Precision Viticulture involves the use of technology to measure vineyard attributes, detect variability and determine the cause of that variation. Such information provides the opportunity to improve vineyard management and wine production outcomes. Its application is based on the following points:

- Vineyards are variable
- Uniform management is not the best strategy
- Vineyards can be divided into ‘zones of similar vine performance’ for improved management
- Spatial data can provide information with great accuracy and at high resolution
- Mapping of individual points within a vineyard can be used to quantify issues and/or identify trends.

**Benefits of Employing Precision Viticulture:**

- Ability to quantify variability
- Accountability and improved return on inputs
- Sustainable and informed management
- Increased profit.

**Getting Started:**

- Make a plan. Adoption of Precision Viticulture can take time and resources, as well as commitment. It is good to know what your business goals and challenges are, so that Precision Viticulture can be used to strategically address these.
- Know where you are. A solid starting point for Precision Viticulture is to get an accurately mapped digital ‘Block Boundary’. Local Precision Agriculture contractors can provide this cheaply, but ensure they use a consistent methodology for mapping all blocks i.e. survey the boundary by locating end/corner–posts, drive an off–set perimeter, etc. Alternatively, it may be easy and cost-effective to hire a differential Global Positioning System (GPS).
- Talk to neighbours, local Precision Viticulture providers and extension organisations (such as SPAA – Society of Precision Agriculture Australia). With Precision Viticulture techniques being applied more and more, also find inspiration from examples in your region!

**What to Measure:**

- **Soil** – This is the primary driver of variability in most, if not all agronomic systems. Electromagnetic Induction (EMI) and in particular ‘EM38’ is the most common method of mapping soil variation across blocks. The mapping is performed by a sensor which measures soil conductivity in conjunction with a GPS input, to deliver a map showing variation in soil properties. Trends in electrical conductivity are then tested (termed ‘ground truthing’) using conventional, but targeted, soil sampling either by digging pits or taking soil cores. The key difference to traditional gridded soil sampling is that soil variation is identified before sampling takes place, thereby reducing the overall sampling requirement.
• **Canopy** – Are vines reflecting the soil variability identified in the EM38 mapping? To answer this question, sensors measuring reflectance data can be utilised. The reflectance data is generally portrayed as either Plant Cell Density (PCD) or Normalized Difference Vegetation Index (NDVI) imagery.

• **Crop yield and fruit quality** – What impact are the combined attributes of soil, canopy and microclimate having on final yield and fruit quality? Knowledge of vineyard zones can help target maturity sampling, while yield mapping can provide an accurate spatial assessment of seasonal crop yield.

• **Points of Interest** – Recording the location of many individual observations can be used to observe trends over time or improve management efficiency (i.e. identification of the location and number of broken posts or dripper blowouts in a block).

• **Vine based measures** – Either for ground truthing of imagery or as a direct measure, it is still important to go out and feel the vines! Pruning weights, point quadrat, crop yield and measures of maturity are all important when applying Precision Viticulture.

### Mapping Soils

EM38 mapping can determine soil variability and characteristics in order to design an appropriate irrigation setup. Timing of a survey should target peak soil moisture (generally late winter), as this ensures consistency. For optimum efficiency while retaining adequate resolution, transects of a block at a spacing of approximately 10–15m are adequate. In existing vineyards, check that foliage wires haven’t been ‘dropped’ as these cause signal interference. Block boundary coordinates can be collected at the same time as carrying out a survey, along with other permanent features such as irrigation valves and the location of soil moisture sensors. Elevation data can also be acquired (provided that the differential GPS unit is used), thereby allowing a Digital Elevation Model (DEM) (i.e topographical map) to be produced.

### Remote and Proximal Sensing:

In established vineyards, reflectance data (from which PCD or NDVI maps are derived) can be either acquired remotely using platforms such as satellites and aircraft or proximally using on-the-ground sensors attached to vehicles. The data should be acquired at veraison and provides a ‘layer’ of information associated with vine size and health.

Healthy vigorous vines provide higher values of PCD and NDVI based on strong near infrared reflectance and very low red reflectance on account of plant chlorophyll absorption.

Being a ratio, values for reflectance data will always be a number between 0 and 1 and this is important for understanding sensor outputs, along with identifying opportunities for their application. The observed value for either index is dictated by the amount of biosynthetically active biomass as it relates to canopy size and health and therefore, PCD or NDVI are essentially the same. However, trial work has shown better correlation of PCD to pruning weight in VSP systems, while NDVI outperforms PCD in correlation of fruit anthocyanins and vine vigour in sprawled, single wire systems.

Differences in PCD or NDVI values may highlight the need to modify irrigation management to account for differences in vine performance.

### Ground Truthing and Establishing Zones

Maps showing layers of spatial information such as block boundaries, DEM, EM38 soil conductivity and reflectance data, can be provided in a
variety of digital formats compatible with most Geographical Information System (GIS) platforms. Importantly, these can now easily be taken into the field on mobile devices in order to locate oneself in the vineyard relative to captured data. Identifying zones and measuring observing the characteristics of variability is called ground truthing.

Ground truthing the data is important and is usually done visually, sometimes in conjunction with vine measures of vigour. Apps such as ‘LAI Canopy’ developed by the University of Adelaide offer a means for rapid, consistent ground truthing and may provide opportunity for calibrating PCD and NDVI imagery, especially for sprawled canopies.

Ground truthing areas of varying soil conductivity, as established from EM38 soil mapping, is done by sampling with two to three soil cores from each area. Characteristics such as depth of soil profile should be manually recorded for each location, as these may show correlation with electrical conductivity. A map of these features can then be produced in addition to maps of soil chemical and physical properties. Further ground truthing in addition to the initial soil sampling can identify how vines are responding to certain soil properties. Depending on the variability in soil characteristics and vine response to this variation, it may be possible to identify zones for differential management.

**Global Positioning System (GPS)**

In order to accurately carry out soil surveys, locate field boundaries, soil pits, individual vines and a range of other ‘point’ data, it is necessary to use a differential GPS to achieve sub 1 metre accuracy. Ideally the GPS will be able to function in conjunction with mobile GIS technology so that the spatial data can be loaded for viewing. Much like navigation software on most mobile phones, proprietary software or one of any number of available apps can be downloaded onto phones/tablets to provide this functionality. The size of a zone being assessed and the importance of being able to identify an individual vine, will determine the accuracy of the positional system employed. In some instances the GPS in a smart device (phone or tablet) may be adequate.

**Consideration of Management Options:**

Having used Precision Viticulture techniques to accurately measure aspects of a property or existing vineyard, the next step is to consider the information gained with respect to management options. The example below reflects opportunities to manage water resources in response to variation in soil properties.

- An irrigation system design may be able to include separate valve sections to allow for different amounts of water to be applied to different soil types. Alternatively, it may be possible to use in-line taps that can be turned on and off as required or it may be possible to bypass sections of the vineyard or add in additional drip line.
- Drip line with variable rate emitters is now available which allows vines to be differentially irrigated according to soil water holding capacity. Similarly, it is possible to obtain drip line with variable emitter spacing.
- Mulching of zones with low water holding capacity will help to conserve water through reduced evaporation. This should result in increased uniformity in vine performance across the vineyard.
- Variable rate pruning in order to adjust bud numbers on vines will ensure that vine balance is appropriate for the soil type and availability of water.

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**Management Options:**

- **A** Valve sections designed to soil type and established management zones
- **B** Drip line duplication
- **C** In line taps
- **D** Variable rate dripper output or spacing
- **E** Variable rate pruning or mulching to match or improve vine potential relative to soil.

**Key:**

- Drip line
- Valve

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*In this representation of a vineyard with two ‘zones’ determined from soil data, the management options listed are all possible!*
Watch for the future
Canopy Temperature for Irrigation Management

Most grape growers would have at some time felt a leaf for its temperature in order to determine whether irrigation is required. This is a good example of a plant-based observation which can now be measured by a sensor and related to irrigation requirements. Infrared thermal camera systems are now commercially available, however, there are still issues to be overcome before thermal imagery can be used for irrigation scheduling reliably.

Subsequently, while a simple ratio of leaf to air temperature can be useful, potentially the best measure of vine water stress is stomatal opening. This can be estimated using four environmental measurements: Leaf Temperature (Tl), Air Temperature (Ta), Vapour Pressure Deficit (VPD) and Dry Reference Temperature (Tdry).

Everard Edwards, CSIRO Agriculture Research Team Leader, Glen Osmond explains how these may be acquired and applied for irrigation management:

"An on-site weather station can provide Ta and relative humidity (from which VPD can be calculated), leaving only Tdry, in addition to Tl of course. Tdry should have similar properties to a leaf and a static, logging, sensor system incorporating an infra-red temperature sensor and a suitable dry reference has been developed by the High-Resolution Plant Phenomics Centre at CSIRO in Canberra. The system is aimed at researchers, but could be employed by growers. However, even with accurate, broad-scale estimates of leaf stomatal opening, a specific irrigation management strategy would still require interpretation of the data by the grower in the context of their own vineyard and fruit composition targets."

Direct plant based measures have great potential in the future irrigation management toolkit.

Information within this document includes summaries of information presented as part of the SPAA Coonawarra Precision Viticulture Grower Group sessions and as documented in:


Smart, R., Robinson, M., ‘Sunlight into Wine; A Handbook for Wine Grape Canopy Arrangement” (1991)

Further information can be found at:
www.spaa.com.au

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