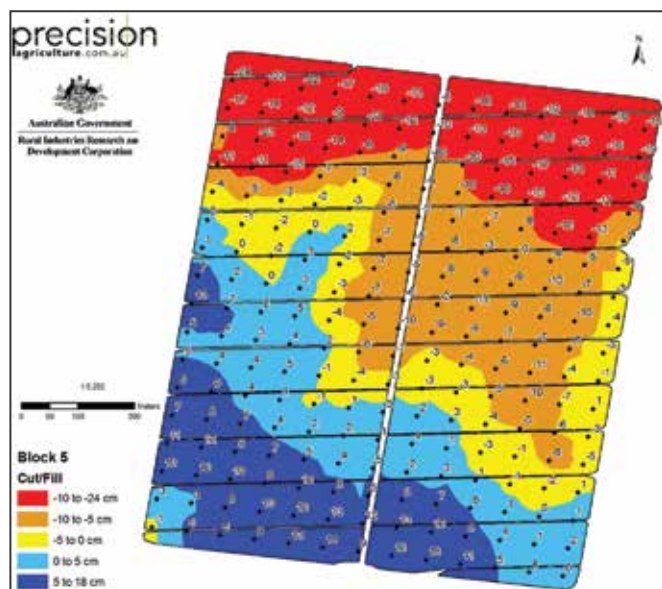
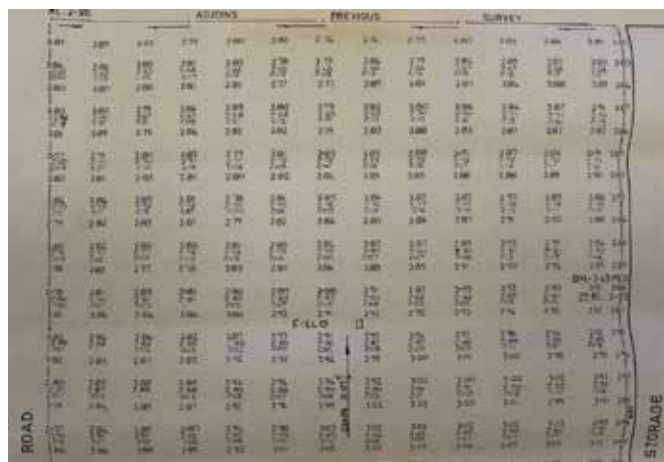
<b>GPS AUTOSTEER</b>	John Deere Greenstar™ RTK using community base station
<b>SPRAYING</b>	Goldacres boomspray using John Deere GS2630 controller
<b>HARVEST</b>	John Deere header with GS2630 for yield mapping



# SLEIGH FARMING JERILDERIE

## BENEFITS TO DATE

Sleigh Farming is honest about the benefits seen with the use of autosteer in rice. Richard says, "It looks good! But more importantly there is much less fatigue." Sleigh Farming is not sure if the savings on inputs due to reduced overlap are sometimes overstated, but reducing them by any margin is a good thing. Avoiding the risk of rice sterility in double-up areas due to extremely high nitrogen applications is also a good thing.



A hard copy cut and fill 'map' (top) can be converted into an electronic cut and fill zone map and used in the analysis of understanding within paddock variability. Use the grid in the hard copy map, create a matching grid in the GIS software, and add the cut or fill value to each point.

Grower: Richard Sleigh, Paddock: Block 5

## LESSONS LEARNT

Sleigh Farming began with  $\pm 10$  cm Starfire™2 autosteer and used this to lay out a number of rice fields two years ago. Where possible the bays were made in multiples of the airseeder width to improve efficiency of operations by cutting out part laps and dry runs. After moving to an RTK system it became clear that the drift in the  $\pm 10$  cm system was much greater than thought and most of the check banks need to be moved.

The distance isn't great but leaving them will mean there is a long narrow strip not sown on one side of the check bank (impacting water movement), and a long strip on the other side which will be double sown. Sleigh Farming recommends, if you are using  $\pm 10$  cm steering and wish to lay out bays in a field, get a contractor to put the check banks in using a  $\pm 2$  cm RTK system—especially on border check with winter crops.

## CHALLENGES TO DATE

Sleigh Farming finds the Greenstar™ system used to operate the steering and recording is too complicated, although yield mapping using the same system in the header is quite straightforward. Greenstar™ does a good job of recording and mapping operations once it is set up, but it is not the simplest operating system to use. This has its challenges when using other drivers. Sleigh Farming would like the process to be as simple as the operator putting a data card into the screen and off you go. As it is currently Richard has to spend time himself setting up the job to ensure the recording will go to plan.

## THE FUTURE

Sleigh Farming looks at PA as an innovation that at present is not an essential tool. You can grow crops without it but it is enjoyable and inspiring to be around the innovative side of agriculture. But you need to be passionate about it to persist and succeed in implementing the various components.

⊕ The ability to conduct on-farm strip trials is attractive. Ultimately it would be great to sit down at the beginning of the season and plan a series of test strips or trials to implement. But that never seems to be given priority. It is a big ask to stop an operation in the middle to change things and put down a test strip. 🟩

# CASE STUDY HICKS FARMING DENILQUIN

## ADOPTING PA TECHNOLOGY

Andrew Hicks farms with his wife Penny, and parents Geoff and Christine (known as Hicks Farming in this study). The desire of Hicks Farming to move into yield mapping (and PA) was triggered when they observed wild variations in yield when they first had a header fitted with a yield monitor. However although they were able to observe large variation within paddocks, they were unable to record where the variations were. The inability to ground truth after harvest and work out what had caused the yield variations meant that they could not address the problems.

## MACHINERY

In 2002 Hicks Farming purchased a second hand data logger and using a Garmin GPS began basic yield mapping.

Over the years they continued to observe large in-paddock yield variation and believed variable rate fertiliser application could be used to improve yield on poor areas and increase overall productivity. In 2010 Hicks Farming made a substantial investment into receivers and controllers (John Deere Greenstar™ 2630) and their PA journey began.

They went straight to an RTK ±2cm system, using a community base station with an annual licence fee. Hicks Farming had a primary goal, to use variable rate fertiliser application before sowing their rice. For this reason they went straight to RTK to get the repeatability from season to season.

Hicks Farming shares machinery in an arrangement with a neighbour so when it comes time to decide on machinery updates and any move to a controlled traffic farming (CTF) system it has to be a joint one. At this stage the airseeder and header don't match in width, but the aim is to move to a CTF system as machinery is replaced. It is likely they will move to a 12 system, but it is complicated by the need to spray banks in irrigation bays and the share arrangement with machinery ownership.

## TECHNOLOGY HARDWARE

Hicks Farming uses a John Deere Greenstar™ 2630 controller and one day they hope to control each piece of machinery with the one system or controller. The benefits of a single controller are:

- ⊕ only one software package has to be learned;
- ⊕ all components communicate with each other once they are set up;

<b>LOCATION</b>	Morago area, north west of Deniliquin
<b>KEY ENTERPRISES</b>	Rice, winter cropping and agistment livestock
<b>TOTAL AREA</b>	2800ha
<b>CROPPED AREA</b>	600ha
<b>IRRIGATED AREA</b>	1000ha
<b>RICE AREA</b>	200–300ha
<b>CURRENT PA SYSTEM</b>	RTK autosteer, variable rate at seeding, yield mapping, moving towards 12m CTF

- ⊕ data is collected in a compatible format; and
- ⊕ wiring the implements into the tractor cabs is simpler.

In 2013 fertiliser (nitrogen and phosphorus) was pre-drilled using variable rate maps developed in John Deere Apex™ Farm Management Software. The aim was to increase yield of regularly poor performing areas. The zones were based on yield maps, but also incorporated 'local knowledge'. One thing Hicks Farming finds useful with the GS2630 screen is the ability to flag things, such as duck damage or lodging. They can also make observation notes on the screen on the go, which provides great background information explaining the yield maps.

Harvest of the first rice crops sown with variable rate fertiliser application revealed benefits in just one season. There was an overall yield increase and variation was reduced—a very pleasing result.



Hicks Farming use John Deere Greenstar™ RTK autosteer and John Deere GS2630 with dry rate controller into a Horwood Bagshaw electric drive airseeder for variable rate fertiliser application.

# HICKS FARMING DENILIQUN

## TECHNOLOGY HARDWARE

**GPS AUTOSTEER** John Deere Greenstar™ RTK using dealer base station

**SOWING** John Deere GS2630 with dry rate controller into a Horwood Bagshaw electric drive airseeder

**SPRAYING** Home made SP boomspray using Trimble auto boom

**HARVEST** John Deere header with GS2630 for yield mapping

## SOFTWARE AND DATA ANALYSIS

Hicks Farming uses yield maps to conduct grain testing and soil testing in targeted locations to ground truth what is being observed. At this stage zones have been developed by looking at the yield maps in consultation with their agronomist. Hicks Farming would consider using a PA consultant to help better interpret and use the yield data.

## LESSONS LEARNT

Hicks Farming have three key ideas to help growers adopting any PA in their cropping system.

- ⊕ Start with a RTK  $\pm 2$  cm system if possible. The investment is worth it to avoid issues related to  $\pm 10$  cm systems which suffer from creep and are not repeatable.
- ⊕ Find a width and stick to it. Even if the process of achieving the ultimate CTF goal takes years, make an informed decision at the start.
- ⊕ Don't react to a single yield map. Variability could be due to the performance of a variety in a particular season, or another seasonal variation. Look at trends over previous years.

## BENEFITS TO DATE

### AUTOSTEER

Hicks Farming sees one of the key benefits to adopting autosteer is reduced fatigue levels. This is especially important at harvest, when picking up a lodged crop. It also helps when using a recorded curve track along a contour bank, removing the stress of operating close to the banks, and makes each operation repeatable with no misses.

Another benefit is increased efficiency in inputs and time. In an ever tightening cost-price environment efficiency gains and increased

productivity are essential to business success. This is particularly important in rice, such a high input crop. Savings can be substantial when overlaps are avoided. The benefit is not only economic. Overlap areas often result in crop lodging and can result in rice sterility, and significant yield loss.

### YIELD MAPS

Hicks Farming is starting to use yield maps combined with EM surveys to identify zones for targeted soil testing and grain quality testing. When in the header the operator stops at the target point in the paddock and collects a grain sample. This allows grain quality attributes to be assessed and related to soil characteristics in zones. Nitrogen, phosphorous and sulphur fertiliser test strips are applied (individually) across these zones and the subsequent yield and grain quality data are used to help make future decisions.



Key zones are identified and 'nil nitrogen' strips are used to quantify yield responses.

## THE FUTURE

Hicks Farming has recently moved to variable rate fertiliser application prior to sowing rice. The results they are getting from the targeted test strips are helping clarify the optimum rates required in different zones and improving their understanding of crop responses. Hicks Farming aims to:

- ⊕ Increase low yielding zones (often a cut area) by applying sufficient nutrients, mainly nitrogen; and
- ⊕ Apply maintenance fertiliser rates to high yielding zones.

Hicks Farming would also like to develop a similar plan to apply gypsum and lime using targeted soil testing to develop a zone map and variable rate application. They realise that variable rate applications are an opportunity and a challenge. As the data asks more questions it becomes increasingly difficult to answer them all. But with more data, better analysis techniques and targeted testing they believe the investment will pay off. It is the next step in increasing productivity, and the key to farm business survival. ■



# CASE STUDY

## DEMO FARM COLEAMBALLY

### BACKGROUND TO THE DEMO FARM

Coleambally Demo Farm is managed by an advisory committee, chaired by Ian Sutherland, with support from Secretary Alison Hayes. The Demo Farm operates as a not-for-profit organisation which allows community organisations to grow crops as a means to raise funds. The Demo Farm is run as a commercial farm and includes some demonstrations and trial plots.

The Demo Farm owns no machinery and uses contractors and volunteers for all operations. This is a conscious decision and allows more community ownership. Contractors/volunteers can nominate to support a specific community organisation. There are many checks and balances in place to ensure organisations contribute more than just labour/machinery and are actively engaged in the whole enterprise.

### ADOPTING PA TECHNOLOGY

Colly Demo Farm uses contractors for all operations and as a result has had a gradual introduction to the use of auto steer and mapping technology. For the production of maize and winter crops, the Demo Farm has developed a permanent bed system set up with RTK  $\pm 2$  cm autosteer, which then becomes a controlled traffic system, with all machinery using the furrows as wheel tracks. The beds have been set up using imperial measurements (6' beds) to match the row-crop implements and tractors which are a standard 24'.

The Demo Farm likes to keep up with technology and adopt local best practice, particularly when advantages have been identified. They also have the privilege to be able to invest in testing and/or demonstrating recently developed best practice. For example, the Demo Farm tested a 15 ha block of beds in bays. The rice bays are flat across the bay and beds are formed up parallel to the contour banks, with a bankless channel at each end of the beds. When the bays are flooded the water runs up the furrows. There is then a 10 cm drop to the next bay. The trial was very successful and a further 70 ha was laid out with beds in bays and there is a plan to set up another 60 ha paddock this summer. Ian describes this production system as "the Mercedes Benz of layouts, with uniform watering and better drainage."

<b>LOCATION</b>	Coleambally
<b>KEY ENTERPRISES</b>	Rice, winter cereals and canola
<b>TOTAL AREA</b>	250 ha
<b>CROPPED AREA</b>	250 ha
<b>IRRIGATED AREA</b>	250 ha
<b>RICE AREA</b>	50 ha
<b>CURRENT PA SYSTEM</b>	Use our contractors systems

At this stage the beds in bays are being used for winter cropping (canola and wheat) but there is potential to leave the beds in place and grow rice, a practice being adopted around Griffith. You harvest the rice then direct drill wheat into the beds.

### MACHINERY AND TECHNOLOGY HARDWARE

In rice, nearly all the tractors are using GPS autosteer now. There is a range of systems being used by contractors, some with  $\pm 10$  cm steering, but most with RTK  $\pm 2$  cm. Some bring their own base stations, while others use one of the licenced community base stations available.

### SOFTWARE AND DATA ANALYSIS

At this stage yield maps are used as a source of general information and for discussions with the agronomist. They provide discussion points for further investigation and to bounce ideas around. As more data is collected then professional analysis and interpretation is likely to be beneficial.

### LESSONS LEARNT

In 2012/13 the rice harvest was a joint effort with five harvest contractors working in the same paddock. The Demo Farm got yield maps from three of the five headers, meaning there were strips with no data. After looking at the partial yield map the Demo Farm realised the importance of asking for yield maps. Even the partial map you could still identify good and poor areas which can then be used to apply different treatments.

# DEMO FARM COLEAMBALLY

Ian says, "Yield maps seem to ask more questions than giving answers. Yield maps are so important because there is a lot to learn."

## BENEFITS TO DATE

Convenience rather than economic benefits may be the key benefits to guidance at this stage but you would never go back. There are many small advantages that are hard to put a finger on.

As for yield mapping, the fact that the data raises questions is a great thing which makes you go and look for answers. Identifying what is causing an area of the paddock to under perform and conversely why another area is out-yielding the rest. The next step may be variable rate applications, particularly for nutrients. This is likely to be more beneficial and have greater economic returns in irrigation compared to dryland production.

## CHALLENGES TO DATE

One issue the Demo Farm has is unique to the operation because it uses multiple contractors and the difference between imperial and metric systems. It may seem like the difference is only millimetres but across a paddock it is magnified. This is not a problem in the permanent beds where 6' beds are the industry standard for row crop machinery.

## THE FUTURE

Coleambally Demo Farm is always looking at updating practices and technology to benefit the farm returns, and is used as a trial and demonstration site. Currently two companies have plans to trial automating the concrete stops at each end of the bays in the bankless channel system. This will allow irrigators to open and close the stops remotely and/or at a set time. This will add to the automation already in use with the Coleambally Irrigation System which is fully automated. Water can be ordered from the farm office computer with as little as two hours notice and flow rates can also be monitored remotely. ■

# CASE STUDY

## ARNOLD FARMING JERILDERIE

### ADOPTING PA TECHNOLOGY

Bobbie Arnold is one of the younger members of the Arnold family managing 3500 ha south of Jerilderie. Bobbie works with his Grandfather, Father, two brothers and their families (known as Arnold Farming in this study).

Arnold Farming moved into PA when they updated their header about 10 years ago and it came with yield mapping capacity. Since then they have been collecting yield data and have moved to RTK autosteer for all operations.

Arnold Farming can't pinpoint the major source of information which encouraged the move to PA but admits much of it came through the machinery dealers. The primary aims of the move to PA were:

- ⊕ reduced overlap which leads to minimising inputs, and
- ⊕ the option to move to variable rate fertiliser application.

### MACHINERY

Currently all tractors, the self-propelled boomspray and the header use Greenstar™ RTK autosteer.

<b>LOCATION</b>	Jerilderie
<b>KEY ENTERPRISES</b>	Rice, winter crops (mainly dryland), sheep and cattle
<b>TOTAL AREA</b>	3500ha
<b>CROPPED AREA</b>	3100 ha
<b>IRRIGATED AREA</b>	1500ha
<b>RICE AREA</b>	400ha
<b>CURRENT PA SYSTEM</b>	RTK auto steer all operations, yield mapping, variable rate fertiliser spreading

Arnold Farming has used the yield maps to develop hand-drawn zones and then apply in-crop nitrogen at different rates according to the zones.

Recently Arnold Farming invested in a variable rate-capable Amazone spreader to allow targeted application of fertilizer, in particular nitrogen or urea.

Arnold Farming also has a 16 ft Horwood Bagshaw land-levelling bucket, fitted with John Deere iGrade system for GPS land levelling.



Arnold Farming had to invest in their own RTK base station to successfully use iGrade on their land-levelling bucket. The bucket has a receiver fitted to it so that accurate levels can be achieved.



# ARNOLD FARMING JERILDERIE

## IRRIGATION LAYOUT

The use of auto-steer at sowing has enabled irrigation layouts to be improved to avoid part-width laps where possible. This greatly reduces overlap and issues with lodging and infertility caused by doubling up seed and fertiliser.

## TECHNOLOGY HARDWARE

Arnold Farming use the  $\pm 2$  cm John Deere Greenstar™ GPS system and recently moved from using the community base station to investing in their own John Deere Starfire™ RTK receiver. This was needed when they added a John Deere iGrade feature to their Horwood Bagshaw land-levelling bucket controlled by the GS2630 display. To enable the iGrade feature to be effective the base station needs to be within 1.5 km of the paddock being levelled.

Variable rate spreading from prescription maps is what Arnold Farming is moving to with the Amazone spreader. Currently they are using its controller but plan to use the GS2630 display to spread at variable rates from prescription maps.

### TECHNOLOGY HARDWARE

<b>GPS AUTOSTEER</b>	John Deere Greenstar™3 RTK with own base station
<b>SOWING</b>	Air cart GS2630 display
<b>SPRAYING</b>	John Deere SP boomspray with GS2630 controller
<b>HARVEST</b>	John Deere header with GS2630
<b>UREA SPREADING</b>	Amazone linkage spreader with own controller
<b>GPS LEVELLING</b>	John Deere 9510R tractor pulls 16 ft Horwood Bagshaw bucket, fitted with John Deere iGrade system controlled by GS2630 display

## SOFTWARE AND DATA ANALYSIS

Arnold Farming has not used any specific data management or analysis at this stage. One thing they have done is use the yield maps in conjunction with cut and fill survey maps (on a purely visual basis) to identify zones and then manually vary fertiliser rates when topdressing urea.

## LESSONS LEARNT

One key aspect of adopting PA with both new and adapted machinery is the challenges faced in linking up different branded units. Arnold Farming aims to run everything with the Greenstar™ display in the future. This will avoid the need to learn how to use multiple controllers and software systems, and simplifies the cable network in the tractor cab.

Arnold Farming has noticed that each piece of machinery is slightly more expensive when you upgrade to GPS/autosteer ready. This may change as GPS ready becomes a standard feature rather than an optional extra.

Successful and profitable adoption of variable rate fertiliser (or other input) application will rely on experimentation. Arnold Farming needs to determine how much you can scale back on cut areas of rice fields, and how far you can push the yield on fill areas. What is the best balance of application to optimise paddock returns?

## BENEFITS TO DATE

### AUTOSTEER

Auto steer is great and has:

- ⊕ reduced overlap
- ⊕ reduced overall inputs
- ⊕ enabled set up of rice bays to multiples of the airseeder width
- ⊕ improved the accuracy of yield maps

### YIELD MAPS

Arnold Farming has been collecting yield maps for about 10 years but haven't fully utilised them. Even so, they have highlighted the variability within the fields and have given them enough confidence to manually vary urea application rates to cut and fill zones.

## THE FUTURE

Arnold Farming sees the future of PA in rice in prescription maps with the aim of optimising yield to maximise returns on inputs, particularly nitrogen. They hope to be able to develop prescription maps and then use variable rate application of fertiliser with the airseeder rather than the spreader.

The adoption of variable rate all relies on experimentation with crop inputs to identify the best way to manage the zones being identified. ■

# CASE STUDY BRILL FARMING GRIFFITH

## ADOPTING PA TECHNOLOGY

Clinton Brill operates a diverse irrigation farming business with his wife Kylie, and parents Bruce and Glenda (known as Brill Farming in this study). Brill Farming has 1200ha of irrigation (winter crops, rice and clover) and also runs sheep, bales fodder, and bales straw (wheat and rice).

Brill Farming properties are set up with gravity feed irrigation with bankless channels. The bays are flat with a 10–15cm drop to the next bay.

Livestock are excluded from one farm which is gradually being redeveloped with 2m beds within the bays. As the bays are set up the aim is to have runs in multiples of 8m to suit the bed former which was purchased in shares with a neighbour. The 8m then suits the 24m width of the boomspray and the 24m wide swath of the spreader. All tractors used for in-crop operations are row-crop and set up on 2m wheel centres to suit the beds.

Brill Farming grows 200 to 250ha rice each year, depending on water allocation, and has been adopting PA technologies for the past 10 years. They began in 2003 with yield mapping and a moisture meter on the header. Initially these were installed on the header to monitor grain moisture for harvest timing, and to assist with loading trucks legally using load calibration.

Brill Farming believed PA technologies could help them better manage zones in his rice and winter crops. Over the past 10 years aerial imaging\* has been used in rice each year as a management tool. This data highlighted the yield differences within and between fields, particularly those associated with cut and fill areas from bay development.

## MACHINERY

Five years after starting the yield mapping John Deere ATU (auto track universal) steering was installed in two tractors. ATU is a steering column rather than hydraulic-based steering system. It allowed Brill Farming to autosteer two tractors with an investment of \$20,000. This was considered to be an economical option compared to retrofitting hydraulic blocks and wiring to the two tractors. This system uses Starfire™1 GPS and is accurate to ±25cm.

\* Aerial imaging: NDVI or Normalised Difference Vegetation Index used to estimate dry matter and determine nitrogen fertiliser application rates at panicle initiation

<b>LOCATION</b>	Griffith
<b>KEY ENTERPRISES</b>	Rice, wheat, canola, sheep, clover, clover hay, wheat and rice straw
<b>TOTAL AREA</b>	1200 ha
<b>CROPPED AREA</b>	1200 ha
<b>IRRIGATED AREA</b>	1200 ha
<b>RICE AREA</b>	200–250 ha
<b>CURRENT PA SYSTEM</b>	RTK autosteer with in-crop operations on tracks

Replacement tractors are now purchased autosteer ready. Due to the diversity and geographical spread of the operation and the age of some tractors at Brill Farming, each tractor set up so it is able to be used for both spreading and spraying. This allows tractors to be interchanged if there is a breakdown or timing of operations clashes.

## TECHNOLOGY HARDWARE

In 2013 the boomspray was updated to a Cropland 4024. The local John Deere dealer was employed to set up the boomspray to be operated using the John Deere GS2/3 controller. This reduced the time spent by Brill Farming to get the implement functioning correctly.

When the Kuhn spreader was purchased the Kuhn rep and local dealer helped get the John Deere GS2/3 controller to communicate with the spreader.

In 2014 another PA technology investment was made. John Deere iGrade was purchased to move to GPS land levelling with the All Farm bucket. This involved hydraulics and wiring on the tractor and an RTK GPS system, and the iGrade software. GPS levelling requires RTK GPS and uses two units:

- ⊕ one as the mobile base which needs to be within 1.5km of the tractor for accurate operation; and
- ⊕ one fitted to the laser-bucket.

One advantage with the John Deere RTK system is that the units can easily be converted from an RTK base to a receiver on a tractor. When Brill Farming

# BRILL FARMING GRIFFITH

## TECHNOLOGY HARDWARE

**GPS AUTOSTEER** John Deere RTK using GS2/3 controller and John Deere ATU steering using StarFire™1

**SPRAYING** Cropland 4024 with Cropland controller and Greenstar™ 2/3

**SPREADING** Kuhn spreader with Kuhn Controller and Greenstar™ 2/3

**HARVEST** John Deere ATU steering, yield mapping using John Deere brown box

**GPS LEVELLING** John Deere 9430 tractor pulls a All Farm bucket, with a John Deere hydraulic block controlled with GS2630 display (iGrade feature)

is not land-levelling, both RTK units can be used as receivers on tractors and use the neighbour's base station.

## SOFTWARE AND DATA ANALYSIS

Brill Farming is analysing data at this stage. They look at yield maps in John Deere Apex™ software. In the future land-levelling maps will be loaded as an extra layer. The next step is unclear but it is likely professional assistance will be needed to get the best out of the data that has been collected. The analysis of multiple years of yield data overlaid with cut and fill maps will ensure benefits are gained for the farm business.

## LESSONS LEARNT

Brill Farming can't stress enough the importance of having new implement controllers set up to match your GPS system. They need to be functioning correctly well before they are needed in the paddock. Get a guarantee from the dealer that they will ensure the system is working at or soon after delivery, before you commit to purchase. A commitment of technical support by the dealer is the key. If you are on your own, hours and hours can be spent trying to get controllers to communicate with implements, which quickly becomes very frustrating.



Brill Farming invested in their own RTK base station to use iGrade on their land-levelling bucket. The bucket has a receiver fitted to it so that accurate levels can be achieved.



Brill Farming finds the whole steering and GPS system fantastic when it is working well but it can create problems and chew up a lot of time when things don't work. For example:

- ⊕ Multiple operators: when the system is used by multiple operators with different skill levels it can take a lot of time to make sure everything is set up correctly before an operation is started.
- ⊕ Swapping screens (steering controllers): moving from one tractor to another is quite straight forward as long as you remember to change the appropriate settings to the correct tractor and implement, especially implement width and offset.

## BENEFITS TO DATE

The key benefits seen by Brill Farming are:

- ⊕ no over-spray by the boomspray;
- ⊕ ease of operation when spraying as you have a coverage map and auto-shutoff;
- ⊕ confidence when spreading due to the coverage map; and
- ⊕ convenience of knowing field levels over a whole field with John Deere iGrade.

## CHALLENGES TO DATE

Clinton Brill says, "Knowing the right people to talk to is one of the biggest challenges to adopting any PA technology". Brill Farming's neighbour has shared a lot of ideas and they have spoken to a number of other growers. Finding sound technical advice, particularly on machinery purchases is difficult.

Using or operating the technology can also be quite difficult, which is a problem when employing staff, particularly casuals – the training and troubleshooting can easily become quite time consuming.



Rice yield data will be used to prepare zone maps for variable rate fertiliser applications.

## THE FUTURE

Variable rate fertiliser spreading is the next step for Brill Farming. One of the keys will be developing the application maps. This is where Kylie Brill's computing skills will help greatly to develop the maps. They will start with land-levelling as the initial map layer and overlay yield data, and panicle initiation NDVI data. In the first place they will use the John Deere Apex™ software but Brill Farming is looking into getting SMS (a GIS data management program) if needed. They will also seek advice and assistance from a PA consultant as required. ■

# GNSS AND GPS

## GNSS AND GPS

GNSS stands for Global Navigation Satellite System. GNSS is used to pinpoint the geographic location of a user's receiver anywhere in the world through the use of satellites.

There are four constellations used by GNSS:

- ⊕ GPS (Global Positioning System)–USA;
- ⊕ GLONASS–Russia;
- ⊕ Galileo–Europe; and
- ⊕ Beidou/Compass–Chinese systems.

GPS was developed by the US Department of Defence and is maintained by the United States government. The term GNSS is being used more than GPS as time goes on.

GNSS applications include:

- ⊕ navigation–location, speed, direction, altitude/height, points of interest, and auto-steering;
- ⊕ surveying and mapping;
- ⊕ construction and engineering;
- ⊕ remote sensing (EM38, NDVI, imagery)
- ⊕ mining; and
- ⊕ agriculture (cropping, horticulture, livestock).

Developments in the agricultural use of GNSS began with steering machinery; initially as a visual display to aid the driver, then for auto-steering. Harvesters with yield monitors now use GNSS to create maps of yield (and sometimes grain protein and moisture) across the paddock. More recently, blades and buckets of earth moving equipment are being controlled automatically with GNSS-based machine guidance systems.

Data derived from farm operations (i.e. harvesting, remote sensing) can be used to implement variable rate applications of farm inputs (seed, fertiliser, lime, gypsum).

The use of GNSS in agriculture has yielded tremendous benefits in terms of controlled traffic farming (CTF), row crop operations, spraying, more effective use of inputs, and greater precision in land grading, during both the survey and levelling stages.

## IMPROVING RICE LAYOUTS AND LEVELLING WITH GNSS/GPS TECHNOLOGY

There is significant opportunity to use existing GNSS technology for field survey, re-design of layouts, and implementation of re-levelling. GNSS accuracy is now good enough to replace laser guided systems, and offers additional benefits compared to traditional techniques (see page 8).

### FIELD DESIGN

Operational efficiency can be increased by matching bay widths with implement widths in order to avoid half-runs and ensure the start and finish of a bay is at the same end of the paddock. These efficiency gains are maximised under a controlled traffic farming (CTF) system. The simplest system uses a sprayer and spreader width three times the width of the seeder (for example 9 m seeder with a 27 m sprayer and 27 m spreader).

The harvester matches the width of the seeder. Wheel spacings are also matched, typically 3 m spacing to match the header.

Science has proven the soil benefits of minimising wheel compaction effects and rice growers who have implemented CTF systems have reported operational efficiency gains. Many CTF growers are now using GNSS to develop field designs as they set up new paddocks, but few go back and redesign existing layouts. This highlights the fact that the benefits may not immediately outweigh the cost of a redesign. For further information on layout design see grower case study 'Nathan Pate, Tocumwal' in *Precision Agriculture in Rice Production: Grower Experience and Insights*.

CTF is also helpful for monitoring and assessing on-farm trials as every pass of the seeder is followed perfectly with the harvester. These trials are hugely valuable for growers who are looking to test ideas or products and want some hard data and to develop an accurate understanding of the return on their investment.

# LAYOUTS AND LEVELLING



Cab clutter is the inevitable result of implementing GNSS technologies.

## FIELD SURVEYING

Elevation data can be collected during routine operations (ideally seeding) utilising existing systems when auto-steering (using Real Time Kinematic 'RTK' GPS), enabling the monitoring of bay levels and assisting in the prioritisation of individual bays for re-levelling. However it is recommended to conduct a survey specifically for land levelling, as close as possible to the time when the work is to be carried out. Care needs to be taken to avoid deep wheel tracks or rutting caused by previous passes across the field.

Never use elevation data from a harvester as the readings are influenced by the weight of grain in the header box. A full box of grain will affect the total mass of the header and increase the potential to sink into the soil and compress tyres, which will alter GPS recorded elevation.

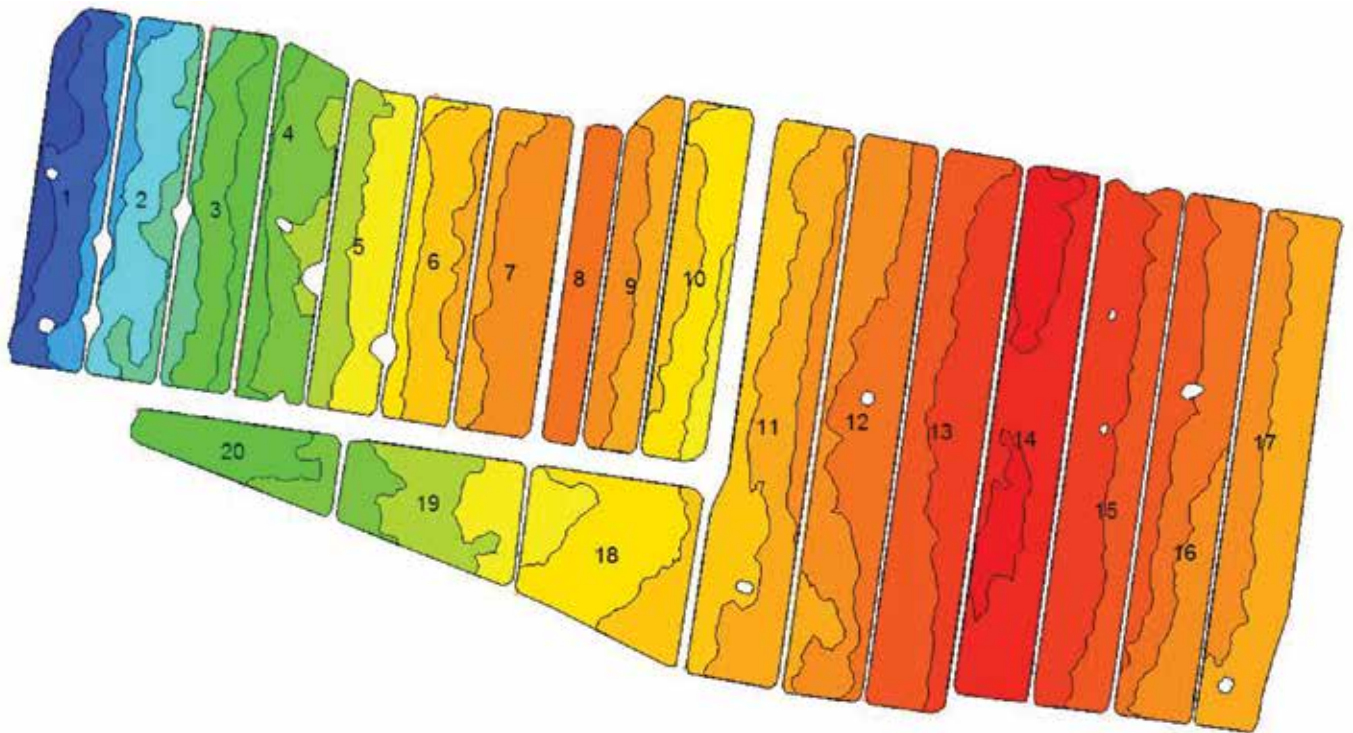
Most auto-steer displays have the ability to log elevation data and many do it without the grower even knowing. In some cases you may need to check the settings of the display to ensure the data is being logged at a desirable density. (Some systems default to the maximum time/distance between data points to prevent the display from blocking up with data). Ideally you want to collect a data point every one to three seconds or five to ten metres. The data is linked to a job and is stored within the display as an application map.



Cotton-reel spacers are used to spread the front axle of tractors to 3m centres. The image on the left is a John Deere spacer which is warranted. The one on the right shows a locally engineered retrofitted version.



# FIELD SURVEY



A digital elevation model of a rice paddock using 5 cm contour lines.

Extracting data from the display varies for each brand but essentially the process involves transferring the data onto a USB stick or simply copying the data from the storage card. There are several software programs available which can read the specific files from most displays (i.e. Trimble = Track3D, JD = fdd, Agleader = agdata,

Autofarm = sqlite) including Trimble Farmworks and Agleader SMS. Once the data has been collected a Digital Elevation Model (DEM) can be created.

## FIELD LEVELLING

It is very important to use a full GNSS receiver on the levelling bucket or blade. Growers and contractors are starting to invest in these systems.



A poorly levelled rice bay can result in significant weed burdens and yield losses.



The components of a GNSS levelling system.

## ACCURACY IN LAND-FORMING

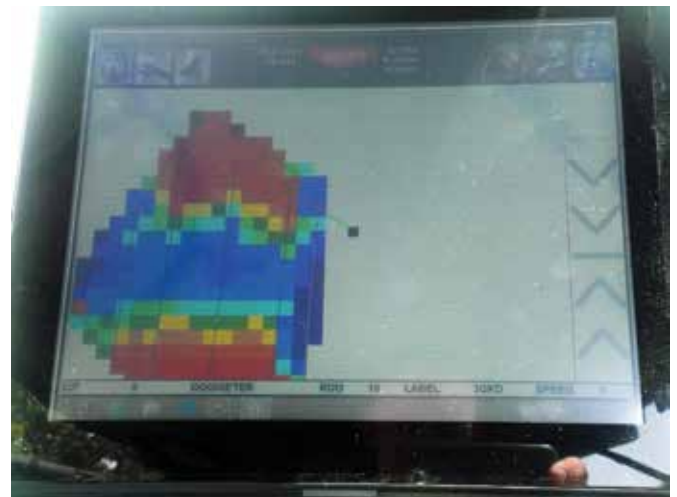
Land-forming requires the highest possible level of elevation (and position) accuracy to achieve fine vertical adjustments. It is highly recommended that only GNSS receivers be used on the levelling machinery, as GPS alone will not provide the required accuracy.

### SYSTEMS

There are two types of systems.

*Real Time Kinematic (RTK)* is a system used to enhance the precision of satellite based positioning systems by using a ground based single reference/base station to provide real-time corrections and enable centimetre-level accuracy. It is highly recommended that the base station be within two kilometres of the levelling operation to be effective, especially in the vertical plane.

*Network Real Time Kinematic (nRTK)* is a system that also offers centimetre accuracy in real time but without the need for an operators reference/base station, as it uses GPS raw carrier phase observations gathered from a network of Continuously Operating Reference Stations (CORS). The coverage of any nRTK GNSS service is only limited by the number of available CORS and the quality of the wireless data link used to transmit the correction to the users (i.e. mobile phone networks capable of allowing data – such as NextG). nRTK should only be used when the system is operating on full network corrections; using nearest base (NB) connections is likely to lead to errors as the distance between the base and receiver can be tens of kilometres.



In-cab screen displaying design file and grade controls.

# SYSTEMS

## COMMERCIALY AVAILABLE SYSTEMS

A number of hardware and software systems are available on the market, each with a range of features and compatibilities. A brief outline of each of the main players in the market today is included here. The information supplied has been taken from the individual company's promotional material, and readers should make their own enquiries to obtain details of

functionality and suitability. Further advice regarding types of systems and suitability to grower requirements should be sourced from your local Precision Agriculture consultant.

<b>BRAND</b>	Farmscan AG
<b>SOFTWARE NAME</b>	LevelGuide
<b>SUMMARY SPECS</b>	LevelGuide is an Australian software program integrated within the wider AgGuide mapping and guidance program that offers auto-steer, implement guidance, variable rate control and spray control, including boom section switching. Used with existing GPS units as long as vertical accuracy and reliability is satisfactory. Can use full multi-plane cut-fill designs, single plane designs or be setup simply like a laser by setting grades in the PC or using single, double or triple reference points.
<b>WEBSITE</b>	<a href="http://www.farmscanag.com/products/levelguide">www.farmscanag.com/products/levelguide</a>

<b>BRAND</b>	Topcon
<b>SOFTWARE NAME</b>	AgForm-3D
<b>SUMMARY SPECS</b>	This system uses the X30 control console with dual frequency, dual constellation GNSS antennas, a MC-R3 receiver and HiPer AG RTK base station. Applications include field levelling, contours, tiles and ditching.
<b>WEBSITE</b>	<a href="http://ag.topconpositioning.com/ag-products/gps-landlevelingsurveying/agform-3d-software">ag.topconpositioning.com/ag-products/gps-landlevelingsurveying/agform-3d-software</a>

<b>BRAND</b>	Davco OptiSurface Pty. Ltd.
<b>SOFTWARE NAME</b>	OptiSurface™
<b>SUMMARY SPECS</b>	Optisurface™ software, developed in Queensland, operates independently of hardware and offers massive reductions in soil moved (in some cases up to 90%) by working with the natural topography of the land. You can conduct a survey using Trimble, AGPS, or John Deere systems, then import that into Optisurface™ to create different designs depending on user requirements. The final design can be loaded back in these systems for automatic control of the bucket.
<b>WEBSITE</b>	<a href="http://www.optisurface.com">www.optisurface.com</a>



<b>BRAND</b>	Trimble®
<b>SOFTWARE NAME</b>	Field Level™ II
<b>SUMMARY SPECS</b>	Using a FmX/FM1000 Monitor and Antenna/Rover (one on the tractor and one on the implement), applications include the survey, design and installation for field levelling, contouring, levees, tiles and ditches. Levelling models include: point and slope; multi-plane; flat-plane; and contour. Field Level II also accepts Optisurface™ design files. Trimble also offers water management software through Farmworks™, however this is primarily focused on sub-surface and surface drains, not levelling.
<b>WEBSITE</b>	<a href="http://www.trimble.com/Agriculture/field-level.aspx">www.trimble.com/Agriculture/field-level.aspx</a>

<b>BRAND</b>	AgLeader®
<b>SOFTWARE NAME</b>	Intellislope®
<b>SUMMARY SPECS</b>	The Intellislope® system uses an Integra monitor for field survey, design and tile installation only (it does not have field levelling features). Intellislope® software features include: drainage analysis mapping, tile installation designs, plan the depth and grade of the tile, control the installation and capture topography data during tile installation.
<b>WEBSITE</b>	<a href="http://www.agleader.com/products/intellislope/">www.agleader.com/products/intellislope/</a>

<b>BRAND</b>	John Deere® and PCT
<b>SOFTWARE NAME</b>	iGrade™ and TerraCutta
<b>SUMMARY SPECS</b>	iGrade™ uses a GreenStar™ 3 (GS3) (recommended) or Greenstar 2 (GS2) monitor with a John Deere 450/900 RTK station and a StarFire3000 or iTC™ Antenna/Rover Model for levelling, ditching, grading and plane generation. The system uses Surface Water Pro Plus software for automation ditches, tiles and contours, and TerraCutta for multi-fit application including cut & fill by plugging in a laptop or tablet to the JD controller via a serial port cable. iGrade™ activation works with many of the different John Deere Ag Management Solutions. As the system is connected to the tractor additional functions are possible such as load limiting—where by the scraper will be automatically raised when engine speed and/or slip thresholds have been exceeded. However the load limiting system is disabled when using TerraCutta software.
<b>WEBSITE</b>	<a href="http://www.deere.com.au/en_AU/products/equipment/agricultural_management_solutions/field_and_crop_solutions/igrade/igrade.page">www.deere.com.au/en_AU/products/equipment/agricultural_management_solutions/field_and_crop_solutions/igrade/igrade.page</a>

# GPS OR LASER

## GPS/GNSS VERSUS LASER LEVELLING

### **BENEFITS AND CHALLENGES OF USING GPS**

- ⊕ GPS is not affected by atmospheric issues (drift with temp changes) enabling the potential for around the clock capability.
  - ⊕ Land-forming designs can be pre-loaded onto GPS displays, providing an opportunity for the grower to review and change the design.
  - ⊕ Using multiple grading tractors and buckets, the job can be loaded into each machine. Laser requires each machine to be set up individually.
  - ⊕ GPS levelling enables the ability to work across the entire paddock (approximately three kilometre radius of base station for base cuts, and approximately one kilometre for final grade), whereas laser levelling requires working within smaller zones. This reduces time, fuel and compaction.
  - ⊕ GPS can operate 24/7 with the use of auto steer and guidance to aid driver ability.
  - ⊕ Tractors are coming steer- and level-ready via CAN Bus and hydraulic systems.
  - ⊕ GPS follows curvature of the earth, laser is a straight line. Curvature of earth is approximately 20cm vertical over 1.6km horizontal.
  - ⊕ Satellite constellation issues can arise at certain times of the day and periods of the year (i.e. poor around December). Less of an issue in time as more satellites become available.
- ⊕ Sunspots play havoc with GPS signal.
  - ⊕ Vertical Dilution of Precision (VDOP) is critical for accuracy (0.7 to 1.2 is good, greater than 2.4 there is too much error in the VDOP). VDOP is related to appropriate satellite coverage.
  - ⊕ Laser transmitter requires maintenance calibration.
  - ⊕ Older laser systems are being phased out, spare parts expensive.
  - ⊕ Manufacturers moving to GPS based systems.
  - ⊕ Laser accuracy can be affected by dust particles, physical interferences and heat shift.





