Strategic cropping lands program
Fitzroy Basin Association Inc. (FBA) is funded by Australian and State Government programs

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About Fitzroy Basin Association Inc. (FBA)

Fitzroy Basin Association Inc. (FBA) is central Queensland’s leading Natural Resource Management (NRM) body. FBA is a community-based organisation that works to protect natural assets, increase the adoption of best management land practices, and promote sustainable development.

FBA works with stakeholders across central Queensland to provide planning direction, information, advice and practical support.

Through our network, FBA provides information, resources and technical assistance to farmers and graziers to adopt improved land management practices.

Through this approach FBA is ensuring more sustainable and profitable production, improving water quality, minimising impacts on reef health and protecting the diversity of our local flora and fauna.
About Precision Agriculture Pty Ltd (PAPL)

As a leading provider of precision agriculture services, Precision Agriculture Pty Ltd aims to improve customer productivity and profitability through better, more informed management decisions.

It’s all about data, insight and action.

Whether it’s on-farm, for industry or government we collect, measure and interpret data to find opportunities for technology to deliver savings and unlock potential. We provide practical assistance and support to apply our findings to the real world.
About the “Precision agriculture—targeting variability to increase productivity in strategic cropping land” project

This project aimed to improve productivity, profitability and sustainability of agricultural production systems for central Queensland (CQ) cropping agribusinesses. Using 40 case study farms across the region (including both dryland and irrigation farms) the project critically reviewed participants’ farm practices and management thus identifying areas for improvement, with a focus on reducing paddock variability and thereby increasing productivity. Learnings, and relevant information, identified through these activities was disseminated to the broader cropping community through workshops, demonstration days, and communication products including this booklet. This project was funded through the Queensland Government Strategic Cropping Land Mitigation Program.
Introduction

Precision agriculture is a very broad term. At its most basic, precision agriculture encompasses any farming practice or technology that enables farm management to measure and respond to agronomic, environmental or economic factors at a far finer scale than what has traditionally been possible. When implemented in the right way, precision agriculture provides growers with information and tools that enable them to:

- develop a history of farm records
- improve decision-making
- target farm input use and improve effectiveness and efficiency
- unlock yield potential
- foster greater traceability
- enhance marketing of farm products

One of the best-known precision agriculture practices is Variable Rate Application (VRA) of fertiliser or other inputs – so well known that sometimes there is the misconception that precision agriculture only refers to VRA. However, there is a range of other relevant technologies and practices with differing degrees of cost, complexity, and potential benefit.

This booklet has been produced by Precision Agriculture Pty Ltd (PAPL) and Fitzroy Basin Association Inc. (FBA) to introduce the breadth of precision agriculture technologies and applications most relevant to central Queensland grain growers. It provides an outline of general precision agriculture technologies, a few case studies of local growers and their precision agriculture journeys, a guide to assessing the economics of precision agriculture opportunities on your farm, and a directory of local product and service providers who may be able to help you on your journey. This represents a key outcome from the Queensland Government funded project *Precision agriculture—targeting variability to increase productivity in strategic cropping land.*
Precision agriculture practices and technology for central Queensland

As part of the project *Precision agriculture—targeting variability to increase productivity in strategic cropping land*, grain producers in central Queensland were surveyed about their use of and interest in precision agriculture. Most of the producers surveyed were aware of a range of precision agriculture possibilities but only a few were widely used. In this survey, growers expressed a range of short and long-term goals in the precision agriculture space (see table below).

Knowing where to start for an individual property can be a challenge for the uptake of precision agriculture technologies. This guide was produced to outline the main technologies and practices to help you begin or continue your precision agriculture journey.
### Common on-farm technology goals in central Queensland

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Table 1: 65 farmers within 200 kilometres of Emerald were surveyed on their current usage and goals as they relate to the use of technology on farm. The most common goals are outlined below. Some technologies appear in both columns because a short-term goal for one farmer might be a long-term goal in a different farming system.
Satellite guidance

Global Navigation Satellite Systems (GNSS) is a fundamental technology that enables many precision agriculture practices seen today, from autosteer to variable rate. GNSS (often called GPS) provides the location data essential for many machinery guidance and precision agriculture applications. There are four constellations of satellites used by GNSS to provide the positioning information:

- GPS (Global Positioning System)—USA
- GLONASS—Russia
- Galileo—Europe
- Beidou/Compass—Chinese systems

There are a number of related machinery guidance options on the market today which vary in their accuracy. A wide range of applications use lower accuracy GNSS such as farm mapping, variable rate control, and yield mapping. High precision guidance (autosteer) is an enabling technology for innovative crop management practices (like controlled traffic farming).

The table below outlines the characteristics of several GNSS positioning methods and relevant uses on-farm. Modern precision farming platforms leverage GNSS in support of advanced features such as section and rate control.
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<td>Differential GNSS</td>
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<td>Yield mapping, geographic information site surveys, soil zones</td>
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<td>15-20 km from base station</td>
<td>Single base VHF/UHF Radio</td>
<td>Automated machine guidance, CTF, inter-row sowing, geographic information site surveys</td>
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<tr>
<td>Network Real-time Kinematic (CORS)</td>
<td>0.02m-0.05m</td>
<td>Anywhere in network with 70-100 km triangles</td>
<td>Network via Radio rebroadcast, Internet and mobile phone</td>
<td>Automated machine guidance, CTF, inter-row sowing, geographic information site surveys</td>
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Table 2. Characteristics of several GPS positioning methods.
**Autosteer technology and precision farming platforms**

Autosteer will improve crop input efficiencies by minimising overlap (generally 5-10% savings) and the equally important underlap. These savings alone often mean the investment is returned within 2-3 years. Autosteer technology utilises the GNSS systems outlined previously to accurately position and control machinery.

A key factor to consider when deciding on the best system for your needs is proximity to local support/dealership. Most issues with autosteer tend to be associated with initial installation and tuning, so a local dealership with a good support reputation is critical. Many systems now include a modem/high gain mobile phone antenna which enables technical support to remotely diagnose issues. Connectivity in the cab is also beneficial for automated data transfer, so each mapped job can be sent to your farm mapping program on your computer. You will also need to know whether the system can talk to your existing controllers (sprayers, seeder, harvester, etc.).

When comparing systems, it’s also important to understand that navigation accuracy can be reported in two ways:

- pass-to-pass accuracy is typically measured in a 15 minute window
- year-to-year/static/in-season accuracy is repeatable over a longer time frame and is more relevant to practices like CTF
Controlled traffic farming

Controlled Traffic Farming (CTF) is a system of crop production where wheels are driven on hard permanent tracks, which requires machinery widths and wheel spacings to be closely matched. CTF also relies on high-accuracy GNSS to attain operation-to-operation and year-to-year repeatability. In grain production the wheel-spacing and ‘lap’ width are generally determined by the header, which cannot be easily modified. Other implements are then modified to be multiples of the header width. Common systems are 9m and 12m, with 3m wheel spacing. The key is to research machinery options, decide on a width and stick to it. A 9m CTF system may work with a 9m wide planter and header front, and a 27m wide sprayer. Spreading could then be 18m or 27m depending on the implement capabilities.

The potential benefits of CTF (particularly when combined with zero-till) include improved soil structure and water capture, reduction in runoff, and savings in fuel and chemicals. For example: GRDC research suggests that CTF on the black clay soils of central Queensland can result in an additional 20mm of stored soil moisture and a related 0.4t/ha boost in grain yield.

CTF is also helpful for monitoring and assessing on-farm trials as every pass of the planter is followed perfectly with the harvester. These trials are hugely valuable for growers who are looking to test ideas or products and want some accurate data on the ideas tested, with added benefit of being able to develop an accurate understanding of the return on their investment - especially when combined with NDVI or yield mapping.
**Digital farm maps**
A high quality, accurate digital farm map is a basic building block that can help enable a range of precision agriculture practices or management outcomes.

As well as the obvious benefits of a good map as a general management tool, most farm mapping platforms will allow you to add other layers of data that are available from government departments, such as vegetation maps or roads and tracks. This can give you a clear understanding of arable areas and be useful for complying with various legal requirements.

Digital farm maps can also be imported into other software or online platforms. This includes farm management software for record keeping that is linked to paddock locations, or to download crop imagery that is ‘clipped’ to your paddock boundaries for easy analysis and file management.
Yield and protein mapping

Yield mapping technology is one of the currently most underutilised data layers available to farmers to explore and manage their production variability.

A yield map can be useful for benchmarking, on-farm trials, or as part of the process of creating management zones for strategic application of inputs. As yield is the result of the season, the landscape and countless agronomic interactions, yield maps must be ground-truthed with farmer historical knowledge, soil testing or other data layers. When interpreting yield data, it is also valuable to have multiple years of data to understand the seasonal impacts and trends. Yield data can identify zones of variable productivity, which warrant further investigation but will not identify factors that are constraining yield without additional knowledge and/or data.

The adage “good data in, equals good data out” applies to yield mapping. Taking time to set up the machine prior to harvest will help collect useful data that can be used to make management decisions in improving farm profitability.

The following are some tips for collecting useful yield data:

1. **Check yield monitoring equipment pre-harvest**
   Look at the grain flow sensor, are the deflector plates worn or are objects jammed behind the plate? Irregular data collected from the previous harvest is an indicator that the sensor or plates may be worn. Additionally, is there any damage on the cables?

2. **Set up boundaries and guidance lines**
   This is highly recommended to reduce the need for post-harvest data cleaning. Many GPS displays also require boundaries in order to use variable rate technology. Boundaries can be drawn in using a farm...
management software or physically mapped (driven) in the paddock. This can be a worthwhile process as a one-off investment using RTK quality GPS (2cm accuracy). If you do not have access to this equipment it is possible to hire it from your local dealer or get a contractor to do it.

3. **Data card/display setup**

   Your yield monitor writes data to a USB or compact flash card directly. Many growers find it easiest to buy a new card at the start of each harvest and store the old one as a backup (in addition to copying the data onto their computer). Use good quality memory cards. Some systems have maximum card limits, e.g. a 1GB card is too big for a John Deere 2600 screen. If your monitor writes data to an internal memory, it is a good idea to do a full export to a USB and then clear the screen to ensure you have enough space available. Again, make sure you make a copy of the backup to your PC and an external storage device.

   If you have boundaries/guidance lines mapped in a farm management software, update the management tree to ensure the Farm/Field names are correct. In most precision agriculture software programs, you can now preload all the paddock names and crop types, guidance lines and boundaries to your USB/data card or send them wirelessly to the machine. This is referred to as a ‘setup file’, which you can also engage a contractor to create. This is particularly recommended if you have multiple headers working together so they will all have the same run lines. Using a setup file also drastically improves the ease of post-processing as the paddock names are consistent.

4. **Set up the harvester**

   Set up some basics including the height of the comb where mapping ceases when the comb is lifted, vibrations and calibrate moisture (with a handheld moisture meter if possible).

5. **At harvest time**

   • calibrate header at start of each crop type and do not alter settings half way through a paddock
   • enter the correct crop type for each paddock
   • record grain weight totals for each paddock for post-processing
   • raise the header front at end of runs, to reduce amount of rubbish data
• limit a maximum of two headers working in the same paddock – one header per paddock is ideal
• when running numerous headers in the same paddock, try to harvest side-by-side as this assists post-harvest calibration (name the headers differently)
• beware of header height switch, especially when changing crop types
• check GPS is working properly and that yield data is being recorded throughout the day (where possible)

6. Data management
Download the data regularly (at least weekly) to a farm management program, especially at start of harvest to ensure everything is working well. Telematics makes this step easy as you can login and check the data being uploaded straight from the header. Before you upload the yield data from a card or USB into the farm software program always make a backup by copying and pasting the entire card onto computer.

7. Look at your maps
Don’t wait until you have years of data, start looking at it now. You may find the data quality is substandard, which could be fixed prior to future harvests even if you don’t intend to use the data in the near future. You may also find ‘low-hanging fruit’ in your yield data which can be addressed without significant investment or expensive variable rate equipment requirements.

Protein mapping is a relatively new technology first developed in Australia by Next Instruments and is a complementary technology to yield mapping. This technology provides real-time readings of harvested grain protein, moisture, and oil, as well as storing data which can then be processed into maps that show how these characteristics vary across the paddock. This technology can have a variety of practical uses, such as segregating grain based on quality, strategic mixing of grain to maximise quality of each load, or to determine the level of nutrient removal in grain at each point in the paddock to help inform variable rate application.
Remote sensing and crop imagery
Remote sensing simply refers to collecting data from a distance. Crop or paddock imagery collected by satellite, plane or drone is the most frequently encountered application of remote sensing in agriculture. Satellite imagery (30m to 30cm resolution) offers a low-cost whole-farm monitoring or assessment opportunity. Drones or Unmanned Aerial Vehicles (UAVs) can provide similar services as a satellite but also have the flexibility to target timing and the area that is monitored. They offer a superior resolution (1m to 1cm) for more detailed insights into crop and even individual plant performance, but at a generally greater commitment of cost and time. Manned aircraft can generally be considered the middle-ground between these other two options.

NDVI (Normalised Difference Vegetation Index)
Outside of true-colour photography, the most frequently encountered type of imagery utilises the Normalised Difference Vegetation Index (NDVI). Healthy plants reflect certain wavelengths of light and strongly absorb others, and this can be measured using a multispectral camera. NDVI converts this raw data into a simple indication of canopy density, biomass and plant vigour that can correlate well with final yield. However, before using NDVI imagery, it’s important to be aware of a few key factors:

• NDVI can indicate a healthy plant, but not what kind of plant – a vigorous patch of weeds (or even surface moss) will look exactly the same as the healthy crop. More generally, NDVI can show a difference in plant growth, but it won’t define the reason for it.

• If you’re comparing imagery over time, it’s generally important for all data to come from the same specific source (such as a particular satellite). It’s also important that the right kind of camera is used: many cheaper sensors that are used on drones are just a normal camera with a special filter attached, which means it can be used to calculate NDVI but images from different paddocks or different times won’t be directly comparable.

NDVI is a potentially useful tool for detecting areas of different crop performance in-season, but ground-truthing is important to extend and validate any insights. For example, a nutrient imbalance would require additional soil testing
to understand what is deficient, while suspected diseased crop would need to be tested to identify the pathogen and to prescribe a treatment. When the appropriate further investigation is completed, and by combining NDVI with other data layers, it can inform the need for a range of activities including variable rate nitrogen (N), variable rate fungicide and crop growth regulants, strategic weed control (spray and/or cut for hay) and definition of seasonal yield constraints such as waterlogging, pests and sub-soil constraints.

**Soil and landscape mapping**
Understanding how soils and the landscape (e.g. elevation) vary within a paddock can help explain observed crop variability, inform effective surface water management, and is a critical step towards variable rate management.

In addition to yield and protein maps and the remote-sensed imagery discussed earlier in this booklet, there is a range of tools that can help map paddock variability on the ground. The relevance of each tool on your farm will be determined by the soil constraint or productivity issue of interest. Often a single source of data may not be enough to define the issues and the treatment: in this case combining multiple layers of data will be more useful in getting the insight that you need.

New technologies for mapping soils and landscape are constantly emerging. Common and proven tools and layers used to define and describe variability include:

**Soil testing** can define a broad range of soil physical, chemical, biological and hydraulic properties. Disease pathogen and nematode monitoring can be included in this process. Conventional soil sampling may combine multiple soil cores taken on a transect across the paddock or in a random distribution in order to provide a single ‘average’ indication of soil characteristics for a whole paddock. For a deeper insight into soil variability across a paddock, several cores
can instead be taken in strategic locations or ‘management zones’ identified by other information layers (such as those outlined below), but these locations may only be relevant for specific soil characteristics, since not all characteristics will have the same distribution across the paddock. The most detailed information is provided by grid soil mapping (soil transect sampling per grid unit, typically 1-4ha). A grid soil map can provide a baseline for several seasons (especially for farmers who can link nutrient removal maps via their yield data). Phosphorus, pH(CaCl2) and exchangeable cations (potassium (K), sodium (Na), magnesium (Mg), aluminium (Al)) are the more common soil elements tested when grid soil mapping (0cm to 10cm).

**Elevation data** accurately describes the rise and fall of terrain across a paddock and is a critical input for precise water management such as drainage design, water logging zones, and erosion control. Elevation data can be collected during routine operations (ideally seeding) utilising existing systems when auto-steer is used. Most auto-steer displays can log elevation data and many do it without the grower even knowing. Avoid using elevation data from a harvester as the readings are influenced by the changing weight of grain in the header box, or from a sprayer as changes in tank level will have a similar impact. It is recommended to conduct a survey specifically for elevation when highly-accurate data is required, such as for land levelling. Once the data has been collected a Digital Elevation Model (DEM) can be created.

**Electromagnetic induction/Apparent Electrical Conductivity (EC)** is measured by tools such as the EM-38, DUALEM or Veris MSP. EC is an indicator of soil salinity, clay and soil moisture. For many paddocks it can provide a useful soil map, but which characteristic is having the greatest impact will need to be validated with additional measurements. Soil cores and associated analyses (ideally segmented cores to explore changes over the soil profile) are essential to extract paddock management value from such soil maps.

**Gamma radiometrics** are another soil mapping tool used predominantly in combination with EM-38 on sand plains and in gravel soils where soil conductivity is less effective in isolation. It measures the natural radioactive decay of potassium, thorium and uranium in the top 30cm to 45cm of the soil. This has potential use as another indication of changes in soil type.
Variable rate applications

Crop yield across a paddock can vary for a wide variety of reasons: underlying factors such as soil type, structure, depth, available moisture, and topography, or issues such as insects, diseases, weeds, temperature, and past management practices or previous crop performance. Variable Rate Applications (VR, VRA or VRT) of chemicals, fertiliser, ameliorants, or physical operations such as tillage, is intended to respond to this variation in a way that more precisely targets soil and crop requirements at any given point.

This requires an understanding of exactly how this variation occurs and what is driving it, which generally requires additional investigation alongside your own historical knowledge. Various tools that can be used for this are outlined elsewhere in this booklet, but include soil and landscape mapping, yield maps, or remote sensing. Often, the most reliable results will come from combining several different data layers. Deciding what information is important and relevant will depend on exactly what the target is.

When addressing within-paddock variability the highest Return On Investment (ROI) is often achieved by addressing the key soil health factor/s limiting crop performance. Soil acidity (VR lime) and sodicity (VR gypsum) are examples of strategies that can ameliorate soil constraints and in doing so unlock yield potential. For example, the aim of the VR lime is to establish a minimum target pH level (e.g. pH(CaCl2) of 5.5) across the entire paddock, while avoiding costs and issues associated with over-liming (such as reduced nutrient availability).

As the key soil constraints are ameliorated and broader measures of soil health are improved, site-specific crop management can be implemented. Seasonal management strategies (predominantly VR nutrition, disease and pest control) are often developed with the combination of underlying soil levels (grid or zonal soil testing) and crop monitoring information (NDVI, yield maps and physical inspection). Macro nutrient supply (predominantly N, P and K) via seeding and spreading are the most common VR strategies employed.
Turning data into a VR prescription can be done several ways. In most cases, management zones are created that encompass areas of similar performance or input requirement. The complexity and number of management zones is influenced by the extent of paddock variability, but also by the technical capability of relevant machinery and the size of the paddock. For example, in a small paddock or where fertiliser rates can only be changed by varying the speed of the spreader in the paddock, a very small number of zones is appropriate. In a large paddock or with variable rate capable spreading machinery a larger number of zones can be used for more precise management. Although it can be tempting to use the same management zones for several different inputs, this should only be done when supported by the evidence: different nutrients are often not distributed in the same way across a paddock.

In other cases, variable rate inputs may be applied ‘on-the-go’ using tractor mounted sensors that directly control application machinery. The WEEDit is an example of such a system: this uses optical sensors to detect weeds in fallow situations and only apply chemical to these areas.
Case study: Muidart Station

Andrew and Priscilla Wedel and their children farm on Muidart Station, west of Dysart, combining approximately 2000ha of dryland cropping with a substantial cattle enterprise. The property encompasses a range of different soil types including alluvial soils and black self-mulching downs. Sorghum is the primary crop, but the Wedel’s also produce chickpeas, wheat, corn and oats depending on rotation needs, market prices, and seasonal conditions. At Muidart, precision agriculture has long been a central part of the farming system.

Making controlled traffic farming work

The Wedels were relatively early adopters of CTF, taking the first steps in 2002 towards what is now a well-established system – but the shift didn’t happen overnight. Conversations with other CTF farmers and experts at field days around the district gave Andrew the confidence that the benefits were there. However, because of the expense involved with machinery investment and modifications, the transition had to be spaced out over several years.

Rather than quickly buying a cheaper option that may only do half the job, Andrew explains, “You’re better off sticking with what you’ve
already got until you can afford [the right machinery]”. This doesn’t mean only buying new – “there’s lots of good second-hand gear – just make sure it’ll do what you want it to do.”

According to Andrew, he was initially motivated by the potential for yield and efficiency improvements, which were very quickly realised under the CTF system.

By 2007 everything was on tram tracks based around the 9m header front, but the shift towards 12m fronts meant that by 2016 the system had to change. This involved a new summer crop planter and a 36m sprayer, but the existing winter crop planter was simply modified by removing the wings to bring it down to 12m from 18m.

In 2018, Muidart moved from 10cm accuracy satellite guidance to a 2cm accuracy RTK setup with their own base station, motivated primarily by the large expense that the existing subscriptions were costing them every year. Andrew has noticed additional benefits to the higher accuracy, mainly in terms of machinery staying more precisely in the existing wheel tracks.

**Precision machinery delivers savings**

Investments in machinery have consistently delivered substantial benefits to Muidart, particularly as a result of improved efficiency. For example, a new Caiman SP sprayer with 12 section control has resulted in savings of more than one tank of chemical per paddock thanks to reduced over and under-lap and more efficient turns. Similarly,
a Precision Planting setup on the summer crop planter that combines vSet meters with vDrive motor systems and DeltaForce downforce control has delivered better plant establishment as well as approximately 10% savings in seed. The summer planter is also equipped with a liquid system that allows Andrew and Priscilla to apply custom liquid fertiliser brews at planting developed alongside consultants from Australian Soil Planners (ASP). These are designed to deliver balanced soil fertility and improved soil function.

Challenges and lessons learnt
Everything new comes with teething issues, which means that the availability and distance to relevant technical support is front of mind for the Wedels when looking to invest in new technology. For example, when choosing a new sprayer, close proximity to the local distributor (and a good warranty) helped to push the Caiman SP purchase decision. This doesn’t mean that issues don’t happen – for example, the new RTK base station had a range of problems when first installed, from random cut-outs to connectivity issues. These problems are always frustrating:

“It seems worse than it is when it’s happening,” shares Priscilla – but thanks to good support these kinds of problems have generally been resolved as quickly as possible.

Similarly, support in the form of agronomy expertise and peer group learning opportunities continue to be Andrew and Priscilla’s most useful resource for continuing to refine and innovate their approach to precision agriculture. Through ASP, Muidart is involved in two grower days each year – one before the winter crop, and one before the summer crop – that provide a valuable opportunity for group learning, including sharing the results of on-farm trials that Muidart and other ASP growers are involved in running.

For people considering a move to CTF, Andrew recommends investing time in research and planning at the outset to avoid the prospect of costly changes halfway through the journey:
“Work out what you’re going to be and stick with that”.

The future
There are a few potential precision agriculture developments on the horizon for Muidart. From a machinery perspective, they are considering investing in a WEEDIt to enable spot spraying of weeds. More broadly, Andrew is keen to put their farm data to work. Thanks to RTK guidance, machinery operations are generating large amounts of precise data but this has not yet been used for any practical purpose. They are also interested in exploring the value of other sources of crop information, such as satellite imagery.

An area where this could be particularly useful is in managing soil and crop variability within each paddock. Whilst currently applying uniform inputs across a paddock, Andrew says that he sees the potential in moving towards a variable rate approach.

“Driving around you can see the variability, so it would be nice to do something about it. Every paddock could have up to half a dozen changes”, said Andrew.

Making this work would depend on getting their ducks in a row in terms of machinery, money, and time.
Case Study: Muidart Station
Case Study: Dalkeith

John and Kate French farm at Dalkeith, a 2400-hectare property between Capella and Dysart. Approximately 60% of their country is used for cropping, with sorghum, wheat and chickpeas the main crops.

The French’s took over the farm from Kate’s parents in March 2017 and have been working hard to bring their plans to fruition. With much of their capital dedicated to the purchase of land, this has required a pragmatic approach to developing the farming system - particularly when it comes to more expensive precision agriculture practices and technologies.

“We have a long vision and have a long goal. We can see where we want to be, but we’re just starting out. It’s all about small wins: you’ve got to start somewhere...doing little projects, step-by-step, will get you where you want to be,” says Kate.
Guidance and CTF
Dalkeith has a well-established CTF system that was originally underpinned by Leica RTK guidance. However, a lack of support for the older Leica technology in Australia and ongoing issues with it on-farm meant that the existing wheel tracks were just followed by eye for several years. This meant that tramlines had become both wider and deeper than desired.

In keeping with their methodical approach to farm improvement, the French’s first purchased a wheel track renovator. This has allowed them to progressively bring their tramlines back to a ‘clean slate’ before investing in a new guidance system. This has both improved the impact of the existing wheel tracks, and given them the freedom to optimise the location and direction of their tramlines under the new guidance system.

After their previous struggle with long-term technical support, the French’s were determined ensure that their next guidance system was as ‘future-proof’ as possible. This helped narrow their choice down to a few of the major players that were very well established and widely used and supported in their local area. At this point “it was really just a case of Ford or Holden”, says Kate. Ultimately, they decided on a Trimble setup with 4cm accuracy delivered via subscription on a single
screen that will be shared between machinery to save costs. Since their neighbours are also on a Trimble system, this has the potential for future investment in a shared RTK base station.

**Farm management software and mapping**

Farm management and mapping software has been a central interest for the French’s, which provides them with a firm and reliable base for decision making.

The French’s use the AGDATA Phoenix Financial modules for bookkeeping and financial management, and ProductionWise (and the associated mobile app) for planning and recording cropping operations. Unlike traditional paper-based recording systems, these software packages have enabled them to not only keep on top of what is going on but also draw more valuable insights that can inform future planning.

“If you want to do any data analysis – like cost per hectare, inputs on paddocks, gross margins – it’s just a click away. The numbers are already there and you can easily manipulate them,” explains Kate.

After attending free training organised by FBA and AgForce, Kate has also added the AGDATA Phoenix Mapping module. The workshops opened her eyes to the benefits of a digital farm map to logistical planning and as a reference that is easily shared with workers and contractors. Since then, Kate has been gradually expanding the Dalkeith farm map with additional layers and more accurate boundaries. As well as its immediate applications, this will simplify the process of adopting other digital technologies where digital paddock boundaries are required, such as when downloading satellite imagery.
Making the most of every opportunity
When it comes to getting started with farm mapping software, Kate strongly recommends taking advantage of any available training opportunities – and allowing yourself enough time to come to grips with it even if it doesn’t initially click.

“Give yourself 6 months to a year to use it”, she recommends.

The French’s have found organisations like FBA a valuable source of training and information, as well as direct support through project funding. For example, the French’s have leveraged government funding delivered by FBA to subsidize the cost of their new Trimble guidance system. By taking advantage of opportunities like this whenever they arise, they reduce their costs and make faster progress towards their goals than might otherwise be possible.

In the future, the French’s hope to move towards a precision planting setup to improve efficiency and reduce the current soil disturbance caused by a two-pass seeding and fertiliser operation, but in the meantime, they are focused on getting the very best out of their existing gear. Pursuing efficiency and constant incremental improvements are all part of the plan to optimise the productivity and sustainability of their existing land, rather than just getting bigger.
Case Study: Dalkeith
Case Study: Karinga

Scott Muller farms alongside his father Gordon on Karinga, just outside Biloela, with 800ha dryland cropping, 200ha irrigated, and a cattle enterprise on the remaining 800ha. Whilst mainly winter croppers, growing wheat and chickpeas, the Mullers have started to incorporate a summer crop of sorghum or mungbeans in response to changing seasonal conditions. Karinga is characterised by an adaptable farming system supported by the methodical pursuit of paddock insights for targeted decision making.

Keeping their eyes on the prize

Whether it be new practices or technology, the Mullers are careful to remember that their goal is to improve productivity and efficiency. This is well illustrated by their approach to CTF.

In 2010, a move towards zero-till led into a full CTF system supported by 2cm RTK guidance – initially based on a 9m header width. This has evolved into a 12m width after the purchase of a new Case IH 7140 header with 12m front last year. Alongside their CTF system the Mullers have retained the additional machinery and flexibility required to respond appropriately to different production constraints. This means they can rapidly respond when other on-farm challenges require a different approach – such as herbicide resistant Feathertop Rhodes grass that defies non-mechanical control. While the priority is to maintain zero-till CTF, the Mullers are pragmatic in their approach.
“There’s no one size fits all—you’ve just got to adapt. You’ve just got to be able to adapt with the season, and every season’s different,” Scott said.

Experimenting with variable rate
This desire to adapt practices to suit changing requirements in the paddock has helped foster a keen interest in VRA. Karinga encompasses a range of different soil types, with up to five texture changes in any one paddock that include everything from heavy black to sandy scrub soils, and similar variability in crop performance.

In this context, applying inputs in response to a ‘representative average’ just isn’t possible, which means that a uniform application may be well over or under what is required at different parts of the paddock. Consequently, the Mullers hope that VRA will offer improvements in both efficiency and productivity.

Their foray into VRA began by building a reliable base of information about paddock performance in order to form management zones and target applications, but they have encountered issues when trying to put this data to work in their machinery.

“Everyone knows their own paddock to a degree, but you need several years of good, consistent data to really make VRA work,” explains Scott. “When I got close to being able to do it (VRA), that was when I hit that clash between [different machinery brands] and nothing worked.”

Case Study: Karinga
Incompatibility between a mix of different screens and controllers frustrated Scott’s initial attempts at a practical VRA system, making it challenging to find relevant technical advice. This has convinced Scott that sticking with a single brand when the time comes to upgrade will pay dividends. He is also hopeful about the potential for ISOBUS, a compatibility standard that is increasingly incorporated into agricultural screens, controllers and machinery, to help overcome these kinds of issues.

**Data collection and analysis**

In the meantime, the Mullers are focused on expanding the systems that they use for gathering and recording farm data, which reflects Scott’s view that it is important for any decision to be based on hard data.

“If you know exactly what you’ve put on and where you’ve put it, that’s valuable. If you don’t have that data, then how can you improve on it?" says Scott.

This has included the development of an accurate digital farm map, which has also been printed on a whiteboard as a simple but effective method of recording farm operations for day-to-day management. They have explored the use of satellite NDVI imagery and have established an effective yield mapping program. When it comes to collecting paddock data, Scott stresses the importance of taking the time to ensure that the setup is right.

“Yield maps are only good if your header is calibrated…The information you get out is only as good as the information you put into it. You have to have all your ducks in a row before you even start, otherwise you’ll get a false reading.”

In the case of yield maps, it took a season of experimentation and ironing out the kinks before Scott was comfortable with the quality and accuracy of the data.
The Mullers are currently searching for a new home for their data but they have not yet found a farm management software package that they are satisfied with. Their ideal vision involves layering NDVI and yield maps in a desktop software package to identify areas of poor performance. These locations can then be shared with their agronomists and navigate to them using an app. Soil sampling or other methods can then be used to assess the appropriate treatment and design a variable rate prescription to suit.

**Lessons learnt and next steps**

The Mullers believe that previous data and experience has been, and will continue to be, their most useful resource when it comes to improving their farming system, alongside a good agronomist to help make sense of the data and a resourceful and adaptive approach to trying new things. Despite its challenges, Scott remains convinced that VRA makes sense and is worth pursuing once he can overcome his current machinery issues.

“You’ve got to look at it (VRA) like a business…if you don’t have to be putting it (chemicals and fertilisers) on, why are you putting it on?”.

At the end of the day, the Mullers’ focus on the bottom line will ensure that precision agriculture delivers good value for Karinga.
Case Study: Karinga
Case Study: Boonal Downs

Andrew and Leonie De Boni, along with their two sons and daughter-in-law, farm at Boonal Downs north of Capella. They grow 1200ha of chickpeas, wheat and sorghum alongside a cattle enterprise that occupies the remainder of the 2300 ha property.

The De Boni’s only moved to the area four years ago, shifting from a small cane and cattle property near Airlie Beach to take advantage of the magnificent soils, range of grain and cattle marketing opportunities, and much greater room for expansion.

“Coming off a very small farm before, coming here was like drinking from a firehose,” reveals Andrew.

A “jackpot” chickpea crop in their first year helped them to rapidly progress their plans for an efficient, productive farming system. In 2019, the De Boni’s experienced their first successful summer crop since moving to Boonal Downs.
A precise start
A highly accurate Trimble RTK guidance platform was one of their most valuable early investments in precision agriculture. The upfront cost was the main challenge involved, but the De Boni’s were able to take advantage of their neighbour’s existing base station and also move the one screen between their machinery for further savings.

Nevertheless, going with a high precision setup from the start was an easy decision to make.

“With irregular shaped paddocks I really don’t know how you could be efficient and effective without GPS. You would be doing that much overspraying and missing, particularly with chemical use…” says Andrew.

“One thing with GPS is the certainty that it gives you. It’s easy to justify the cost given the benefits between chemical, fuel, labour, and mental health – it just does your head in otherwise,’ Andrew further explained.

Precise guidance is a facilitative technology for a range of advanced precision agriculture practices: as it is, the De Boni’s estimate that they only use 10% of the possible features on their precision farming platform and are keen to pursue further training to get even more out of the system.
Good support makes decisions easy
Getting their guidance up and running (and keeping it that way) has been helped by over-the-phone support – and the availability of good support remains a central part of the decision-making process when it comes to investing in technology. As a general rule, the De Boni’s believe that there’s value in sticking with the most popular and established brands, even if they aren’t the cheapest. It means that advice or parts are readily available and reduces the risk of being left with an unsupported technology earlier than expected.

“We buy Toyotas and we buy John Deeres, because of support. There’s always a cheaper alternative but they just haven’t got that backup service. For example, with tractors there’s so many brands coming over - but where are you going to get the parts?,” questions Andrew.

The De Boni’s are keenly aware of the importance of understanding the ROI offered by any new technology or practice change. Their previous experience in the sugar cane industry demonstrated the value of staying just behind the cutting edge to make sure that the benefits have been proven before making the jump.

“We’re very cautious with change, we look at return on investment, because with the cane industry it went from 1.5m rows, to 1.8m rows, and then to 2m, and then to double rows – people were spending a fortune on adapting machinery, and now a lot of people have gone back. There was no real benefit. You’ve got to be cautious and make sure that return on investment is there,” explains Andrew.

Most useful resources
Andrew and Leonie believe that getting good advice has been central to their success to date, whether investing in new technology or making decisions about the broader farming system. The De Boni’s always make a point to seek out expertise to support their decision making – whether that be in the form of professional advice from their agronomist or other experts, input from their neighbours, or through taking part in relevant education opportunities.
“Sometimes some people feel a bit intimidated to ask the question with their peers. And I think that’s why we’ve been so lucky: we haven’t charged in here and think we know what we’re doing, we have come in and put our hands up and said, ‘listen, we’re new to this,’ and people have been so willing to help us,” says Leonie.

“The first thing we did, basically, was go straight to professional help, and local people were also really willing to help out…BMP (Best Management Practice) courses and other education [also] helped us through.”

“When you go to those things, that’s when you can network and find out where to go when you need assistance.”

When considering a new project or machinery investment, the De Boni’s will undertake some background reading on the Internet to form an initial understanding, before exploring the subject in more depth with relevant experts and other farmers with first-hand experience. Andrew suggests that when considering a new purchase, to ask the supplier for two other people who have bought one in the past – and then give them a call to find out what their experience has been like.
Future Plans
Continuing education is a priority, with the De Boni’s recently completing the RCS ‘Farming & Grazing for Profit’ course. Amongst other benefits, this has allowed them to set up a central platform for recording their farm data. They expect this to deliver a much clearer understanding of exactly what is going on in the farm – and potentially, when combined with the large amounts of spatial data collected by their guidance system, enable the kind of insight that can support even more precise farm management down the track, such as variable rate applications.

The De Boni’s are also evaluating their next step in terms of satellite guidance. To reduce their reliance on their neighbour’s base station, they are considering switching to a satellite subscription service instead. Whilst this will result in some reduction in the accuracy of operations at Boonal Downs, they are concerned that they may not recoup any investment in a new RTK base station before new technology makes it obsolete.

For now, however, the focus after four years of rapid development is on consolidation – and making a plan for what’s next.
Case Study: Boonal Downs
Economics—is precision agriculture worth it for you?

This chapter is adapted from information produced by GRDC project RDP00013 ‘The integration of technical data and profit drivers for more informed decisions’, including specific case study data for the Northern Region contributed by Agripath. RDP00013 project partners were Agripath, Meridian Agriculture, Macquarie Franklin, Corporate Agriculture Australia and Rural Directions Pty Ltd.

Researchers for GRDC project RDP00013 undertook more than 60 interviews and compiled 21 case studies in all major cropping areas in Australia to determine the impact of precision agriculture on farmers’ bottom line. They discovered that the net economic benefit per hectare generated from the application of precision agriculture technologies ranged from a low of -$90 per hectare to a high of $75 per hectare. This wide range in net economic benefits per hectare show that precision agriculture benefits are highly situational for several reasons:

- there is a wide range in the capital investment required to implement different precision agriculture technologies
- alignment between key profit drivers and precision agriculture technologies can be very different in different regions and agro-ecological zones
- the physical characteristics and variation in soil types across different regions can drive very different benefits and outcomes from a common technology
- local climatic conditions and climatic variability can influence the scale and frequency of the benefits generated by some technologies
- variation in local input pricing for products such as lime
- variation in commodity pricing (inputs and outputs) influencing the benefit over time
- how a grower chooses to apply a technology and the yield and cost base from which they are starting
- different levels of implementation and operational skill across a farm management team
- operating scale can influence both how much area fixed costs can be spread over. A larger farm will also receive a greater overall benefit from a more moderate per hectare benefit.

As a result, it is very important to take a structured and objective approach to assessing precision agriculture opportunities. What makes sense for your neighbour or in a single case study may not deliver the same benefits on your farm.
Understanding the impact of precision agriculture

When assessing precision agriculture opportunities, it’s important to remember that the benefits can directly or indirectly influence farm profitability.

CTF is an example of a high impact outcome that has resulted directly from the application of precision agriculture in central Queensland. Northern Region Research trials and farmer experience have demonstrated that CTF offers the ability to harvest and capture an additional 20mm of stored soil moisture through improved and more consistent infiltration of rainfall. This additional 20mm of stored soil moisture can boost grain yields by 0.4 tonnes per hectare and increase net profit by up to $75 per hectare. This is a substantial profit driver on heavy, black, clay soils that are very capable of storing out of season rainfall. CTF is also a technology that can now be implemented for a relatively low capital investment as auto-steer capability now comes standard on most new tractors, self-propelled sprayers, and harvesters. Given the low capital cost, if you have access to this technology there is a strong case for applying it as it provides scope to increase profit potential by $75,000 for every 1,000 hectares farmed.

An example of an indirect impact could be NDVI mapping picking up an uneven spreading pattern from a urea spreader with a damaged spinner flute, with uneven urea spreading causing a 6% yield loss across a paddock worth $70 per hectare. In this example, the NDVI mapping identified the issue in a timely manner, but a physical examination of the spreader or testing the spreading distribution could also have identified the cause. This illustrates how important it is to assess whether precision agriculture is the best way to solve a problem – or if a realistic alternative exists that doesn’t require further investment.

Similarly, precision agriculture is often a refinement to a production system. In this case, it is important to ensure that you have fully explored the fundamentals of agronomy and operational timeliness within your farm before seeking Economics—is precision agriculture worth it for you?
the further system refinements potentially available through precision agriculture. Ensuring excellent implementation against the fundamentals of crop rotation, crop agronomy, and operational timeliness throughout the full management calendar are often the ‘low hanging fruit’ to capture first.

A checklist for assessing precision agriculture opportunities
The following checklist is a practical tool that will help you make a reliable assessment of whether a new precision agriculture practice or technology will make sense on your farm. If ‘yes’ can be answered to all 10 of these important questions, then the application of the precision agriculture technology has been well considered and is likely to result in a suitable economic benefit over time.

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<tr>
<th>#</th>
<th>Checklist for assessing precision agriculture opportunities</th>
<th>Yes/No</th>
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<tr>
<td>1</td>
<td>Have I fully exhausted the internal opportunities to increase gross margin and net profit through crop rotation, crop agronomy, and operational timeliness?</td>
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<td></td>
<td>If no, recommend that these are explored first.</td>
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<td>2</td>
<td>At what stage of the development cycle is the precision agriculture product and application? Has the product been robustly tested in a commercial environment?</td>
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<tr>
<td></td>
<td>Products and applications which are further along the commercialisation pathway generally have a lower acquisition cost and greater capability.</td>
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<td>3</td>
<td>Does the technology influence long term average crop yield?</td>
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<td></td>
<td>Technologies which leverage from increased crop yield often generate a stronger net economic benefit, as greater yield from a small to moderate increase in cost can often allow robust outcomes to be achieved.</td>
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</table>
4 **Is the precision agriculture technology the most cost effective mechanism to achieve the outcome that I am striving for?**

Sometimes there are alternative channels to achieve a desired outcome. It is important to select the most cost effective channel to achieve a desired outcome wherever possible.

5 **Have I undertaken a robust economic assessment of the opportunity to apply the technology and this analysis demonstrates a positive net benefit?**

The range in net economic benefits can be substantial and is often very sensitive to the acquisition cost of the technology and the robustness of the assumptions supporting the benefit.

6 **Do I understand how the benefit will be influenced by climatic seasonality? Do my assumptions accurately reflect the likely benefit or cost saving by taking a long term perspective which captures the influence of climatic seasonality which will be inevitable?**

Some technologies have very different payoffs under different seasonal conditions. It is important that this seasonality is understood and captured in an economic analysis. Tools such as CliMate can be used to add rigour to assumptions around seasonality and the way in which it may influence the benefit.

7 **Do I understand how my available level of scale influences the commercial feasibility of applying this technology?**

A technology which is commercially feasible for one business may not pass the commercial feasibility test for a smaller scale business.

8 **Have I used long term, decile 5 pricing rather than spot pricing when calculating the net economic benefit?**

Spot pricing can substantially influence the value of the benefit or cost saving that can be realised and as a result can be misleading. This is particularly so when spot pricing is substantially different from the longer term average. This principle applies to both input cost prices and grain prices.
Table 3. Checklist for assessing precision agriculture opportunities.

In addition to an economic analysis to support the decision to pursue precision agriculture technologies, it is also important to acknowledge that the use of precision technologies can be a valuable motivator for some growers. Working with precision technologies can increase interest and commitment to agriculture for some growers and this can be a very beneficial outcome over the long term. A technology that motivates you to look more closely at the unique soil types and production zones across your property and assess how you can optimise the productivity of each land class is valuable.
References and further reading

The Australian Controlled Traffic Farming Association https://www.actfa.net/

Fitzroy Basin Association—Grain and crop grower services https://www.fba.org.au/services/grain-growers/


Society of Precision Agriculture Australia Resources https://spaa.com.au/resources/


<table>
<thead>
<tr>
<th>Business</th>
<th>Phone</th>
<th>Address</th>
<th>Website</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Cotton Grower Services (CGS)</td>
<td>07 4982 2255</td>
<td>Gregory Highway, Emerald QLD</td>
<td>cgs.com.au</td>
<td>CGS is a cotton, irrigated row crop &amp; dryland broadacre specialist supplier; distributing a large range of precision equipment, services &amp; solutions, as well as premium brand crop protection &amp; production products.</td>
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<tr>
<td>Farmers Edge</td>
<td>1800 931 339</td>
<td></td>
<td>farmersedge.ca</td>
<td>Farmers Edge provides end-to-end solutions that incorporate hardware, easy-to-use software, digital agronomy, AI-driven analytics and technical support, to help growers get value from farm data, manage risks and maximize returns.</td>
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<tr>
<td>Milne Bros Equipment</td>
<td>07 4930 0333</td>
<td>Cnr Gladstone Rd &amp; Derby St, Rockhampton QLD</td>
<td>milnebros.com.au</td>
<td>Milne Bros Equipment is the longest established machinery dealerships and tractor sales in Central Queensland.</td>
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<td></td>
<td>07 4982 4824</td>
<td>67 Macauley Rd, Emerald QLD</td>
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<td></td>
<td>07 4992 1099</td>
<td>61-67 Dawson Highway, Biloela QLD</td>
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<tr>
<td>Precision Ag Solutions</td>
<td>07 4634 5150</td>
<td>6 Kimberley Court, Torrington, Toowoomba QLD</td>
<td>precisionagsolutions.com.au</td>
<td>Precision Ag Solutions offer a suite of precision technology products and product support services and data management and analysis services to farmers, including the Ground Breaker Precision Planter developed by Toowoomba Engineering.</td>
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<tr>
<td>Precision Agriculture Pty Ltd</td>
<td>1800 773 247</td>
<td>Temora Innovation Centre, 361 Trungley Hall Rd, Temora NSW</td>
<td>precisionagriculture.com.au</td>
<td>As a leading provider of precision agriculture services, Precision Agriculture aims to improve customers' productivity and profitability through better, more informed management decisions.</td>
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<td>Business Name</td>
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<td>Precision Seeding Solutions</td>
<td>0447 442 146</td>
<td>pssag.com</td>
<td>Precision Seeding Solutions is the Premier Precision Planting Dealer for the East Coast of Australia.</td>
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<tr>
<td>Ready to Run Maintenance</td>
<td>07 4982 2021</td>
<td>readytoruncq.com.au</td>
<td>Ready to Run offers a range of specialised services to the agriculture industry, assisting your business to ensure safe and efficient operation of your machine practices. Suppliers include Ag Leader, Outback Guidance, ARAG, SmartSTEER and SmartLEVEL.</td>
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<tr>
<td>T3RRA</td>
<td>0428 922 668</td>
<td><a href="http://pts-ag.com/">http://pts-ag.com/</a></td>
<td>T3RRA provides practical solutions for landforming and agricultural water management, including T3RRA CUTTA and T3RRA Design.</td>
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<tr>
<td>Vantage NEA TRIMBLE</td>
<td>1300 TRIMBLE</td>
<td><a href="https://www.vantage-wa.com.au/">https://www.vantage-wa.com.au/</a></td>
<td>Vantage NEA is a leading Trimble Agriculture distributor, specialising in machine control GPS, data collection and farm management solutions that help improve farmers’ bottom lines.</td>
<td></td>
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<tr>
<td>VNet</td>
<td>1300 VANDER</td>
<td><a href="http://vnet.net.au/">http://vnet.net.au/</a></td>
<td>VNet Precision Farming is the technology division of Vanderfield, enabling customers and their agronomic advisors to utilise the technology on their farm machinery and associated data to its full potential. All Vanderfield store locations offer VNET products and services.</td>
<td></td>
</tr>
</tbody>
</table>
Contacts

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