Frost assessment

and protection feasibility

at

Peregrine Wines

Bendigo Vineyard

Climate Consulting

April 2019

disclaimer

Climate Consulting Ltd has performed all data collection and analysis to the best of its ability. However as the climatic variables measured are unpredictable at times, Climate consulting Ltd cannot be held liable if the findings and recommendations enclosed in this report do not hold true in all situations.

Any recommendations made in this report pertain to the specific site investigated only.

Climate Consulting Ltd is not liable to any third party affected in any way by the contents of this report.

executive summary

This report presents results and recommendations from an investigation into frost risk and mitigation at a proposed vineyard for Peregrine Wines at Bendigo, Central Otago. Surface meteorological observations have been analysed from two climate towers and a network of remote temperature data loggers for eight observation periods during March and April 2019.

Analysis has revealed a modest spatial minimum temperature variation of 1.6°C across the study area. This will contribute to an increased risk of frost to cooler areas on many occasions. The vineyard has been categorised with a high to very high frost risk, and frost will extend across all areas of the property during cooler outbreaks in spring and autumn.

Inversion strengths above the vineyard are rated as good. While wind machines have been suggested as an effective method of frost mitigation, their efficacy will be reduced while operating in weaker inversion conditions and when near-surface temperature falls below -2°C. The final section of the report provides idealised configurations for six and eight wind machines respectively. The eight wind machine configuration is recommended as it will extend frost mitigation across a greater area of vineyard to lower temperatures.

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1.0 introduction

1.1 Aim and Objectives of the Report

The aim of this report is to interpret microclimatic information that is used to quantify the relative frost risk and determine the most effective method of frost mitigation at a proposed Bendigo vineyard for Peregrine Wines. The report draws conclusions from near-surface temperature and wind observations obtained during clear settled weather, typical of radiation frost events in spring.

Prior to initiation of the investigation the following site specific objectives were identified;

1. To quantify the relative frost risk over the proposed vineyard area
2. Determine the necessity and subsequent placement of wind machines as a method of frost mitigation

1.2 Physical Setting

The proposed 39 ha development encompasses an elongated area of predominantly flat land approximately 18 kilometres north-east of Cromwell, Central Otago. The property is accessed from Loop Line Road, a few hundred metres off State Highway 8 (Figure 1). The property is bound by an existing vineyard along the western periphery and there are numerous vineyard developments within the immediate area. An old river terrace follows the eastern boundary and wraps around much of the proposed vineyard area, ranging in height from 5 – 15 m. Mature Pines follow part of the property boundary with Loop Line Road and a line of fragmented Pines run centrally east / west across the block dividing the proposed vineyard area into halves. Mean elevation of the property is 225 m above sea level.

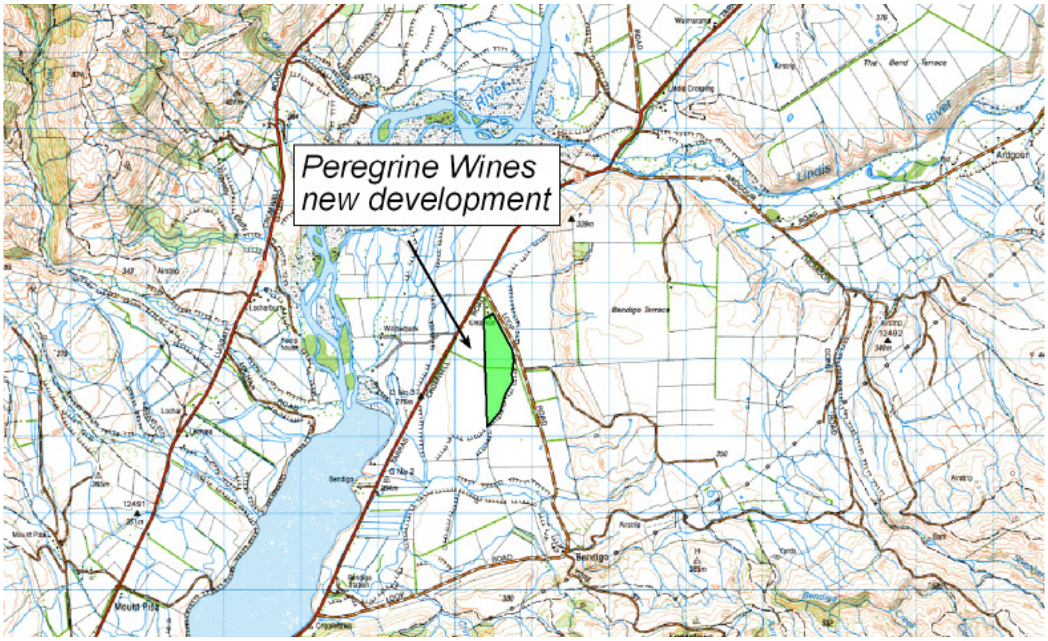

Figure 1 *NZS260 series topographic map showing location of a proposed vineyard development for Peregrine Wines, Loop Line Road, Bendigo.*

1.3 Useful terms and Definitions

The following section may provide useful definitions of key words and processes that are used through following sections of the report.

An **inversion** forms as a result of strong radiational cooling at the ground surface at night. The process is most intense when weather conditions are clear and surface winds are absent or very light. During these times, the air closest to the ground cools at a faster rate relative to air at higher elevations, and so a temperature difference develops between vine height and the free atmosphere. The overnight inversion strength is in a constant state of flux, and governed largely by a handful of local physical parameters which are part of a much larger, dynamic atmospheric boundary layer system. Inversion strengths are the product of atmospheric moisture content, amount and height of cloud cover, atmospheric stability, local topography and near-surface wind velocities. The vertical temperature profile of an inversion suggests that most of the temperature difference will occur within the first eight to ten metres above the ground, with the warming trend decreasing with height. Identification of near-surface inversion conditions during frost events are essential for the successful implementation of some frost protection measures.

Drainage winds or **'katabatic drift'** is a term used to describe a gravity induced flow of cold air that flows down a slope in response to radiational cooling of the ground. As the air closest to a sloping surface cools more quickly than air at the same height further away from the slope, the cooler air is pulled down slope by gravity and is observed on the valley floor as a cool breeze. At great distances from the coast, the cooler dense air continues to move down slope until it has merged with a layer of air of similar density (temperature) and eventually forms a pool of cold air. In New Zealand, the extensive network of river valleys drains the cold air across areas of flatter topography and often out toward the coasts. The directions of katabatic winds are governed primarily by the alignment of local topography, and are consistent from one frost event to the next. In this respect, katabatic wind direction has a great influence over the placement and coverage of frost mitigation.

When atmospheric pressure gradients are weak winds may '**decouple**' (detached from the surface) after sunset. If conditions remain settled overnight, the formation of a nocturnal boundary layer may include an inversion layer and katabatic drift. However, in some cases the interaction of synoptic winds with terrain at higher elevations can interfere with the development of local katabatic drift. These conditions can lead to a **transition zone** near the surface, where a complete absence of wind is often accompanied by a sharp decrease in temperature. If atmospheric conditions are cool a transition period result in unexpected frost.

2.0 field techniques & equipment

2.1 Instrumentation

Temperatures in the vertical field are measured using Harvest Electronics temperature sensors. These sensors have a claimed accuracy of 0.16°C between 0 - 50°C with response time of less than 2 minutes in flowing air at 2 metres per second. Sensors are mounted on the mast at heights of 1 m and 15 m to decipher inversion strengths.

Wind speed and direction are recorded using the Novalynx 200–WS-02F sensor. Accuracy of the wind sensors are ± 0.5 metres per second (ms^{-1}) with starting thresholds of no greater than 0.5 (ms^{-1}). In this respect the instruments ideal for monitoring very light wind conditions.

The temperature and wind data are transmitted using GPRS and HSDPA technology through a Motorola G24 or H24 cellular module. The internal data logger has been designed by Harvest Electronics and is controlled by a Texas Instruments, low power MSP430 microprocessor. The logger and modem are of industrial standard and widely used across most New Zealand Meteorological Service and National Institute of Water and Atmospheric research (NIWA) Automated Weather Stations (AWS).

Remote temperatures were recorded using Onset hobo "Pro temp V2" loggers with. The Onset Pro temps have a claimed accuracy of 0.2°C between 0 - 40°C. Each logger was mounted at a height of 1.2 meters above the ground and housed in a solar radiation shield to protect the sensor from the effects of sunlight, rain and nocturnal terrestrial long wave radiation.

2.2 Placement of Instrumentation

The site-specific objectives identified at the outset of this investigation influenced the placement of instrumentation around the existing and proposed vineyard areas in Figure 2.

Two climate towers were installed, one on each half of the proposed development. Tower 1 was located amongst the southern half of the block and Tower 2 further north and closer to the old river terrace. The Towers measured temperature at 1 and 15 metres, together with wind speed and direction at a height of 8 m. This Information is used to confirm katabatic drift direction as this is a crucial factor in the precision placement of wind machines. Climate towers were supplemented with 27 remote loggers that collected 5 minute near-surface temperature data from the proposed vineyard area.

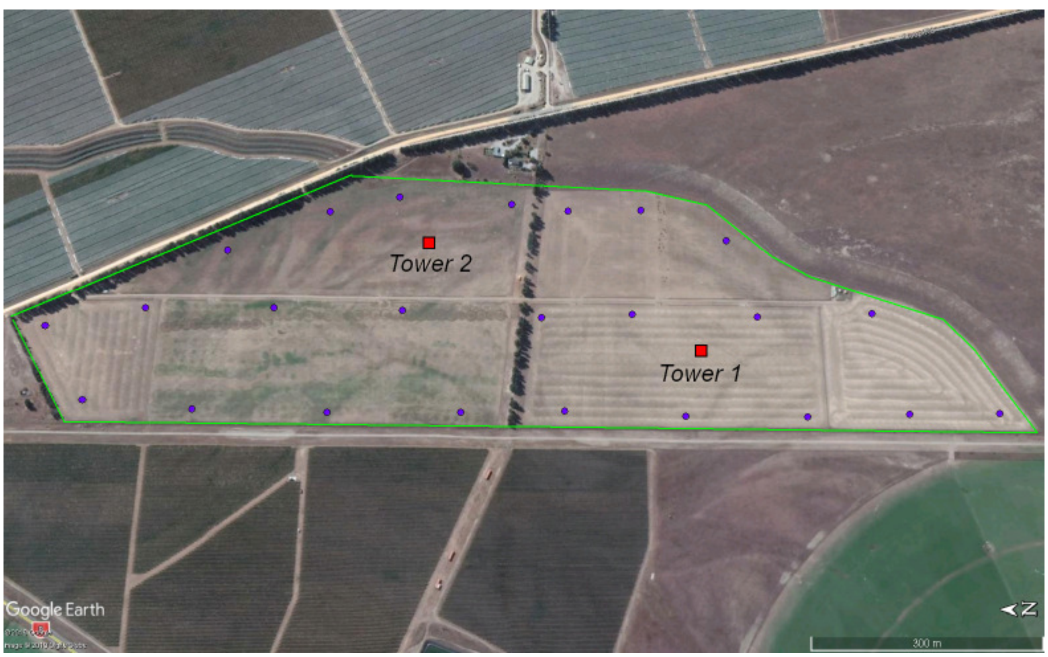

Figure 2 *Instrumentation deployment across the study area. Climate towers are represented by the red squares and the remote data loggers by small purple dots.*

3.0 data collection

3.1 Special Observation Periods (SOPs)

Data was collected for a period of 34 days from the 7th March – 10th April 2019. In this time a number of nights provided suitable weather for the purpose of the study, although analysis has focussed on eight Special Observation Periods (SOP's) when overnight cooling processes became well established during frost conditions.

The requirements for a SOP are predominantly clear skies and light near-surface winds. These conditions allow near-surface boundary layer processes associated with radiative cooling to become established. These processes are repeated during subsequent radiational cooling conditions which includes spring frosts. The information can be used to optimally locate frost protection.

Special observation periods included the following nights:

SOP1	14 – 15 March
SOP 2	27 – 28 March
SOP 3	28 – 29 March
SOP 4	1 – 2 April
SOP 5	2 – 3 April
SOP 6	5 – 6 April
SOP 7	6 – 7 April
SOP 8	7 – 8 April

Data was collected during settled anticyclone conditions that followed several cool southerly outbreaks. Frost was recorded on the last 4 SOP's (5 – 8) and remaining observation periods each recorded minimum temperature below +2.5°C. The lowest air temperature of -4.8°C was recorded by two data loggers on the morning of April 7th (SOP 7). This temperature fell 0.1°C short of exceeding the 14 year April temperature records from Cromwell EWS.

4.0 results & interpretation

4.1 Inversion characteristics

Inversion strengths are calculated by subtracting the temperature at the bottom of the tower (1.0m) from the elevated temperature at the top of the tower (15m) for each five-minute sample of temperature. As a "general" guide inversion strengths of less than 2°C within the first 15m above ground offer conservative benefits when engaged for frost protection. Inversion strengths of 2.5 - 3.5°C provide more consistent protection, whilst inversion strengths of 4°C or greater are of significant value.

Average inversion strengths are obtained from the data once a steady state or "mature" nocturnal boundary layer has developed. This usually occurs after the onset of katabatic drift winds. At times the inversion strengths appear stronger than calculated averages however, these occasions are often prior to the predictable onset of drift winds or when drift winds are partially or completely cancelled. While temperatures usually decrease at a reduced rate after the onset of katabatic drifts, it is important to analyse inversion strengths closely during the coldest time of the night, usually just before sunrise, to help determine the success of mechanically mixing air by either wind machines or helicopters.

Inversion development was monitored continuously by the climate towers and results are summarised for the eight observation periods by time-series plots in Figures 3a and Figure 3b. The following two graphs not only provide an indication of wind machine efficacy, but an opportunity to observe local climatic phenomenon that might impede or reduce inversion strength on some occasions.

The average inversion strengths for near-surface temperatures below +2°C are classified as "Good", with 2.4°C at Tower 1 and 2.5°C at Tower 2. There is however, considerable variability of inversion strength over the course of a single night and between SOP's. Inversion development is affected by many factors, such as katabatic drift speed, the presence of cloud, moisture on or near the surface, the relative contribution of air from nearby tributary gullies and atmospheric stability.

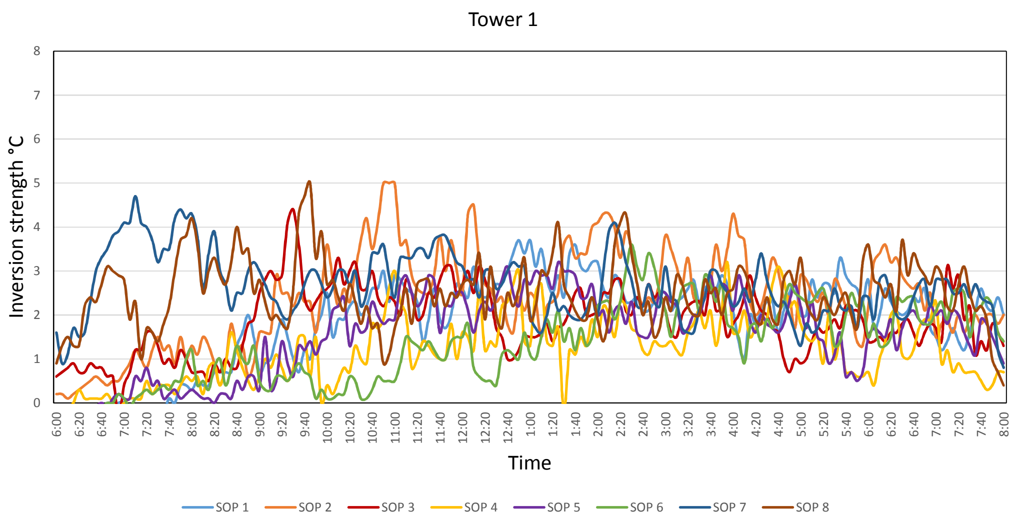

Figure 3a *Inversion strengths at Climate Tower 1. An average strength of 2.4°C was observed during settled weather and when near-surface temperature is <2°C.*

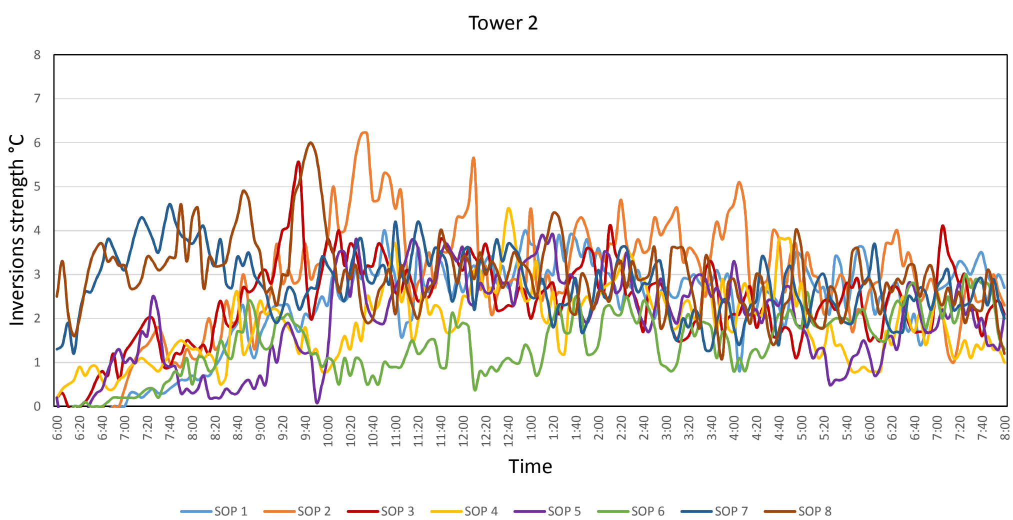

Figure 3b *Inversion strengths recorded at Climate Tower 2 for near-surface temperature < 2°C. The average strength is very similar at 2.5°C.*

Both time-series plots of inversion strength reveal a slight convex curve in the general signature, in other words, inversions appear strongest about midnight, and then show a gradual reduction in strength toward dawn. In some cases this trend will flag cold air damming or ponding in the study area, as the layer of cold air near the surface builds under stable conditions pushing warmer air layers higher above the property. This phenomenon reduces the observed inversion strength at our recording height of 15 m. However, the inversion signature may also reflect a change in near-surface wind drift speed or direction. To examine the inversion signature further, SOP 4 presents a typical radiative overnight cooling scenario and data from this night is presented in Figure 4.

The time-series plot of inversion development for SOP 4 reveals good inversion development (apart from one or two intermittent spikes) until about 4:30am. From this time the rate of near-surface cooling appears to reduce while inversion temperature (15 m) continues to cool at a linear rate for a further 2 hours. This phenomenon is in fact characteristic of some cold air build-up or "filling" of the general Bendigo region. Cold air from the extensive mountainous terrain is draining and collecting in lower-lying areas of the regions complex terrain and this is likely to reduce inversion strength on a fairly regular basis. It is likely to form part of the regions nocturnal climatology.

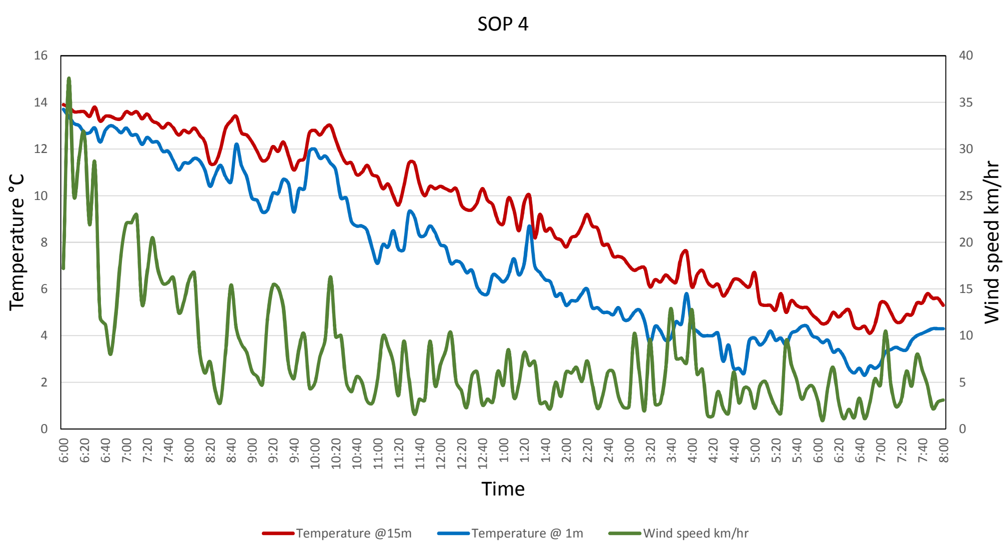

Figure 4 *A time-series plot of Inversion development for SOP 4. Strongest inversion conditions occur between midnight and 4am, followed by a reduction toward dawn. This is characteristic of cold air filling basin-type topography.*

SOP 7 presented an interesting opportunity to observe near-surface temperature at the extreme cold end of the April spectrum. In Figure 5, the projected assistance of wind machines to raise near-surface temperature are indicated on the time-series graph by the orange dashed line. This line represents two thirds of the instantaneous inversion strength (at tower 2) added to the near-surface temperature. This temperature projection embodies a sound approximation for temperature within a vineyard environment had wind machines been installed. Clearly near-surface temperature within the hypothetical vineyard still fall below zero, but the time and severity of sub-zero conditions are reduced. There is anecdotal evidence for additional cumulative effects of multiple wind machines operating adjacent to one another. The result is believed to reflect increased local turbulent mixing of warmer air above the surface, as well as overlap of some wind machine warming footprints at the surface.

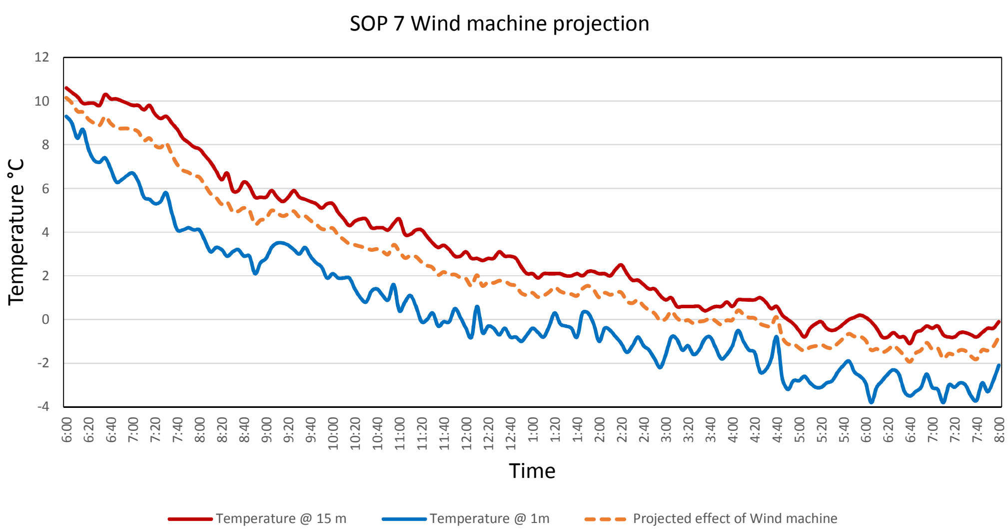

Figure 5 *A time-series plot of Inversion development for the coolest overnight period SOP 7. The projected influence of wind machines to near-surface temperature could be assumed by the orange dashed line. The time and severity of the frost is reduced.*

In Figure 6 inversion strength has been regressed with near-surface temperature for all logged temperature values below +2°C. This scatter plot is useful to clarify whether inversion strength changes as a function of near-surface temperature. In this case there is no clear association. Inversion strength remains relatively constant as near-surface temperature decreases below zero.

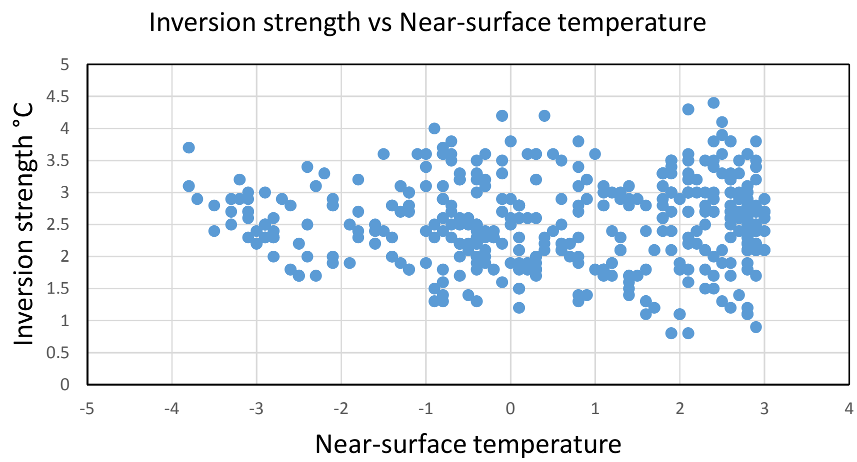

Figure 6 *Regression plot of inversion strength and near-surface temperature for all logged data below +2°C. The plot does not reveal any clear association.*

4.2 Katabatic Drift

Wind measurements were monitored continuously so that katabatic drift could be determined during each radiational cooling event. The onset of katabatic drift is defined by an instantaneous change in mean wind direction from a pressure driven (synoptic) wind, to a wind reflecting drainage of colder air from the most dominant hydrological catchment. Katabatic drifts are easily discernable from wind generated from other forces overnight as the breeze velocity and directions remain constant. They are also predominantly generated during clear, settled weather.

Drift winds that move down sloping topography are often channelled into rills and waterways. As the confinement of these channels reduce, the cool dense air may spread and meander across flatter landscapes and eventually merge with pockets of air of similar density forming large cold pools. Small catchment areas and mountain ranges close to a study site initially have the greatest influence over the speed and direction of drift winds. Mountain ranges a greater distance away may have an effect later in the night, when radiational cooling processes have become well established. When local topography is complex, katabatic drifts become increasingly variable, but they are still measureable. Drift information is used for the optimal positioning of frost protection such as wind machines.

The wind rose plots in Figures 7a and 7b illustrate the 5 minute averaged speed and direction of katabatic drift recorded at the climate towers for near-surface temperatures below +2°C. Wind drift direction is indicated by the orientation of the wind barbs, while the average direction is determined by the narrow red line.

Wind data from both towers has revealed a predominantly east-north-easterly (72°) katabatic drift, although each plot reveals considerable meander. Katabatic drift forms readily within the complex terrain surrounding Bendigo, and the resultant direction at the vineyard site reflects many tributary drainage catchments. While the origin of the katabatic drift is not clear, it may form part of a more significant current emanating the Lindis River that eventually spills over the Bendigo plateau before moving across the Peregrine Vineyard site.

Mean drift wind speed was marginally higher at Tower 1 at 2.8 km/hr, whilst Tower 2 recorded 2.7 km/hr. Mean wind drift speeds did not exceeded 10 km/hr at either tower while near-surface temperature was below +2°C. Calm conditions (mean wind speed less than 1.0 km/hr) were observed 8% of the time at both towers. The 10 km/hr mean wind speed criteria is important as some wind machine brands are programmed to shut down at higher speeds, while in near-calm conditions wind machines elliptical warming footprints become more circular.

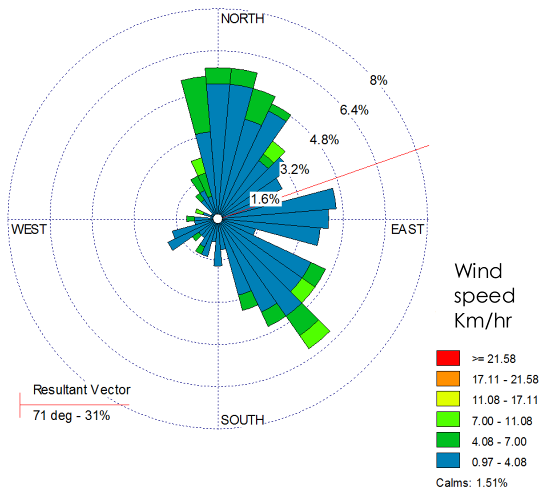

Figure 7a *Katabatic drift speed and direction recorded at climate tower 1. Drift direction was predominantly east-north-easterly (71°). There is an extensive contribution of drift wind from a wide range of other wind directions.*

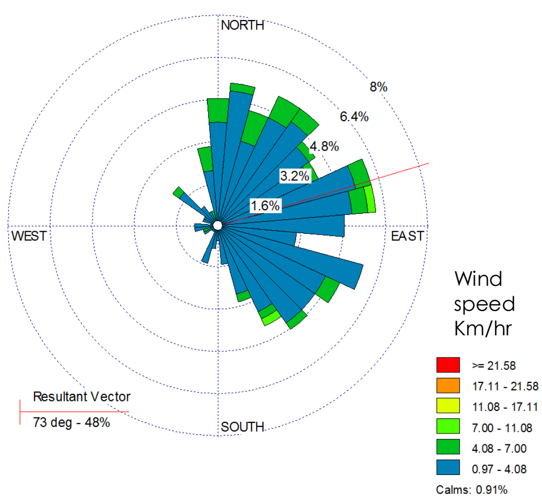

Figure 7b *Katabatic drift speed and direction recorded at climate tower 2. Drift direction was again predominantly east-north-easterly (73°). There is a further contribution of drift wind from a wide range of other wind directions.*

Figure 8 presents a larger schematic of drift winds around the Bedford Road Vineyard. Katabatic drifts are indicated by the blue arrows. Drift winds are confined by steep-sided valley walls to blow down the Wairau Valley.

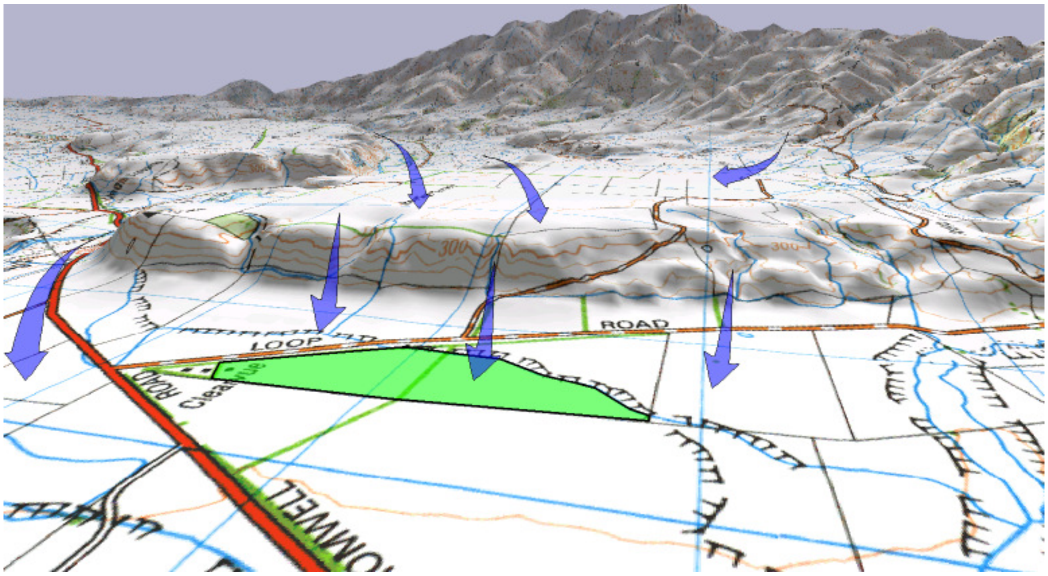

Figure 8 *Drift winds were recorded from the east-north-east. These winds may have origin within the Lindis River Catchment and spill over the Bendigo Plateau before affecting the proposed vineyard location.*

4.3 Spatial variation of near-surface temperatures

The deployment of remote temperature data loggers provides information on the spatial variation of minimum temperatures. Near-surface temperatures have been shown to form repetitive patterns under clear settled conditions. The near-surface minimum temperature maps are a useful way to confirm existing ideas regarding frost risk and may also be used as a guide to placement of frost protection. Cooler temperatures are associated with higher frost risk and have a blue shading on the maps while warmer areas are coloured orange.

In Figure 9 the spatial variation of minimum temperature indicates a mean 1.6°C variation between the coolest and warmest areas of the proposed vineyard. Coolest temperatures were found to occupy the northern half of the property, especially areas nearest the western headland with an existing vineyard. The cooler temperatures extend eastward across a significant area of the northern half of the property.

Warmer temperatures were observed in areas closest to the old river terrace that wraps around the eastern side of the property. The reduced frost risk is often associated with increased mean wind speed but this is unlikely to be the case here. While there could be increased turbulent mixing from air moving off the Bendigo Plateau, areas at the foot of the escarpment also have a diminished view of the sky which is known to reduce long-wave cooling of air closest to the surface.

Even though the temperature map indicates the expected variation of actual minimum temperatures during frost, the *temporal* variation (the timing of the minimum temperature) may reveal a different pattern. Future frost monitoring may demonstrate that the time of coolest temperature varies at different locations around the property, and the amount of time an area stays below zero is not necessarily a function of actual minimum temperature.

All areas of the proposed vineyard have been classified as having a high to very high frost risk. High frost risk zones could expect to observe several spring and autumn frost events most seasons.

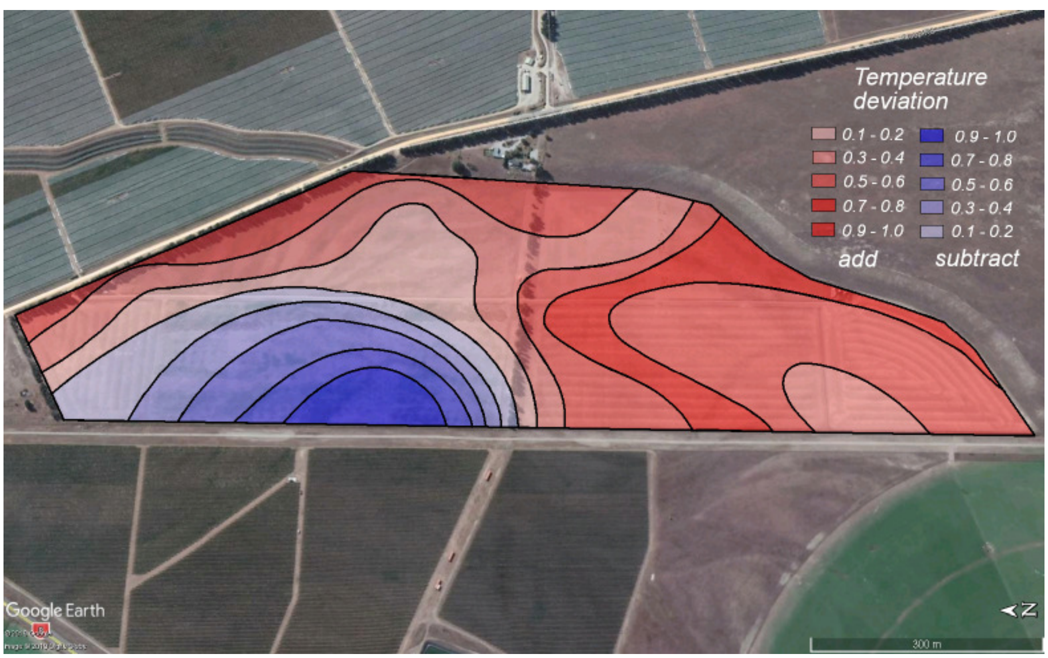

Figure 9 *Spatial variation of near-surface temperature across the proposed Peregrine Vineyard. Despite areas of warmer temperatures, frost risk has been categorised as high to very high across the development.*

In Figure 10 minimum near-surface minimum temperature has been compared between the location of climate Tower 1 and Cromwell Electronic Weather Station (EWS) for twelve clear settled nights. The mean minimum temperature at the proposed vineyard site was 1.1°C cooler across these events. Although there is some variance between specific nights, the Bendigo property is almost consistently cooler. Despite the short data comparison period this information will be useful for planning vineyard operations using local frost forecast information.

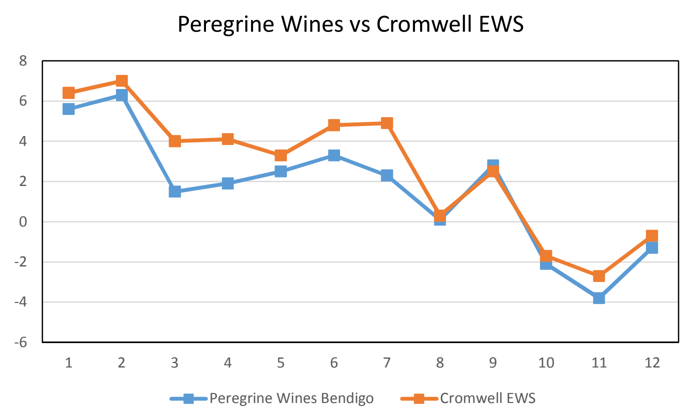

Figure 10 *A comparison of near-surface minimum temperature between the Tower 1 location and Cromwell EWS for twelve clear settled nights during March and April 2019. Minimum near-surface temperature was 1.1°C cooler at the Bendigo location.*

Table 1 provides a projection of frost across the proposed vineyard. The data has been amassed from Cromwell EWS using 14 continuous years of temperature data. The mean monthly minimum temperature could be expected to occur most months, whilst the extreme temperature is the coldest recorded in the past 14 years. Interestingly, historical data suggests April poses the greatest risk of coldest temperatures.

Table 1 *Mean monthly and extreme event minima for the proposed vineyard site.*

Month	***Ave Monthly low***	***Extreme event***
March	0.5	-1.0
April	-2.5	-3.9
October	-1.3	-3.3
November	0.3	-1.3

5.0 discussion and recommendations

As mentioned, frost risk over all the proposed vineyard area is high to very high. The map showing temperature deviation around the property (Figure 9) is relative only to the investigative area, so the risk of frost will extend across all perceived lower-risk areas through cooler outbreaks in spring and autumn.

Inversion strengths over the proposed vineyard are traditionally satisfactory for the installation wind machines as a method of frost mitigation, however, their limitations must be realised while working under weaker inversion conditions or in near-surface temperature lower than -2.0°C. In cooler temperatures the area of effective protection under each machine will quickly reduce. (The protection area is a function of the instantaneous inversion strength and severity of frost).

There is strong anecdotal evidence in support of tightening wind machine spacing in cooler areas to achieve improved mitigation. In this manner wind machines are positioned so that projected warming footprints provide some or considerable overlap. A greater number of wind machines in a confined area is believed to increase turbulent mixing from within the inversion layer to vineyard canopy height.

With this in mind, two possible configurations for wind machines are illustrated in Figures 11a and 11b. The size of warming footprints indicated assume a 6.5 ha warming footprint under good inversion conditions using a 4-blade machine design. The orientation of the wind machines cannot be changed as this is governed by the predominant katabatic drift direction.

In Figure 11a six wind machines provide mitigation to approximately 90% of the proposed vineyard area. In this configuration the coolest area of the development receives little or no air movement from wind machines. The coolest area of the proposed vineyard is beyond the warming capacity of wind machines even during modest frost events. This area of the development could be utilised in other ways, however, if the full potential of the development is to be realised then 8 wind machines would provide superior mitigation (Figure 11b).

Analysis of historical temperature data supports the installing of a greater number of wind machines. Data has shown that a mean monthly low temperature in April will result in a reduced warming footprint size. In these cooler events a 6-machine configuration will expose a significant area of the proposed vineyard to frost.

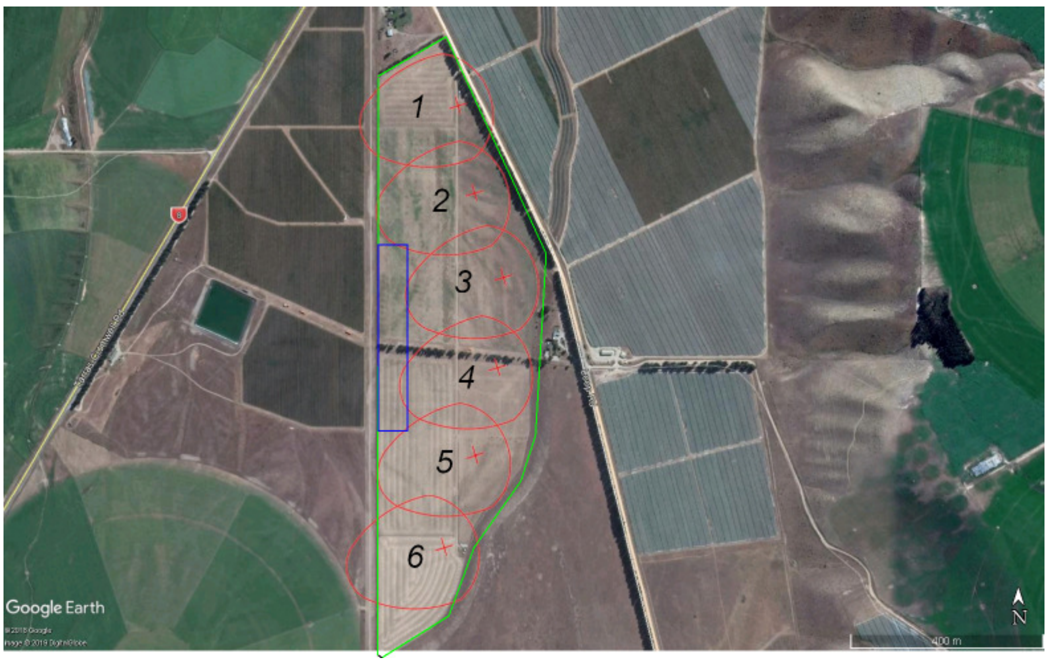

Figure 11a *Projected area of warming from 6 wind machines installed across the proposed Peregrine Vineyard. An area of development inside the blue rectangle receives little or no mitigation.*

Figure 11b *A comprehensive frost mitigation uses 8 wind machines. machines 7 and 8 provide significant overlap to machines 2 – 5, although a considerable portion of the warming footprint from machines 7 and 8 spill into the neighbouring vineyard.*

GPS coordinates for wind machines will be provided following a decision on final wind machine numbers and block design.

While the success behind a wind machine is traditionally ascribed to favourable inversion conditions, the warmer air brought down onto a crop is now believed to account for about half of the frost protection. It is equally important that a wind machine has the ability to dry the surface of crop before temperatures fall below freezing. In other words, the momentum of air flow forced through the crop is just as important as a lift in temperature from an inversion. The amount of airflow through a vineyard can be increased by tightening the spacing between wind machines to ensure overlap of warming footprints between adjacent machines, and aligning vineyard rows to facilitate air movement from a wind machine down the row. Forcing dryer air from aloft through the vineyard prior to frost conditions reduces dew formation on surfaces of leafs and vines, and when a dryer leaf surface falls below zero apparent frost damage is reduced when compared to a wet-freeze situation. Ultimately the level of frost protection provided by a wind machine will be a function of near-surface temperature, inversion conditions on the night, near-surface wind speed, correct machine positioning and timeliness of machine operation.

Initiation of frost protection should be made in accordance with local knowledge and area specific frost forecasts. Wind machines are normally automated to commence operation before temperatures fall to zero degrees, most usually start at air temperatures of +0.5°C. If wind machine temperature probes remain unshielded, then machine start-up temperatures should be programmed (at the machine) to commence at temperatures closer to zero degrees. Higher start-up temperatures generally waste fuel and annoy neighbours.

NEW ZEALAND WINE
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Viticulture Gross Margin Report

Central Otago | **2019**

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Variety Gross Margin Benchmarking

Central Otago I **2019**

In collaboration with

Ministry for Primary Industries
Manatū Ahu Matua

If you have any questions relating to or for further information on the model please contact:

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Gross Margin Definition:
The gross margin in this report provides an indication of Pinot Noir profitability per producing hectare in Central Otago. It is calculated by subtracting operating costs [labour and other direct expenses] from gross revenue. The gross margin varies annually based on prevailing market and climatic conditions.

New Zealand Winegrowers and the Ministry for Primary Industries would like to express our thanks to contract and winery growers in June and July for their participation in our variety gross margin benchmarking programme.


Prophets
Central Otago

Key Parameters and Financial Results

Pinot Noir	2019	2018	2017
Total Production[1] (t/ha)	**7.0**	**7.3**	**4.0**
Average return ($/t)	**$4,220**	**$3,845**	**$3,985**
Grape income ($/ha)	**$29,360**	**$28,075**	**$16,105**
Vineyard direct expenses ($/ha)	**$18,040**	**$17,430**	**$13,770**
Gross Margin ($/ha)	$11,320	$10,645	$2,335
Gross Margin ($/t)	$1,625	$1,460	$580

[1] Figures may not add to totals due to rounding

Background

The MPI viticulture monitoring programme was reviewed in 2013 and the decision to develop gross margins of dominant grape varieties in the main growing regions was trialled for the 2015 season. The success of the trial has led to the continuation of the gross margin format and has also seen the expansion of the programme to Otago in 2017.

Ten vineyards provided data for a total of 14 blocks representing 243 hectares of a total 1,495 hectares in Pinot Noir in Central Otago. The majority of participants were winery growers, growing for the premium or super-premium market.

The gross margin calculates the revenue less direct expenses for growing, harvesting and marketing the crop. It does not take account of overheads such as administration, debt servicing, tax, drawings or development and capital spending.

Blocks in Survey

14

Key Points

Central Otago Pinot Noir achieved a gross margin of $11,320 per hectare, up six percent on 2018. This, despite an increase in labour expenses, was due to similar yields as 2018 combined with a reported increase in price within the survey group.

Average yields for the survey group were 7.0 tonnes per hectare, down slightly on the survey group from 2018.

Average price reported by this grower group was $4,220 per tonne, which is $495 higher than the 2018 industry average price for Pinot Noir.[1]

[1] New Zealand Winegrowers Average Grape Prices 2018 Final

Gross Margin

$11,320
per hectare

↑ from 2018

Production

7.0 tonnes
per hectare

Central Otago weather data

	Growing degree days[1] (GDD)			Rainfall (mm)		
Month	**2018[2]**	**2019**	**Long Term Average**	**2018**	**2019**	**Long Term Average**
June	0	0	2	22	7	29
July	0	0	1	28	31	26
August	12	0	5	16	6	18
September	43	17	28	18	45	25
October	122	79	66	6	31	34
November	221	106	131	36	94	34
December	286	225	215	9	38	30
January	375	271	254	47	54	43
February	173	207	221	97	15	42
March	161	216	170	49	55	28
April	54	29	60	64	50	29
May	10	9	12	33	50	46
Total	**1457**	**1157**	**1165**	**425**	**475**	**384**

[1] GDD – growing degree days. GDDs are a temperature index, calculated by taking the average of the daily high and low temperatures compared with a baseline (10^{C}). They help predict the date that a flower will bloom or a crop reach maturity.
[2] Year refers to year of harvest.
Source Niwa (Cromwell)

Pinot Noir Gross Margin

The Central Otago Pinot Noir gross margin was $11,320 per producing hectare, equal to $1,625 per tonne. This is $675 per hectare up on the 2018 survey group.

The 2018/19 growing season in Central Otago was extremely variable with frosts occurring in both Spring and Autumn but overall growing degree days were near average with above average summer rainfall.

Flowering was patchy across the district but overall better than average due to very warm 2017 flower initiation conditions. Powdery Mildew pressure was high through the December to early January period and growers are becoming increasingly vigilant for this disease.

Regular rainfall through January and particularly March increased berry size and improved yields for many growers compared to their earlier forecasts.

The gross margin shows an average yield of 7.0 tonnes per hectare for the survey group, similar to the group's 2018 yield of 7.3 tonnes per hectare. New Zealand Winegrowers reported Central Otago average[2] yields up 2 percent on 2018.

There was a range of yields, from 3.8 to 8.3 tonnes per hectare and prices from $3,700 to $4,400 per tonne, reflecting the high-end market most Central Otago growers are producing for.

Average price received for the survey blocks, at $4,220, was up $375 from the 2018 survey group. Comparing just those blocks that provided data in both years of the survey reports no change in prices from 2018 to 2019.

The reported price was also significantly higher than the 2019 New Zealand Winegrowers reported contract price of $3,734. The difference is due to the predominance of winery growers in this survey producing premium and super-premium fruit and placing a greater value on it than contract growers.

Using the New Zealand Winegrowers average Pinot Noir price and the gross margin survey expense data would generate a gross margin of $7,940 per hectare for 2019 and $9,770 for 2018.

Vineyard direct expenses were $18,040 in 2019 up 3 percent, primarily due to increased labour costs.

Central Otago labour expenses, $13,980 per hectare, up $650 per hectare. Wages were higher across all categories due to the increase in minimum wages in both 2018 (5 percent) and 2019 (7 percent).

Pruning costs were up $225 per hectare from the previous year and are expected to continue to rise in 2019.

None of the 14 blocks in this year's survey were machine harvested, with average hand harvesting cost $358 per tonne in 2019.

Working Expenses

$18,040
per hectare ↑ 3%

[2] Vintage Survey yield compared to Vineyard Register area

Vineyard Gross Margin Benchmarking

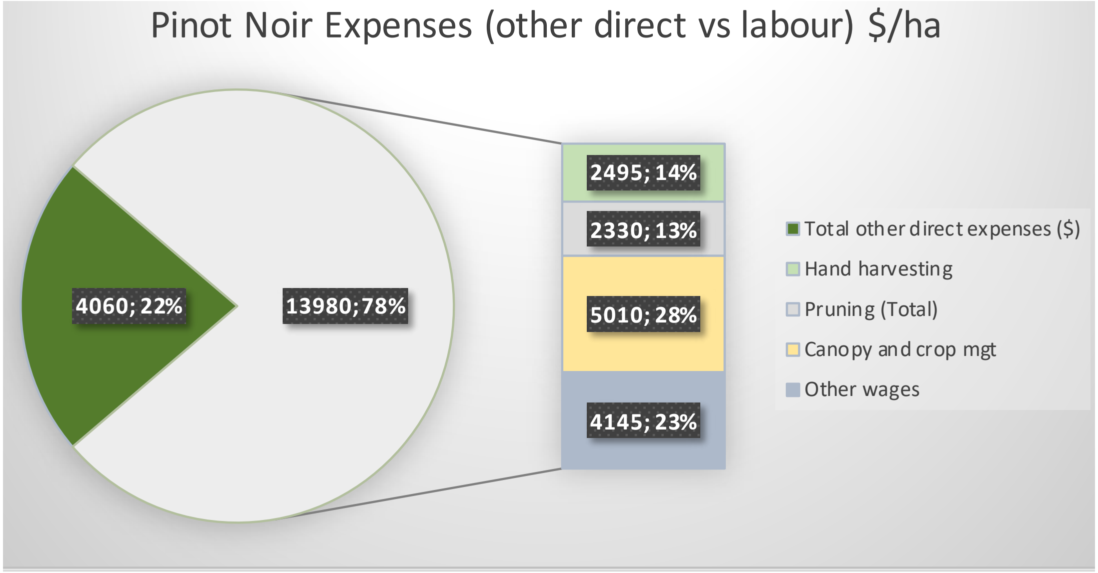
Region: Central Otago

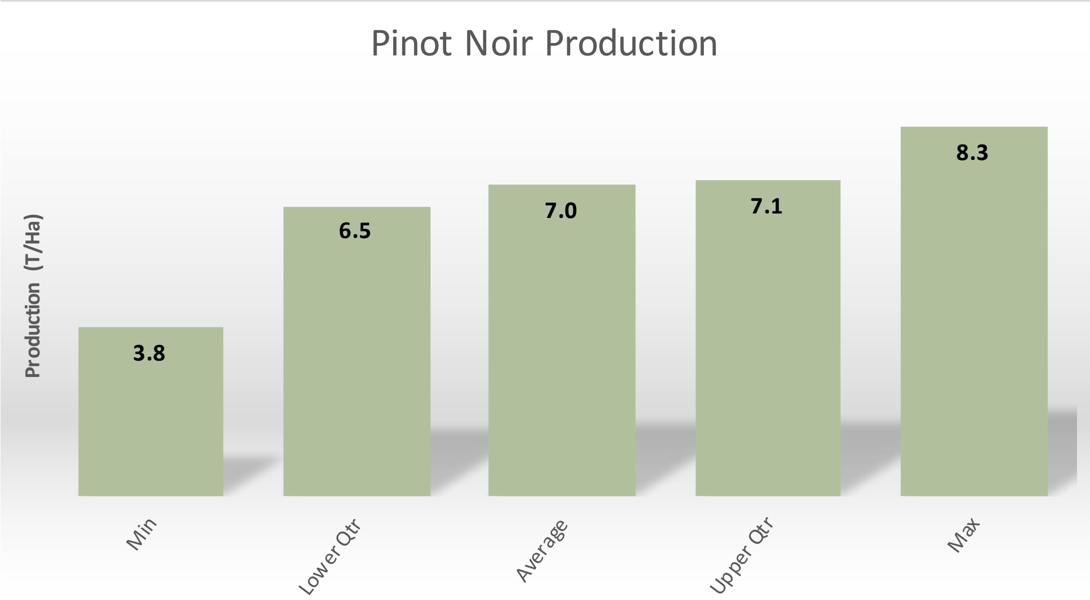
Year: 2019

Variety: Pinot Noir

Adjusted for unpaid labour			$ per producing ha			
	Average				Quartile by Gross Margin[1]	
	2019			2018		
	per Ha	per vine	per row metre	per Ha	Upper	Lower
Unpaid FTE - number	0.0			0.1		
Unpaid FTE - hours/ha	1			9		
Vines/ha	3,141			2,867	2,639	2,500
Row metres/ha	4,183			4,103		
Yield (Tonnes)	7.0	2.2kg	1.7kg	7.3	7.1	6.5
Income $/tonne	$4,220			$3,845	$3,780	$4,485
Income ($)	**$29,360**	**9.35**	**7.02**	**$28,075**	**$26,510**	**$27,645**
Labour expenses ($)						
Hand harvesting	$2,495	0.79	0.60	$2,460	$2,486	$2,717
Pruning (Total)	$2,330	0.74	0.56	$2,105	$1,794	$1,883
Canopy and crop mgt	$5,010	1.60	1.20	$4,800	$3,424	$4,799
Other wages	$4,145	1.32	0.99	$3,955	$3,686	$6,165
Total labour expenses	$13,980	4.45	3.34	$13,330	$11,390	$15,565
Other direct expenses ($)						
Weed and pest control	$522	0.17	0.12	$607	$341	$624
Fertiliser and lime	$239	0.08	0.06	$376	$115	$338
Electricity	$364	0.12	0.09	$255	$184	$428
Vehicle	$574	0.18	0.14	$448	$174	$1,409
Fuel	$615	0.20	0.15	$357	$210	$1,558
Repairs & maintenance	$774	0.25	0.19	$941	$430	$1,605
General	$969	0.31	0.23	$769	$38	$2,726
Machine harvesting	$0	0.00	0.00	$347	$0	$0
Total other direct expenses ($)	$4,060	1.29	0.97	$4,100	$1,490	$8,690
Total direct expenses ($)	$18,040	5.74	4.31	$17,430	$12,880	$24,255
Gross Margin ($/ha)	**$11,320**	**3.61**	**2.71**	**$10,645**	**$13,630**	**$3,390**
Gross Margin ($/t)	**$1,630**			**$1,460**	**$1,930**	**$525**
Number in model	14			35	14	14

[1] Quartile analysis shows the average figures where the gross margin is in the lower or upper quartile,
ie. an indication of the features of higher and lower performance


Pinot Noir Expenses (other direct vs labour) $/ha
4060; 22%
13980;78%
2495; 14%
2330; 13%
5010; 28%
4145; 23%
Total other direct expenses ($)
Hand harvesting
Pruning (Total)
Canopy and crop mgt
Other wages


Pinot Noir Production
Production (T/Ha)
3.8
6.5
7.0
7.1
8.3
Min
Lower Qtr
Average
Upper Qtr
Max

Industry Issues and Developments

Central Otago is a well-established wine growing region that has built a strong reputation for high quality Pinot Noir wine. Winery growers reported that this reputation, combined with strong distribution channels, are extremely important building blocks for their success. It is this reputation that has consistently allowed Pinot Noir grape prices to be the highest in New Zealand. Wineries also reported that they are experiencing good growth in demand from local and international markets.

The 2018/19 season experienced highly variable climatic conditions with frosts at both ends of the season and some warm wet periods in between. While the season was significantly cooler than the exceptional 2017/18 summer, growing degree days were near normal for the 2018/19 summer. The late summer rainfall increased berry size and both growers and winemakers are generally happy with the season's outcome in terms of yield and fruit quality.

There is strong demand for horticultural land in Central Otago with much interest from growers seeking to develop cherry or apple orchards. While some vineyard development is also occurring, this is at relatively low levels. The increased demand for other horticultural crops is one factor contributing to competition for resources such as water, accommodation and particularly labour for many vineyard tasks.

Several growers reported labour is an ongoing concern and are finding suitable workers hard to find. While a seasonal labour shortage wasn't declared in Central Otago this growing season, growers continue to be concerned about availability and the effect of the increasing minimum wage on their business.


NEW ZEALAND WINE
PURE DISCOVERY

Pin at -44.90191, 169.33555

Report prepared by Our Environment, 9:08:23 pm 12/10/2022 Manaaki Whenua - Landcare Research

Pin at -44.90191, 169.33555

Latitude Longitude
44° 54′ 07″ S 169° 20′ 08″ E
NZTM Easting, Northing
1310692, 5021411
Elevation
230m

Land Capability

Land Use Capability

NZ Land Use Capability Unit

nz4s-23
LUC codes have 3 parts: Class + Subclass + Unit e.g. 6e22. The Class (1-8) indicates general land use capability. Subclass identifies the dominant physical limitation or hazard ('e' is erodibility; 'w' is wetness; 's' is soil; 'c' is climate). Units group together areas where similar land inventories have been mapped, and which have similar agricultural suitability, or require similar land management.

LUC Class

4 - Land with moderate limitations for arable use

Dominant limitation to land use

s - Soil physical or chemical properties in the rooting zone such as shallowness, stoniness, low moisture holding capacity, low fertility (which is difficult to correct), salinity, or toxicity first limits production

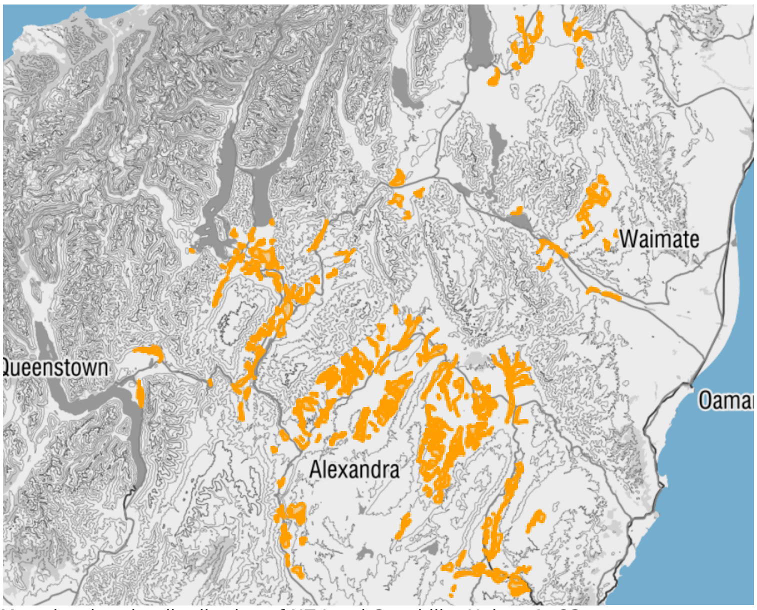
Unit Description

Flat to rolling terraces and fans below 600 m asl with shallow, stony Brown, Pallic and Recent (yellow grey and brown grey earth) soils in low (450-650 mm) rainfall inland districts with cold winters and very dry summers.

Historic regional units

4s9 (South Island (other than Marlborough))

NZLRI Unit Distribution (1:50,000)



Map showing the distribution of NZ Land Capability Unit nz4s-23

Data source: Land Use Capability

The Land Use Capability system categorizes land into eight classes according to its long-term capability to sustain one or more productive uses based on physical limitations and site specific management needs. Productive capacity depends on physical qualities of the land, soil and environment. Differences between ideal and actual land qualities may be regarded as limitations which will affect productivity and land management options. Limitations considered in the LUC include: susceptibility to erosion, steepness of slope, climate, susceptibility to flooding, liability to wetness or drought, salinity, and depth, texture, structure and nutrient supply of the soil.

Data source & provenance

Data source: Land Resource Inventory (LRI)

Pertains to: *Land Use Capability*

This is a single spatial (polygon) layer with national coverage that contains several physical resource themes: land use capability, lithology, soil, etc. In terms of geographical data accuracy the polygon boundaries were originally mapped at 1:63,360 scale, except where more recent mapping was carried out at 1:50,000 scale in Northland, Gisborne-East Coast, Wellington and Marlborough regions. This is regional scale mapping according to the Land Use Capability Survey Handbook (http://www.landcareresearch.co.nz/publications/books/luc)(Edition 3). The minimum polygon size for the smallest area of interest in the LRI mapping was nominally 10 hectares, although some 2% of polygons fall below this threshold. Average polygon size for 1:63,360 scale mapping is 335 hectares, and for the more recent 1:50,000 scale mapping is 98 hectares, reflecting both increased mapping scale and improved standards of mapping.

The LRI is a regional-scale database and caution should be used when using these data at larger scales.

In addition to the geographical accuracy of the polygon boundaries, each resource theme is subject to uncertainties about the attributes (e.g., soil classification). Users should download and familiarise themselves with the relevant sections of the LRIS Spatial Data Layers Data Dictionary to ensure that the data are fit for their intended analysis. This is available for download from here (https://lris.scinfo.org.nz/document/9162-lris-data-dictionary-v3/) in the LRIS Portal.

Interpretations in Our Environment based on the LRI and therefore subject to its data accuracy are: Erosion Severity, Surface Geology and all five of the land suitability classifications.

OURENVIRONMENT

Manaaki Whenua Landcare Research

Proposed Subdivision - Bendigo Loop Road, Bendigo
Graphic Attachment to Landscape Assessment Report

3 November 2022

Document Information

Project
Proposed Subdivision

Address
Bendigo Loop Road, Bendigo

Client
Loop Road Limited

Document
Graphic Attachment to Landscape Assessment Report

Status
For Resource Consent

Revision		
1	For Resource Consent	03.11.2022

Prepared By
Rough Milne Mitchell Landscape Architects Ltd
Project Number: 22221
Author: Paul Smith
Peer Reviewed: Nikki Smetham

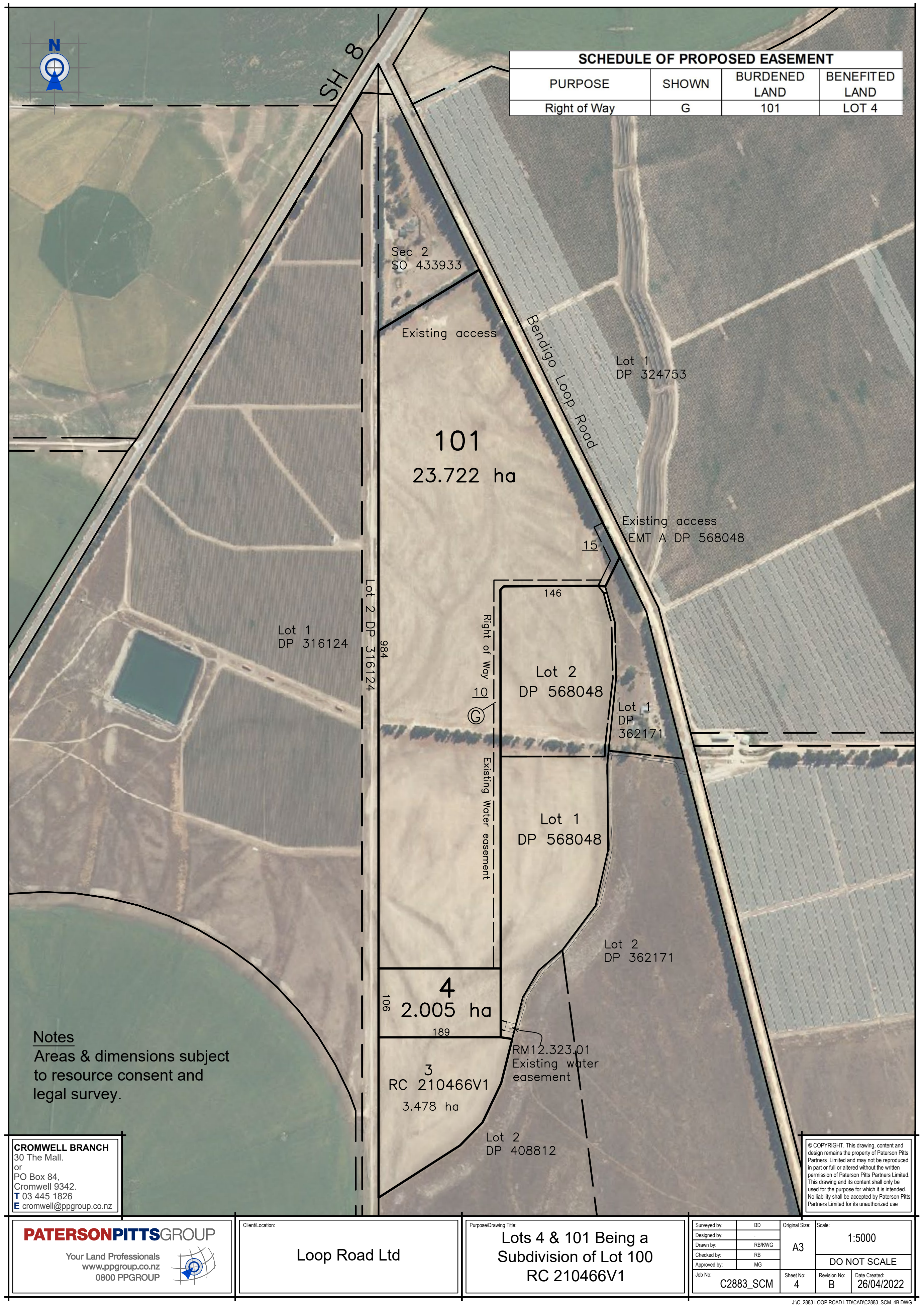
Disclaimer
These plans and drawings have been produced as a result of information provided by the client and/or sourced by or provided to Rough Milne Mitchell Landscape Architects Limited (RMM) by a third party for the purposes of providing the services. No responsibility is taken by RMM for any liability or action arising from any incomplete or inaccurate information provided to RMM (whether from the client or a third party). These plans and drawings are provided to the client for the benefit and use by the client and for the purpose for which it is intended.

Contents

Proposed Subdivision Plan

Notes:
The site consists of Proposed Lot 4 and Lot 101, which will be 2.005ha and 23.722ha in area, respectively.

Proposed Lots 4 and 101 are a subdivision of Lot 100 RC 210466V1.

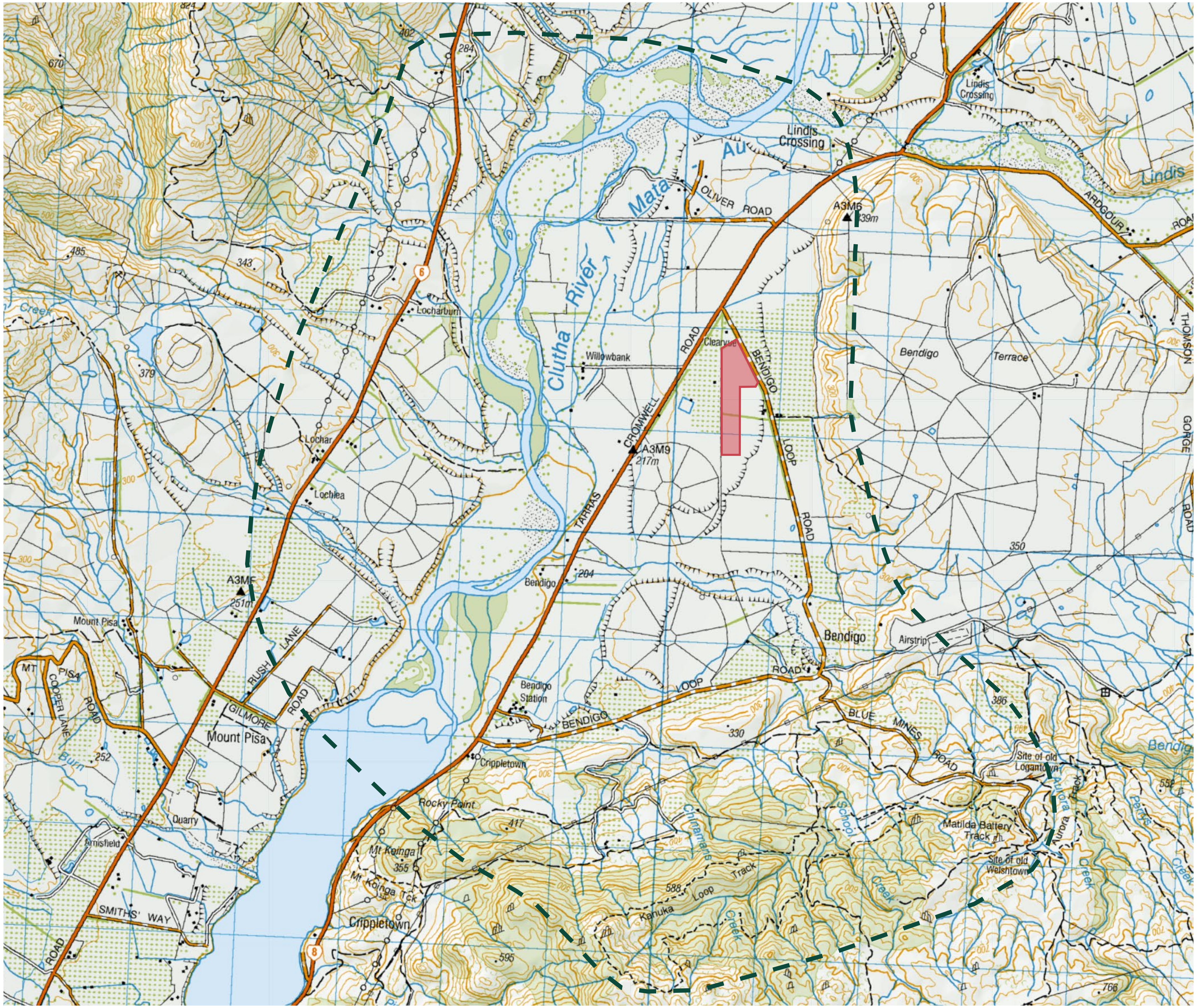


Not to Scale
Data Source: Paterson Pitts Group

Receiving Environment Plan

Legend

(red filled square)	The Site
(dashed corner brackets)	The Receiving Environment

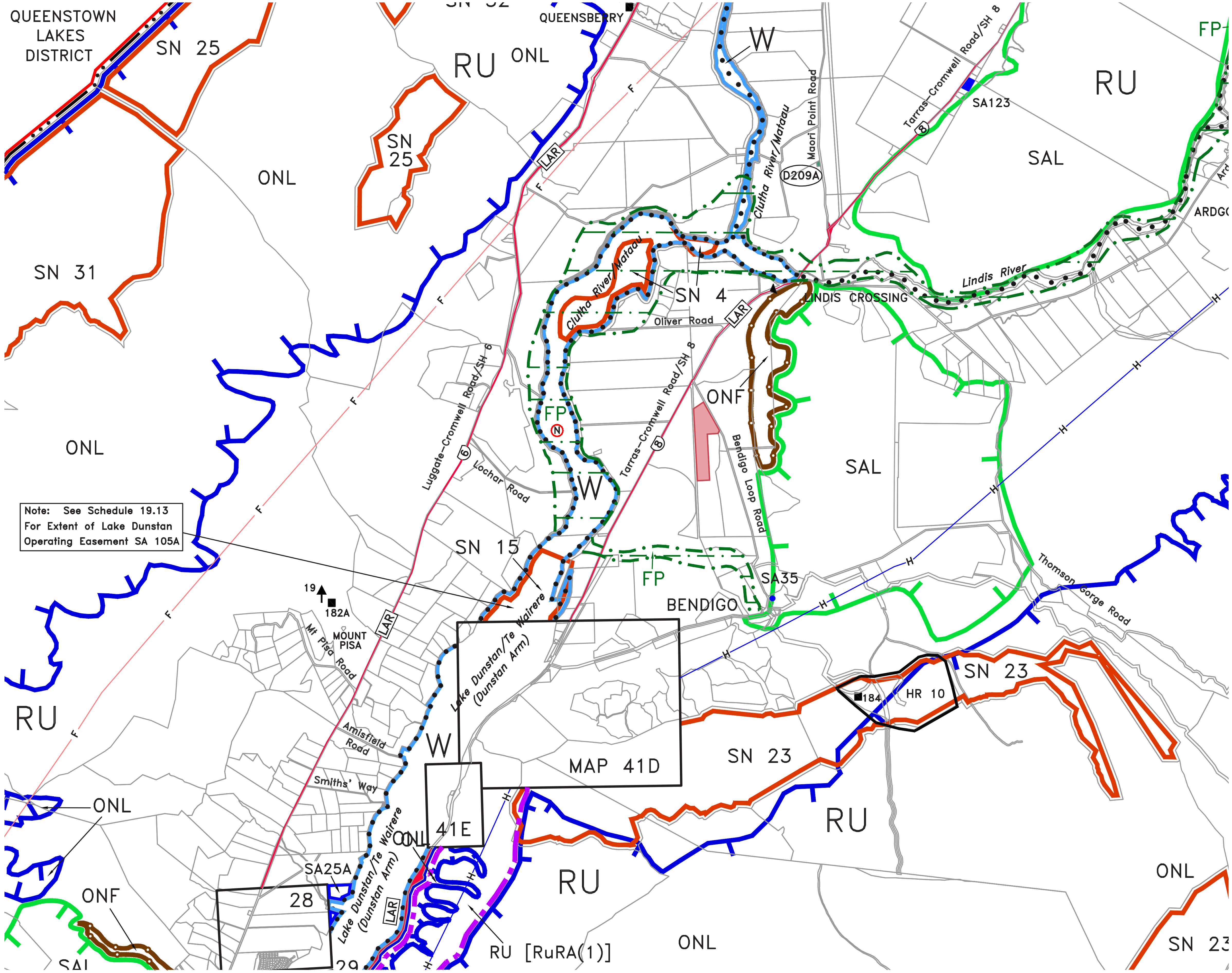


Scale: Grid Square - 500m x 500m
Data Source: www.topomap.co.nz

Central Otago Distric Planning Map 48

Legend

The Site



Not to Scale
Central Otago District Council

Viewpoint Location Plan

Legend

[red box]	The Site
#	Viewpoint Locations

Not to Scale
Data Source: www.app.grip.co.nz

Viewpoint Location Photographs

The site is located behind this shelterbelt.

Viewpoint Location Photograph 1: Located at the interesection of SH8 and Oliver Road. The photograph represents the view to the south from this stretch of SH8 and Oliver Road towards the site and its surrounds.
Date: 14 October 2022 **Time:** Between 9:00am and 11:00am.

The site is located behind this property, its associated vegetation and shelterbelt.

Viewpoint Location Photograph 2: Located at the interesection of SH8 and Bendigo Loop Road. The photograph represents the view to the south from this stretch of SH8 and Bendigo Loop Road towards the site and its surrounds.
Date: 14 October 2022 **Time:** Between 9:00am and 11:00am.

Viewpoint Location Photographs

Viewpoint Location Photograph 3: Located along SH8, beside the driveway to 1811 and 1813 Tarras-Cromwell Road. The photograph represents the view to the northeast from this stretch of SH8 towards the site and its surrounds.
Date: 14 October 2022 **Time:** Between 9:00am and 11:00am.

Viewpoint Location Photograph 4: Located along SH8, mid way between the north and southern end s of Bendigo Loop Road. The photograph represents the view to the east from this stretch of SH8 towards the site and its surrounds.
Date: 14 October 2022 **Time:** Between 9:00am and 11:00am.

Viewpoint Location Photographs

Viewpoint Location Photograph 5: Located along SH8, beside the driveway to 1619 Tarras-Cromwell Road. The photograph represents the view to the east from this stretch of SH8 towards the site and its surrounds
Date: 14 October 2022 **Time:** Between 9:00am and 11:00am.

Viewpoint Location Photographs

Approximate location of Lot 4.

Viewpoint Location Photograph 6: Located along Bendigo Loop Road beside the dwelling within the property immediately north of the site. The photograph represents the view to the south from this stretch of road towards the site and its surrounds.
Date: 3 September 2020 **Time:** Between 9:00am and 10:00am.

Approximate location of Lot 4.

Viewpoint Location Photograph 7. Located along Bendigo Loop Road, south of the shelterbelt along its western side. The photograph represents the view to the northwest from this stretch of road towards the site and its surrounds.
Date: 14 October 2022 **Time:** Between 9:00am and 11:00am.

Viewpoint Location Photographs

Viewpoint Location Photograph 8: Located at 'The Canyon' a private restaurant / venue centre situated part way up the Dunstan Range. The photograph represents the view to the north, including the view from the Kanuka Track, which is a public walking track.
Date: 3 September 2020 **Time:** Between 9:00am and 10:00am.

Viewpoint Location Photograph 9: Located beside the historic school house located along Blue Mines Road. The photograph represents the view to the northwest. It also illustrates how a terrace edge can screen the site from view.
Date: 25 January 2021 **Time:** Between 8:00am and 9:00am.

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LANDSCAPE AND VISUAL EFFECTS ASSESSMENT - PEER REVIEW

RC220191 – LOOP ROAD LIMITED

RESOURCE CONSENT APPLICATION FOR SUBDIVISION AT BENDIGO LOOP ROAD

Ben Espie (Landscape Planner)

vivian+espie

30th June 2023

INTRODUCTION

1 Loop Road Limited (**the applicants**) have applied for resource consent to subdivide Lot 100 of RC210466 (a consented subdivision for which titles have not yet been issued) into two lots; proposed Lot 101 of 23.722ha and proposed Lot 4 of 2.005ha. Lot 100 (**the site**) is access from Bendigo Loop Road. No new services are proposed to be provided and the application states that the application is for productive purposes only. There is a current irrigation water supply.

2 The application includes a Landscape and Visual Assessment Report prepared by Rough Milne Mitchell Landscape Architects dated 3rd of November 2023 (**the RMM Report**). I have been engaged by the Central Otago District Council (**CODC**) to peer review the RMM Report.

3 Full findings of a landscape and visual effects assessment are not set out in this report. This report gives review comments on the RMM Report and discusses its methodology, completeness, plausibility, findings and conclusions. This report generally uses the headings of the RMM Report as a structure to the review comments.

METHODOLOGY

4 The RMM report is appropriately guided by Te Tangi A Te Manu, Aotearoa New Zealand Landscape Assessment Guidelines[1] (**the NZILA Guidelines**). The report follows a clear and suitable structure.

---

[1] Te Tangi A Te Manu, Aotearoa New Zealand Landscape Assessment Guidelines, April 2021, New Zealand Institute of Landscape Architecture.

DESCRIPTION OF THE PROPOSAL

5 The RMM report describes the activity accurately as per the application. The report then goes on to discuss future activities that would be permitted. It does not mention future activities that would be controlled or restricted discretionary. I shall discuss this further below.

RELEVANT POLICY PROVISIONS

6 The RMM Report discusses provisions of the operative Central Otago District Plan (**the ODP**), and concludes that the activity is restricted discretionary. I understand that this is not correct and that the activity is a fully discretionary activity pursuant to Rule 4.7.4(iii). Nonetheless, the report sets out the relevant ODP considerations in its Appendix 1, although it would have perhaps been useful to also cite Policy 4.4.10.

THE EXISTING ENVIRONMENT

7 I generally agree with the discussion of the existing environment included in the RMM Report. In relation to the consideration of cumulative effects, it would have been informative to set out the recent history of subdivisions that have taken place that have led to the current situation, particularly the subdivisions created by RC210171 and RC210466. These have been recent discretionary activity subdivisions of a parent lot that have created the site and the immediately surrounding vicinity.

ASSESSMENT OF LANDSCAPE AND VISUAL EFFECTS

8 The RMM report firstly discusses landscape effects and then visual effects. In the introductory section to the consideration of landscape effects, the report states that:

"The proposed subdivision will not provide for any new activities within the landscape, or any activities that are not already permitted activities as per the district plan. Therefore, the future use of the site is 'considered to have no more than a minor effect on the environment.'" (with reference to Rule 4.7.1(i) relating to permitted activities).

9 The report goes on the state that:

"The landscape effects that may result from the proposed subdivision is the potential for it to fragment the landscape setting by creating one additional allotment that is relatively small, being 2.005ha in area, within the receiving environment that is mostly comprised of large land holdings that vary in size between 30 and 300ha.

The fragmentation of the landscape can result in quite high adverse landscape effects, in particular the cumulative nature of more properties of this size in this landscape".

10 The RMM report then explains that the current proposal will not lead to adverse effects on rural character or landscape values due to a number of reasons, central to which is that only rural, productive land uses will arise in the future, albeit that farm buildings will be permitted. It is on this basis that the RMM report finds that landscape effects and visual effects will be appropriate.

11 I generally agree with the findings of the RMM report if it can be assured that only rural, productive land uses will arise in the future.

12 While the application states that *"there is no intention to alter current land use"* and that *"the land is to be retained as bare dryland pasture"*[2], the application offers no legal covenants or similar devices to restrict land uses on the two new lots. The lots can, of course, be sold to new owners who do not have the same intentions as the current owners. The application notes that immediately neighbouring lots have been sold.

13 The consent notices that the application seeks to apply to the two new lots indicate that it would be the responsibility of future lot owners to provide potable water and wastewater disposal in the event that the lots are used for residential purposes. The Environmental Site Investigation report that accompanies the application states the understanding that *"the property is proposed to be used for agricultural activities, but that the option for rural residential activities is desirable"* and notes that its investigation covers the potential use of the site for residential purposes.

[2] Assessment of Environmental Effects, Patterson Pitts Group, 010/6/2023, Section 3.

14 In the absence of any legal mechanism to restrict future land use, using the two new lots for residential purposes would be a restricted discretionary activity pursuant to Rule 4.7.3(vii). This would also apply to the adjacent lots that have recently been created by RC210171 and RC210466.

15 Since 4.7.3(vii)(b) restricts residential activity to one per title, the situation prior to the recent subdivisions was that only one residential unit was provided for (as a restricted discretionary activity) on the parent lot. A consequence of the subdivisions that have occurred is that now numerous residential units are provided for (as restricted discretionary activities) over the same area. The currently proposed subdivision would add to this situation.

16 Therefore, if activities that may occur by way of restricted discretionary resource consents are to be considered, it is my opinion that the proposed subdivision will adversely affect rural landscape character and values since dwellings and associated activities would create a domestic or rural living form of landscape character in a vicinity that is currently very open and displayed and has a strong agricultural rural character. This would also result in associated effects on views and visual amenity as experienced from State Highway 8 and Bendigo Loop Road. There would also be potential cumulative effects if the various neighbouring lots created by recent subdivisions were also used for residential or rural living purposes. In the absence of any legal mechanism to restrict future land use, new owners of these smaller lots may have the expectation that a restricted discretionary application to erect a dwelling on their new 2 or 3ha rural lot will be granted.

CONCLUSIONS

17 Overall, I find that the RMM report follows an appropriate methodology, is clear and thorough. It's assessment is on the basis that only rural, productive land uses will occur over the site if the subdivision proceeds. If that is the case, then I largely agree with the RMM report's conclusions.

18 No legals mechanisms proposed by the current application would restrict future land uses. Pursuant to the ODP, the creation of new lots brings with it the provision for residential activity on each lot by way of a restricted discretionary activity. If activities that may occur by way of restricted discretionary resource consents are to be considered, it is my opinion that the proposed subdivision will adversely affect landscape and visual amenity values through the creation of

domestic or rural living character in a vicinity that is currently open and agricultural/rural in character.

Ben Espie (Landscape Planner)

vivian+espie

30th June 2023

Introduction

I have been asked by the Central Otago District Council to undertake a peer review of a Land Productivity Assessment in relation to a proposed subdivision of land on Bendigo Loop Road (RC220191).

Scope

The scope of the peer review is to address the questions as follows:

- If the proposed 2ha allotment and the resulting 23-hectare allotment are adequate in terms of productivity and economic viability to grow grapes.
- If there is a loss of productivity as a result of this subdivision.

Method

The method to complete the peer review is as follows:

1) Gather site specific information relating to soils and climate from independent data sources and compare to the data presented and conclusions drawn in the Land Productivity Assessment
2) Consider the range of wine grapes that can be grown on the site and compare to the conclusions drawn in the Land Productivity Assessment
3) Analyse the implications a small site has on management and economic viability and compare to the conclusions drawn in the Land Productivity Assessment

Site Specific Information

Item	Data (source)	Comparison Data	Commentary and Conclusion
Topography	(Observation, NZ Topo, EM data provided) Generally flat with very low ability to drain cold air. Terrace from the east has katabatic drifts which exit onto the Claim 431 land which then drain onto the land in question.	Appendix 1 Climate Consulting report - similar comments	Site will act as a frost trap as there is insufficient drainage for the cold air which will drift on to the property from the East. Any slope present does not drain across and away from the site. The site displays the characteristics of the remnants of an historical braided river plain.

Item	Data (source)	Comparison Data	Commentary and Conclusion
Soil Profile	(GrowOtago) Well drained, low fertility, moderate profile available water, semi-arid soil	Soil sample results	Soil suitable for the production of grape vines. Will require irrigation and nutrients (particularly for establishment).
Soil type	(S-Maps) Ripponvale 5 *This soil belongs to the Semiarid soil order of the New Zealand soil classification. Semiarid Soils are dry for most of the growing season, and rainfall is not sufficient to leach through the soil, so lime and salts accumulate in the lower subsoil. Nutrient levels are relatively high, but the soils must be irrigated to produce high yields. It is formed in alluvial sand silt or gravel deposited by running water, from hard sandstone parent material. The topsoil typically has loam texture and is slightly stony. The subsoil has dominantly loam textures, with a very gravelly layer from less than 45 cm mineral soil depth to more than 100 cm. The plant rooting depth extends beyond 1m. Generally the soil is well drained with very low vulnerability of water logging in non-irrigated conditions, and has moderate soil water holding capacity. Inherently these soils have a very high structural vulnerability and a high N leaching potential, which should be accounted for when making land management decisions.*	Soil sample results	Low nutrient levels with low CEC but also low base saturation indicating the soils have not been fertilised recently. Very low sulphur which is typical for Central Otago, low pH (medium acidic 5.5-5.6) which will also moderately affect availability of N, P, K, S, Ca, Mg. Soil acceptable for the production of grape vines. However, will require irrigation and nutrients (particularly for establishment).

Item	Data (source)	Comparison Data	Commentary and Conclusion
Frost Events (number)	(GrowOtago) 2.1-3.0 October frosts 0-1 November frosts	Site Survey (Appendix 1)	Material number of damaging frosts. Frost protection will be required.
Frost Events (depth)	(Pers. Experience – Zebra, Claim 431, Knox Estate) Range of minimum temperatures experienced on the property during the growing season. Frosts can be experienced in every month of the growing season. Some frosts will be as cold as -5°C (and very rarely colder than this). Frost events can last considerable periods (in excess of 10 hours).	Site Survey (Appendix 1) High – very high frost risk 1.6°C spatial variation Temp observed 7 April -4.8°C Extreme events – Oct -3.3°C, April -3.9°C	Frosts unlikely to be effectively controlled by wind machines in all events, minimum temperature will be below the capability of a wind machine (due both to the minimum and the lack of inversion layer) to be able to effectively fight frost. Water frost protection system will be required to effectively fight frosts to -5°C but does depend on risk appetite of owner and water availability.
Growing Degree Days (Base 10°C)	(GrowOtago) 1101-1150	1150-1200	Sufficient accumulated heat to ripen an economic crop for most varieties proven to be able to be grown in Central Otago
Rainfall (Annual Average)	(GrowOtago) 451-500mm	No data	The majority of rainfall is during the summer but is insufficient to enable adequate vegetative growth to ripen an economic crop. Irrigation water (at a rate of 10l/vine/day) will be required via a drip irrigation system
Wind	(GrowOtago) Average 10.1-12.0 km/h Maximum 55.1-60 km/h	No data	Although there are likely to be damaging episode of wind the site is not in an extreme wind zone and will be able to withstand the majority of events during the growing season.
Water	Irrigation 1.6ha planted * 25,000 (litres per plant per day at a vine density of 2500 vines/ha) = 40,000 litres (40m3) Frost Fighting (if water used)	RM12.323.01 No water allocation to block indicated	Bore granted consent to abstract 1134cu/day. Supplies water to ~38.9ha. Sufficient for irrigation for grapes (total water requirement if planted at 2500 vines = 972.5m3). Insufficient water to provide water for frost fighting for the entire property if water is the chosen method for protection.

Item	Data (source)	Comparison Data	Commentary and Conclusion
	1.6ha * 50,000 l/ha/hr * 8-hour long frost * 3 days = 1.92m M3 or 640m3 per day.		

The site is suitable to grow most of the varieties propagated in the Central Otago winegrowing region. It will require water frost fighting to fully mitigate risk as well as an irrigation system able to provide sufficient water to enable adequate vegetative growth. It's a low to moderate vigour site which will require additional inputs to achieve yields of 7+ tons per hectare on a sufficient regular basis to make the block economic.

I have gathered frost information from the neighbouring Zebra vineyard. Noting the Climate Consulting report prepared on the site has a spatial variation of 1.6°C (being + or – 0.8°C) this should be considered with the coldest areas on the Zebra site being -0.8°C colder than that recorded below:

Month	Coldest October Temp °C
Oct 2022	-3.3
Oct 2021	-0.9
Oct 2020	-1.0
Oct 2019	-2.2
Oct 2018	-3.8
Oct 2017	-0.9
Oct 2016	-0.5
Oct 2015	-0.9
Oct 2014	-2.3
Oct 2013	-0.6

From the table above it can be noted that 4 of the events (when spatial variation is considered) are likely to exceed the capacity of a wind machine to provide adequate protection in the event of an October frost. This will likely result in substantial damage (but not complete) to the crop in 40% of the seasons, which is not typically acceptable from a risk perspective (typically a 1 in 10 risk is acceptable in my experience).

The -4.8°C event noted by the Climate Consulting report on April 7, 2019, would have resulted in catastrophic damage to the canopy if only wind machines were used to protect the crop and would have stopped the ripening process completely.

Range of wine grapes able to be grown on the site

The following chart illustrates the varieties that can be grown in different Growing Degree Day ranges. The chart is indicative and not definitive, with warmer meso-climates within a cooler region able to economically ripen crops. I have indicated the varieties grown in Central Otago (with a red star) and those that, in my opinion, the site is able to ripen (with a green star). From the chart most varietals are able to be ripened on the site, including all the major varietals grown in Central Otago.

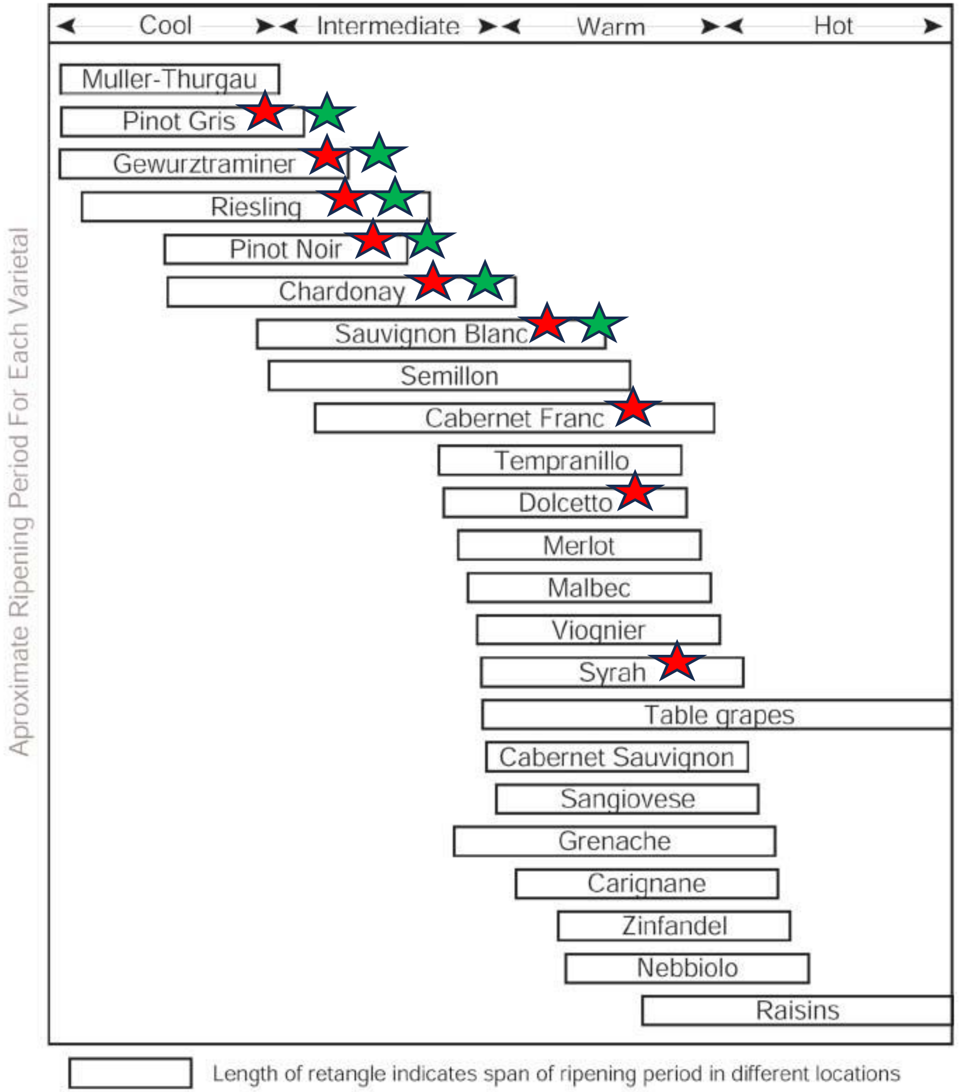


Figure 4 Climate/maturity groupings defined for Oregon based on the approximate ripening period potential for each variety in different locations: from Jones et al. (2002).

Effect the site size has on economic viability

Cost of running a vineyard

In my experience the average cost of running a “normal” vineyard in the Central Otago winegrowing region currently averages about $22,500 per planted hectare. This assumes the size of a vineyard is that of an average vineyard in Central Otago (being 9 hectares – NZ Vineyard Register 2023) and that its run conventionally with all costs captured. The data presented by the Land Productivity Assessment uses information that is out of date (being from 2019). The key category of expenditure is labour (accounting for between 60% and 70% of cost in my experience, which is consistent with the data presented). If the increase in minimum wage from 2019 to 2023 is factored in (being $17.70/hr in 2019 and $22.70/hr in 2023 or 28% plus increases to entitlements – Matariki Day and an increase in sick leave from 5 days to 10 days) then the cost $18,040 * 63% (being the labour component) = $11,365 + 28% = $14,547 or an increase to $21,222 (before the other increases are factored in) which is comparable to my figure. When cost increases for machinery and materials is factored in over the same period then my figure is consistent with the data presented, adjusted for wage and price inflation.

Income generated from grape sales

New Zealand Winegrowers publish average grape prices per tonne annually, based on farm gate sales. The latest data indicates that the average price for Pinot Noir (the most planted variety) is $4,112 per ton. The total production from Central Otago and hectares planted is captured below:

Year	Tonnes	Planted Hectares	Average Yield
2022	12,575	2,055	6.1
2021	10,324	2,029	5.1
2020	8,515	1,930	4.4
2019	11,868	1,875	6.3
2018	11,358	1,873	6.1
2017	8,324	1,886	4.4
2016	9,177	1,880	4.9
2015	8,951	1,942	4.6
Overall average			5.2

It should be noted that the total tonnage applies to all varieties, and typically white varieties crop 15-20% higher than Pinot Noir. White varieties tend to crop higher but have a commensurately lower tonnage price so return below the Pinot Noir return. This chart looks at the yield across all varieties and growing methods. In my experience the yields can be much higher than this on well managed sites with a return of 7t/ha being possible in warmer years.

Applying average pricing to the long-term average (5.2t/ha) to the current pricing this equates to a return of 5.2* $4,112 = $21,382. This indicates that a typical vineyard returns close to break even or slightly below. The confounding factor in here is the total hectares includes areas not fully in production, but this should not be material (as most vineyards in Central Otago are producing). Assuming a yield of 7t/ha can be achieved then this increases to a return of 7.0 * $4,112 = $28,784 or a net return of $6,284 (it should be noted that this excludes any cost of financing or administration and is a pure growing return). Acting purely as a production block, the returns generated range from break-even to ~6k/ha, which is why there are so many brands present in Central Otago – the margin to be made is in selling wine and not grapes, in my experience.

Impact of narrower row spacing/increased planting density

The author of the Land Productivity Assessment is correct that it is possible to increase yield by increasing planting density. There is a limit to what can be achieved here as the machinery is no longer able to pass and the lack of sunlight limits what can be ripened. Moving to a row spacing of 2m (about the narrowest that can be achieved before highly specialised and costly equipment is required) however also increases the cost of growing as the number of vines and the number of row meters increases, commensurately increasing cost as well as yield so the net effect is a slight improvement but not dramatically so.

Impact of organic management

There is no external independent data published on the returns for organic grapes compared to conventionally grown ones, but in my experience, there is an additional margin able to be achieved, somewhere between 10% and 15%. However, this is entirely negated as a result of the lower yields (typically 20% less) and higher growing costs (typically 10-15% higher). There are exceptions to this on higher fertility soils, but these figures are typical in my experience with growing organic grapes in Central Otago. The author has only presented the revenue side of the equation and not the full picture.

Labour efficiency in operating a vineyard

I have undertaken a comprehensive cost comparison exercise with a larger client of mine who has owned and leased vineyards ranging in size from 0.3 hectares to over 30 hectares. This analysis demonstrated the following:

- Under 5 hectares the cost per hectare increases significantly (even if the vineyard is contiguous to other vineyards).
- Under 2 hectares this goes up another level. One of the smaller vineyards was costing upwards of 50,000 per planted hectare to grow the grapes.
- This was caused by the inefficiencies due to using teams and machinery to undertake work on very small blocks, due to the startup taken for tasks. This can somewhat be mitigated by contiguous blocks but not completely.
- Vineyards over 10 hectares became more efficient and over 25 hectares more efficient again.

Having a small block where 1 to 2 people can operate it in the weekends and over holidays does not fully capture the costs of operating the vineyard and in my opinion does not give a true economic picture of the real costs of operating the vineyard.

Impact of the National Policy Statement – Highly Productive Land (NPS-HPL)

The NPS-HPL does afford interim protection to LUC 1-3 classes. There is potential that in the future this may be extended to LUC 4-6 classes where most vineyards are grown in the Central Otago winegrowing region. Until the mapping exercise is completed the author is correct that only applies to LUC 1-3. The land is correctly identified as LUC 4 (NZLRI Land Use Capability 2021, accessed via the LRIS portal).

Loss of productive land (impact of a house site)

If a house and associated amenities (sheds, garages etc) are developed on the land the land where this occurs becomes unproductive and is unable to be used as vineyards anymore. Typically, a building platform in a rural environment occupies 1000m2 but this ignores all the associated land converted to support the residential dwelling (being garden, shed/garages, roading, etc). Once removed from production it is unable to be used again until the house and associated infrastructure is removed. This has a small effect but on a 2-hectare lot as is being proposed starts to become material. Additionally, there will be a loss of productivity due to the impact the need for headlands will have on the property. This will influence productivity on both properties.

Return on investment

Given the likely need for water frost fighting as an optimal solution for frost fighting there will need to be either sufficient supply available directly from the bore or via a storage solution sufficient to provide 3 full nights worth of storage for 1.6 hectares. This is calculated as 1.6ha * 50,000 litres per hectare per hour (sufficient to provide 5°C protection) * 8-hour long frost * 3 days = 1.92m M3 or a 2 million litre dam which is likely to cost around 100k plus the cost of pumping and delivery. If a higher risk appetite means that a wind machine is selected, then a portable wind machine known as a Tow and Blow may be an option to cover the 1.6 hectares at a cost of $65,000. Both options will add significantly to the likely development cost of $110,000 – $125,000 per planted hectare (being cost of development plus the cost to get to the first crop), making the payback period considerably longer. Even with a return of $6,284 this equates to a ROI of $125,000 + $40,625 (being a per hectare cost for the wind machine) or $6,284/$165,625 = 3.7% which is about normal in a grape supply situation in Central Otago (applying the optimal yield of 7t/ha and not applying any loading for the small size of the vineyard).

Overall Conclusion

In response to the two key questions asked by the CODC my responses are as follows:

If the proposed 2ha allotment and the resulting 23-hectare allotment are adequate in terms of productivity and economic viability to grow grapes.

The site can grow and ripen most grape varieties grown in Central Otago. Given the amount of accumulated heat it should have an opportunity to ripen higher yields than the district average with the addition of sufficient nutrients. There is a significant risk posed by frost which will require significant water to enable the risk to be adequately mitigated. More water will be needed to provide protection for the full site. It will, however, not be economically viable to grow grapes on such a small site when considered alone when the impact the small size has on efficiency and cost is considered.

If there is a loss of productivity as a result of this subdivision.

There will be a small but appreciable loss of productivity because of the subdivision. The additional fences which will break the properties up will result in lost productive land as will a potential future house site.

Our Ref: C2883

20 October 2023

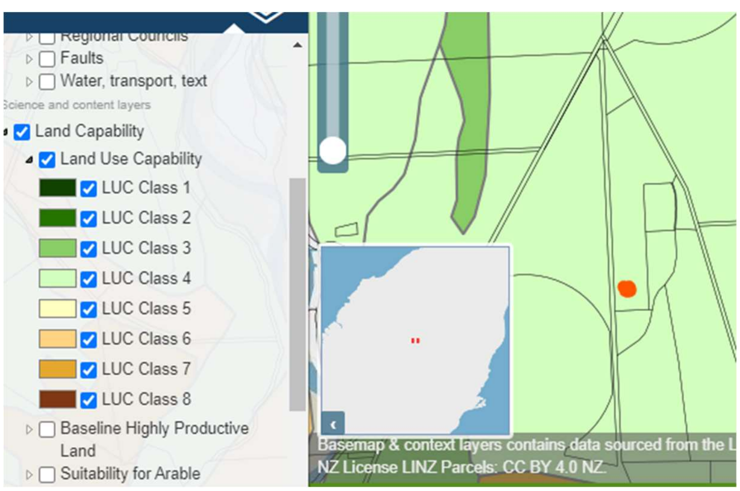
Central Otago District Council
P O Box 122
ALEXANDRA 9320

Attention: Planning Officer

Re: Response to peer review reports
Bendigo Loop Road – Loop Road Ltd

In response to the peer reviews of the s92 request, the applicant provides further information to support the application. The purpose of the information provided below is to address some factual inaccuracies within the peer reviews provided to the Council.

1. **Enhancement of Land Use**
   The land was originally part of high country, fine wool station, with no significant investment on irrigation or pasture. The applicant purchased, over this time, they have engaged in pasture improvement programs by strip grazing cattle and attempting diversity in the pasture. However, these ventures have not been proven to be economically viable on this parcel of land. Even with the investment of bore water, irrigation reticulation systems and a travelling irrigator, the returns have been negligible.



The Land Use Capability classification of the site is 4 – Land with moderate limitations for arable use. This classification is supported by the several years of ineffective farming.

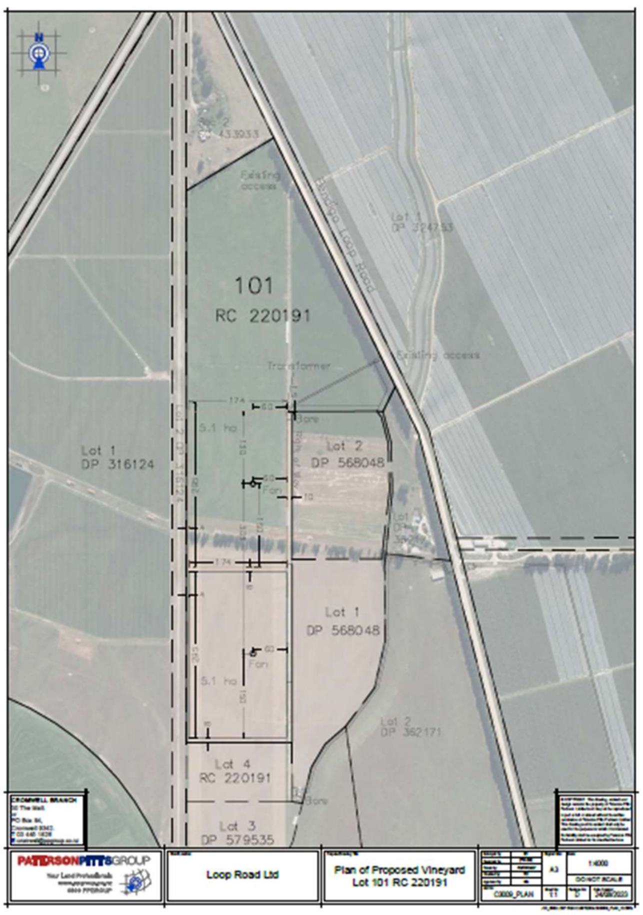
Source: Our Environment Maps.

Given the poor results for the productivity of the land, an investigation was undertaken by the Applicant to determine if viticulture was an option for this block, including previously supplied assessments from consultants and months long frost risk assessments. These reports concluded that the land would potentially be successful under vines given sufficient water and management practices. Currently, the unproductive land is being worked to vineyard by installation of two water bores and piping network throughout the land and more intense internal irrigation supply to the new vines.

2. **Vineyard Development on Balance of Site**

The applicant has recently diverted an order of Sauvignon Blanc vines to the Bendigo property (the attached invoiced is addressed to Mohua Wines Limited, this is a subsidiary of Peregrine Wines, and responsible for their Marlborough vineyards, where the vine was originally destined) to develop the balance area in vineyard. See Lot 101 Scheme Plan C2883_SCM_4B.

The vineyard development plan identified approximately 20Ha of plantable land (Lot 101) and would produce over 190t of grapes each year,164,000 bottles of wine. This volume of grapes does not include the Lot 4 area as the extra land would produce a quantity of grapes that would exceed the capacity of the applicants processing plant. Lot 4 would therefore remain bare unproductive land.



Plan showing the layout of vineyard development on proposed Lot 101.

The resulting balance Lot 101 boundaries is better suited to a larger scale vineyard by providing long even trellis structures to develop the enterprise into an automated vineyard.

3. **Viability of Vineyard Development**

The Applicant has sought further advise from Mr Mark Allen, of Allen Vineyard Advisory, who provides independent advice to many vineyards Nationally in Marlborough, Hawkes Bay, and Central Otago such as Cloudy Bay, Peregrine Wines, Mount Beautiful and Akurua to name a few. Mr Allen has provided comments on the yields that have been achieved in Central Otago vineyards through his advice. Mr Allen's email is attached.

The Dicey report states that the average yield in Central Otago is 6.1Ha tonnes/Hectares (NZ Winegrowers), however, Mr Allan reports that Peregrine Estate has already achieved significantly higher yields in the Bendigo subregion between 9.5 – 11 tonnes/Ha, with row spacings of 2m wide and the vines 1.2m apart giving 4,166 vines/ha (or a row length of 5,000 meters per hectare), then at 2.5 kg/vine yields are achievable. This provides a higher capital invested return closer to 9.4% compared to the 3.7% return outlined in the Dicey report.

4. **Capital Expenditure**

Regarding the Dicey comments concerning capital expenditure for small vineyards, within Central Otago, numerous vineyards utilise contractors to manage the operations, for example Grape Vision offer a wide range of management and contract options on vineyards for absentee owners and local owners.

5. **Water Supply**

As discussed in the application, the site has reticulated water suitable for irrigation from an established consented bore RM12.323.01 with a groundwater take permit, located at the southern end of Lot 1 DP 568048. Since the initial June 2022 application, a second consented bore RM21.042.01 has been drilled at the northwestern corner for Lot 2 DP 568048. A groundwater allocation application is currently underway to supply additional water to the northern portion of Lot 101.

A water supply company Loop Road Water South Limited (LRWSL) has been established to provide irrigation water to Lots 2 & 3 DP 568048, Lot 3 DP 579535 and will be available to proposed Lots 4 and 101. Lot 4 will be serviced by a right of way, right (in gross) to convey water in favour of Loop Road Water South Limited (LRWSL) and right (in gross) to convey electricity. See title RT 1076037.

Lot 4 will be provided with minimum a water allocation from LRWSL of approximately 53,000 L/ha/day. A copy of the draft LRWSL water supply agreement is attached.

The Dicey report indicated that 1.6Ha requires 40,000L/day or 25,000L/ha/day.

6. **Frost Mitigation**

The Dicey report refers to frost data sourced from the western neighbouring Zebra vineyard with the conclusion that crop damage would occur during frost events. While the evidence is there to support Mr Dicey, attached is correspondence from Accolade Wines NZ Limited, the property to the east of the subject site who have successfully utilised wind machines at the Claim 431 vineyard, with little frost damage and producing higher quality and yields.

Unfortunately, the Dicey Report does not discuss the impact of Autumn frosts and the impact they can have on selecting appropriate mitigating technologies.

A significant restriction in the use of water for frost protection is that inability to use it for protection against Autumn frosts. A frost in autumn can have two significant impacts on a vineyard, firstly, it will damage the vine leaves, effectively halting photosynthesis and any further ripening of the grapes, and secondly, it will also hasten the shutting down of the vine for winter, which is a process where carbohydrates in the vines flow back into the vine trunk and stored over winter, then utlitised in the spring to support the initial growth period. When this process is interrupted by a frost in autumn then the next growing season can be impacted. When water is used for frost fighting a protective ice layer encapsulates the delicate buds, insulating them from the cold air temperatures – if this layer of ice was to encapsulate the full canopy structure that exists in Autumn, then significant weight is added to the vine and trellis system and can cause significant damage to both vines and the trellis structures. This is not an issue when vineyards are protected by frost fans.

While the larger vineyards do operate fixed frost fans, there is strong evidence that smaller operation are not utilising this type of equipment, but rather smaller mobile fans providing a reduction in capital expenditure and ongoing costs of maintenance.

One such fan is the portable 'Tow and Blow' free standing machine which offers a transportable option and versatility to smaller operations. Smaller vineyards in the Bendigo region utilise frost netting during the winter months to ward off frost. For example, the Canyon Vineyard Limited.

The Loop Road vineyard under development is installing two electric fixed frost fans roughly centered on each of the 5.1Ha blocks in the land directly adjacent to Lot 4.

7. Effect on Landscape

The Vivian+espie report concludes "that the subdivision will adversely affect landscape and visual amenity values through the creation of domestic or rural living character in a vicinity that is currently open and agricultural in character."

It does not quantify the adverse effects. The subdivision itself does not quantify the adverse effect, but rather the potential land use post subdivision. The report states that any potential domestic or rural living form on Lot 2 would result in associated effects on views and visual amenity. However, these effects may be lessened with landscaping controls through the land use consent if Council considers it necessary at time of application. Suitable design controls through the ODP can ensure that the built form is absorbed into the rural environment.

Lot 101, the balance Lot, once under vines, will lessen any potential adverse effects on the views and amenity from the State Highway and Loop Road.

Section 16 of the Vivian+espie report mentions "the potential cumulative effects if the various neighbouring lots created by recent subdivisions were also used for residential or rural living purposes." Section 4.2 of the Application discusses the cumulative effects can only be considered for the application under consideration and does not need to be repeated.

8. Cancellation of Consent Notice

The Application had requested a new consent notice for RC 210446v1. However, the titles authorising this consent have now been issued referring to CONO 12528484.6 on the new title for Lot 100 DP 579535. A copy of RT 1076037 is attached.

Pursuant to Sec 221 (5) RMA91, a certificate cancelling CONO 12528484.6 is requested.

Even though a residential activity is not supported in this application, it is requested Conditions of CONO 12528484.6 be duplicated to a new Consent Notice to be registered on titles to Lots 4 & 101:

Lots 4 and 101 are intended for productive purposes only and the lots are unserviced land. The provision of potable water, wastewater disposal, power supply and telecommunications will be the future responsibility of owners at the time of building.

1. In the event that Loop Road is sealed, the successor shall upgrade the accesses to the sealed standard in accordance with Part 29 of Council's Roading Policy.

2. If any residential activity is proposed on Lot 101 in the future, this must not be located within the areas identified in Appendix 1, Figure 2 as not suitable for residential development in the Insight Engineering Report title 'Preliminary Environmental Site Investigation at Lot 1 DP 408812, Bendigo Loop Road, Bendigo' reference 21010 dated 14 April 2021.

3. At the time of construction of a dwelling on any of the Lots 4 or 101 or at the time an existing on-site wastewater disposal system is subsequently upgraded and replaced, an on-site wastewater disposal system that complies with the requirements of AS/NZ 1547:2000 "On-site Domestic Wastewater Management" shall be designed by a suitably qualified professional, and:

i. *A copy of the design and designer producer statement shall be supplied to the Chief Executive. The dwelling shall not be constructed until the design and producer statement have been supplied to the Chief Executive.*

ii. *The designer shall supervise the installation and construction of the system and shall provide a construction producer statement to the Chief Executive.*

iii. *An operation and maintenance manual shall be provided to the owner of the system by the designer and a copy supplied to the Chief Executive. This manual shall include a maintenance schedule and an as-built plan of the system dimensioned in relation to the legal property boundaries. A code of compliance certificate for the dwelling and/or disposal system shall not be issued until the construction producer statement and a copy of the owner's maintenance and operating manual have been supplied to the Chief Executive. The maintenance and operating manual shall be transferred to each subsequent owner of the disposal system.*

iv. *Disposal areas shall be located such that the maximum separation (in all instances greater in 50 metres) is obtained from any water course or any water supply bore.*

Given the complexity of the application and subsequent s92 peer review requests, responses, and changes to the Applicants vineyard development plans for the balance Lot 101, the Applicant askes that draft conditions be forwarded for their review prior to any final decision by Council.

If there is any further information required by Council to support the Decision, please contact me.

Yours faithfully

Rod Baxter
Snr Surveyor/Planner

PATERSONPITTSGROUP