Before the Hearing Panel
Appointed by the Central Otago District Council

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| Under | The Resource Management Act 1991 |
| In the matter of | Private Plan Change 14 to the Central Otago District Plan |

**Evidence of Reece Blackburn Hill**

16 September 2020

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**Introduction**

1 My name is Reece Blackburn Hill

2 I hold a Doctor of Philosophy in Soil Science from Lincoln University (2000), a Master of Applied Science in Soil Science from Lincoln University (1994), and a Bachelor of Science with a double major in Biological Sciences and Earth Sciences from University of Waikato (1988).

3 I have completed a Correspondence Certificate in Wine from Eastern Institute of Technology and the Advanced Sustainable Nutrient Management FLRC Short Course from Massey University.

4 I am a past President of the New Zealand Society of Soil Science (2014-2016), and a current member of the New Zealand Society of Soil Science, New Zealand Association of Resource Management, and the New Zealand Institute of Agricultural & Horticultural Science.

5 I have 19 years' experience as a Soil Scientist at Waikato Regional Council, six years' experience as a Soil Consultant at Landsystems, of which I have been full time in this role for the past 1.5 years and three years' experience mapping forest soils in Tasmania.

6 I specialise in soil characterisation, soil mapping, land use capability assessment, regional soil policy, soil quality and catchment and land management. I have applied these skills in numerous projects within Waikato Regional Council and Landsystems, working with individual landowners including farmers and growers, regional and district council staff, Crown Research Organisations, Universities, and Ministry staff (MPI and MfE).

7 I was lead reviewer for the Ministry for the Environment review of national soil quality monitoring and indicators and established the soil quality monitoring programmes for Waikato Regional Council and Nelson City Council. I was lead author of the soil quality monitoring chapter of "Land and Soil Monitoring: A guide for SOE and regional council reporting".

8 I have advised central government and district and regional councils throughout New Zealand in relation to soil management, land use capability, high class soils and the use of soil map information. This included regional council representation on the Land Use Capability Classification System (LUCCS) Governance Group.

9 I have undertaken property scale soil and Land Use Capability (LUC) assessments to identify high class soils for subdivision applications and farm land management, and regional scale soil mapping in the Waikato, Auckland, Bay of Plenty and Otago regions.

10 As part of my role at Waikato Regional Council, I was Lead Technical Writer for the Soils chapter (Chapter 14) of the Waikato Regional Policy Statement which became operative in 2016. Chapter 14 included a policy on High Class Soils (Policy 14.2).

11 As part of my Soil Scientist role at Waikato Regional Council, I provided soil and land fragmentation technical advice to the Ministry for Primary Industries for the proposed National Policy Statement on Highly Productive Land (NPS-HPL).

## My involvement with PPC14

12 My involvement with Private Plan Change 14 (PPC14) has been to undertake a desktop assessment of available soil and Land Use Capability (LUC) map information with regard to the 144 Ripponvale Road site and review documents presented to date relating to high class soils. At the time of writing my evidence, I had not undertaken a field soil and LUC assessment of the site. My evidence is based on available soil and LUC map information (maps, extended legends, and accompanying reports), as well as imagery available on Google Maps.

13 In preparing this statement of evidence I have considered the following documents:

(a) Evidence of James Dicey dated 20 May 2020;

(b) Evidence of Roger Gibson dated 20 May 2020;

(c) Evidence of Ricky Larsen dated 13 May 2020;

(d) Evidence of Brett Giddens dated 13 May 2020;

(e) Evidence of Paul Edwards dated 13 May 2020;

(f) PPC14 Appendix K: Preliminary Site Investigation by WSP Opus;

(g) PPC14 Appendix L: Landcare Research Soil Investigation by Ian Lynn;

(h) Section 42A report;

(i) Response by Section 42A Report Author;

(j) Operative Otago Regional Policy Statement;

(k) Proposed Otago Regional Policy Statement;

(l) Operative Central Otago District Plan;

(m) Available soil and land reports for the Cromwell district and greater Otago region.

**Code of Conduct for Expert Witnesses**

14 While this is not a hearing before the Environment Court, I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court of New Zealand Practice Note 2014 and that I have complied with it when preparing my evidence. Other than when I state I am relying on the advice of another person, this evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

**Scope of evidence**

15 I have prepared evidence in relation to:

(a) Definitions of high class soil.

(b) LUC Classification system for identifying high class soils.

(c) Soil and LUC map information with PPC14

(d) An assessment of the soil map information within Plan Change 14 against definitions of high class and significant soils in the Otago region.

(e) Interpretation of soil map information for land use

(f) Further comments on evidence documents regarding soils.

**Executive Summary**

16 My evidence includes assessment and discussion of the following areas:

(a) Definitions of high class soil.
(b) LUC Classification system for identifying high class soils.
(c) Soil and LUC map information with PPC14
(d) An assessment of the soil map information within PPC14 against definitions of high class and significant soils in the Otago region.
(e) Interpretation of soil map information for Land use.
(f) Further comments on evidence documents regarding soils.

17 From my assessment of the available documents and information I draw the following conclusions:

(a) Based on my assessment of the available soil map information, I conclude that the best available soil map information is provided by Leamy and Saunders (1967), however, the information should be treated with caution due to the scale, especially with regard to the accuracy of soil map unit boundaries.

(b) Based on my assessment of the available LUC map information, I conclude that the best available soil map information is provided by The NZLRI (1:50,000 scale) LUC map information however, this information should also be treated with caution due to the scale, especially with regard to the accuracy of LUC map unit boundaries.

(c) A property scale assessment of soils and LUC could confirm the soils and LUC classes, more accurately delineate map unit boundaries, and identify areas of modified soils, however, the general soil LUC classes, map units and modified soil area are unlikely to change the overall presence of the soils and LUC maps for the site in question.

(d) Inaccurate soil map boundaries are likely to reduce the actual area of Waenga (W5) soils by about 5 ha, based on available slope map information.

(e) Modified soils are estimated to occupy 5.4 ha of the Waenga (W5/b and W5+W3/c) soil area, reducing the productive capability of these soil areas.

(f) Based on the Mcintosh (1993) classification for high class soils the Waenga (W5 and W3) and Ripponvale (R3) soils are classified as high class soils. However, I consider the criteria for soil depth and climate too broad and inconsistent with national criteria now provided in the LUC Survey Handbook 3rd Edition.

(g) Under other classifications the soils on the site would not be considered high class soils due to soil and climate limitations reducing their capability *of being used intensively to produce a wide variety of plants including horticultural crops.*

(h) Based on the high class soils definition provided in the Operative Regional Policy Statement the soils on the site do not meet the criteria for high class soils as both soil and climate limitations restrict the capability of the site to grow a wide range of plants, including some horticulture and arable crops.

(i) Based on my assessment against the Proposed Regional Policy Statement significant soil criteria (a) through to (e) I do not considered the soils on the site in question to be significant soils because they fail to meet the requirements of criteria (a), (c) and (d), and there is doubt to whether they meet criteria (b) and (e).

(j) Based on my interpretation of the soil information for land use suitability provided by Hewitt (1978) none of the soils on the site in question are classed as high for orchards, cropping or food production.

(k) Viticulture on the whole is most suited to soils that would not be considered high class soils (often soils with LUC classes 4s-7s) and does not indicate the presence of high class soils.

(l) High class soils should be considered on a regional and national basis, and suitability for intensive arable cropping is part of soil being considered as high class soils. Defining high class soils based on "high productivity" does not consider soil versatility for a range of intensive land uses - a key concept of high class soils.

(m) Although some of the soils on the site in question are capable of supporting one or two highly productive horticulture crops (cherry orchards and viticulture) their inherent soil and climate limitations are very likely to restrict their capability to support a wider range of horticulture and cropping land uses.

(n) In my opinion the revised structure plan has identified the soil areas where horticulture and viticulture are most suitable given the limitations of soil depth and climate, and areas of modified soil.

**Definitions of high class soil**

18 For clarity, the terms "high class soil' and "highly versatile soils" are commonly used interchangeably to describe New Zealand's best soils[1]. Throughout my evidence I will use the term high class soils, unless a different term is specifically stated in the literature I am referring to.

19 There is currently no single nationally consistent definition of high class soils used in New Zealand but in statutory assessments guidance is taken from planning documents.

20 In his evidence for the Horizons One Plan, Palmer[2] described highly versatile soils as:

*A highly versatile soil is one that is capable of growing a wide range of crops suited to its particular climate. These soils are identified as LUC Class 1 and LUC Class 2. In terms of its physical characteristics, a highly versatile soil is one which:*

- *Occurs on flat land or very gentle slopes (<5 degrees).*
- *Has a potential rooting depth of at least 0.75 m.*
- *Offers little resistance to root penetration.*
- *Suffers very few days of soil-water deficit.*

[1] https://teara.govt.nz/en/soils/page-9

[2] Palmer, A. (Undated). The issue of Protection of class I and class II soils in the One Plan. Submission to Horizons Regional Council Accessed via: http://www.horizons.govt.nz/assets/new-uploads/about-us/one plan/submitters-expert-evidence-2/general-hearing/One-Plan-Versatile-SoilsStandard.pdf

21 In the South Island, the Environment Canterbury Regional Policy Statement[3] provides a definition for highly versatile soils:

*Soil versatility is an expression used to describe the land use capability of soils. A highly versatile soil has few limitations for use, that is it will be suitable for primary production with few inputs such as additional water or nutrients. Less versatile soil will need more inputs to achieve similar production or will simply be unsuitable for agriculture or forestry. In the Canterbury Regional Policy Statement, versatile soils are those soils that are classified as Land Use Capability I or II in the New Zealand Land Resource Inventory.*

22 In their national assessment of the expansion of lifestyle blocks onto high class soils Rutledge et al. (2010)[4] used LUC class 1 and 2 to define highly versatile soils, providing an estimated area of 50,360 ha for the Otago region.

23 Another published assessment looking at the impact of urban trends on the soil resource[5] states that LUC classes 1 and 2 are generally considered to be versatile, noting that 3e is sometimes included.

24 The rationale for the inclusion of LUC 3e is because these soils can have the same high class soil characteristics as LUC class 1 and 2 soils but with an erodibility limitation based on rolling slopes (8-15° slopes) that still allows for machinery use for horticulture and cropping.

25 The proposed Otago Regional Policy Statement and other recent Regional Policy Statements encompass this in their definitions of high class soils[6].

26 Based on the above examples of high class soil, the soils on the site in question would not be identified as high class soils. This demonstrates that the identification of high class soils will vary depending on the definition used, consequently including, and excluding specific soils that fall within or out of the defining criteria.

27 Many soils (including soils that are not considered high class soils) can be highly productive. For example, viticulture is successfully grown on soils that are predominantly not defined as high class soils. However, for this to occur soil and mostly climate limitations have to be managed (e.g. a permanent water supply for irrigation is essential). Another example is the establishment of intensive dairy

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[3] https://www.ecan.govt.nz/your-region/plans-strategies-and-bylaws/canterbury-regional-policy-statement/

[4] Rutledge DT, Price R, Ross C, Hewitt A, Webb T, Briggs C. 2010. Thought for food: impacts of urbanisation trends on soil resource availability in New Zealand. Proceedings of the New Zealand Grassland Association. 72:241–246.

[5] Andrew R, Dymond JR. (2013) Expansion of lifestyle blocks and urban areas onto high-class land: An update for planning and policy. Journal of the Royal Society of New Zealand. 43:128–140.

[6] Waikato Regional Council (2018) Waikato Regional Policy Statement: Te Tauākī Kaupapahere Te-Rohe O Waikato. Waikato Regional Council, Hamilton.

production on soils that are not high class soils. For production to be possible a permanent water supply for irrigation and the addition of nutrients to the soils are essential.

28 My main point here is that high class soils should be defined based on their inherent characteristics of minimal limitations and ability to support a wide range of land uses without management interventions.

## LUC Classification system for identifying high class soils

29 Land use capability is defined as *the land's properties that determine its capacity for long term sustained production*. The productive capacity of the land is determined by the physical qualities of the land, soil and environment and its limitations. Limitations include susceptibility to erosion, steepness of slope, susceptibility to flooding, liability to wetness or drought, salinity, depth of soil, soil texture, structure and nutrient supply and climate[7]. Increasing limitations reduce the land's versatility for use. These concepts are encapsulated in New Zealand's Land Use Capability Classification system.

30 Throughout New Zealand, the Land Use Capability (LUC) Classification is used to identify high class soils. The LUC Classification criteria and their use are defined according to the Land Use Capability Survey Handbook 3rd Edition[8] .

31 The LUC Classification is a recognised criteria for identifying "significant soils" in the proposed RPS.

32 From a national and regional perspective using the LUC Classification to identify high class soils is essential to provide a consistent and relative criteria based assessment of the land's productive capability locally, regionally, and nationally.

33 The LUC Classification can be applied (mapped) at any scale and regional scale LUC map units can differ from those identified at property scale[9]. Regional scale LUC map units can consist of more than one LUC Unit, as is the case for the LUC map information for the area in question (I refer you to **Appendix 1**).

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[7] Lynn, IH, Manderson, AK, Harmsworth, GR, Eyles, GO, Douglas, GB, Mackay, AD, Newsome PJF. 2009. Land Use Capability Handbook - a New Zealand handbook for the classification of land 3rd Ed. Hamilton, AgResearch; Lincoln, Landcare Research; Lower Hutt, GNS Science 163pp.

[8] Lynn, IH, Manderson, AK, Harmsworth, GR, Eyles, GO, Douglas, GB, Mackay, AD, Newsome PJF. 2009. Land Use Capability Handbook - a New Zealand handbook for the classification of land 3rd Ed. Hamilton, AgResearch; Lincoln, Landcare Research; Lower Hutt, GNS Science 163pp.

[9] Lynn, IH, Manderson, AK, Harmsworth, GR, Eyles, GO, Douglas, GB, Mackay, AD, Newsome PJF. 2009. Land Use Capability Handbook - a New Zealand handbook for the classification of land 3rd Ed. Hamilton, AgResearch; Lincoln, Landcare Research; Lower Hutt, GNS Science 163pp.

34 Applying regional scale LUC (and soil) map information at property scale should only be used as a guide rather than assumed to represent the definitive soils and LUC map units for the property.

**Soil and LUC map information within Plan Change 14**

*Available soil and LUC map information*

35 In my evidence I use the term "map information" to refer to maps and associated information provided in the map legend and any associated report containing additional LUC or soil information such as LUC limitations, soil profile descriptions, soil chemical and physical analysis and land use suitability interpretations.

36 The main sources of soil map information available for the area in question are "Soils and land use in the Upper Clutha Valley, Otago" (Leamy and Saunders, 1967)[10], growOTAGO Online Maps[11], S-Map Online[12] and Fundamental Soil Layer[13] soil information.

37 The growOTAGO soil map units for the PPC14 site is provided in **Appendix 2**.

38 Regionally, the growOTAGO data was derived from existing soil map information such as Leamy and Saunders (1967) with limited ground work to fill the gaps. During the compilation, a number of previous soil series have been merged to provide a uniform coverage of soil series. Some simplification and loss of detail were necessary where very detailed soil maps were available[14]. The growOTAGO soil maps are produced at a scale accurate to 1:50,000. The soil map information was based on existing soil map information, which for the 144 Ripponvale Road site is most likely to be Leamy and Saunders (1967).

39 The S-Map Online soil map units[15] for the PPC14 site is provided in **Appendix 3**.

40 A detailed list of S-Map key soil criteria was provided by Lynn in his PPC14 report (PPC14 - Appendix L). The main points to note (as with the growOTAGO soil map information) are that the soil map units are less detailed than the soil map units provided by Leamy and Saunders (1967) and differ slightly in area.

41 The soil map information in growOTAGO and S-map are the same; the S-Map map units are derived from the growOTAGO data. However, the S-map soil map information should be considered more reliable than the growOTAGO soil map

[10] Leamy ML, Saunders WMH. (1967) Soils and land use in the upper Clutha Valley. Otago. Soil Bureau Bulletin 28. DSIR, Wellington.

[11] growOTAGO® Companion Booklet, Otago Regional Council, Dunedin. http://growotago.orc.govt.nz/map/

[12] https://smap.landcareresearch.co.nz

[13] https://lris.scinfo.org.nz/layer/48137-fsl-south-island-all-attributes/metadata/

[14] growOTAGO® Companion Booklet, Otago Regional Council, Dunedin.

[15] https://smap.landcareresearch.co.nz/app/?m=MTM3MzMzYTM

information as it has undergone greater quality assurance by Manaaki Whenua Landcare Research[16].

42 Other soil map information is available for the surrounding district at a scale of 1:15,840. This soil map information includes reports and maps for "Soils of Alexandra District"[17] and "Soils of the Cromwell Gorge"[18]. Although a report is available for the "Soils of the Cromwell Gorge", the map covering the site is not available. My understanding is this map sheet was never completed for the published report.

43 The Leamy and Saunders (1967) soil map is produced at a scale accurate to 1:31,680. Although the oldest of the soil map information sources, it provides the most detailed and accurate soil map information mapped as part of a soil survey. The soil survey area covers approximately 60,000 ha of the Upper Clutha valley.

44 This soil map information should be considered the most reliable of the available soil map information and at a regional and district level provides adequate soil map information for decision making. However, applied at the property scale there are some boundary inaccuracies.

45 A soil map for the PPC14 site is provided in **Appendix 4**.This map is mostly based on the soil map information from Leamy and Saunders (1967), with the addition of the "AW" steepland soils which was derived from Fundamental Soil Layer soil map information[19] and added for completeness.

46 S-Map soil map information is a simplified version of the Leamy and Saunders (1967) soil survey so spatially the map units are of less detail. However, the soil characteristics data associated with the identified soil siblings provides useful additional information about the soil profile.

47 S-Map soil siblings are members of a soil families and partition soil families based on unique combinations of drainage class, topsoil stoniness, soil depth, texture contrasts, and a sequence of up to six functional horizons[20].

48 For the Ranf_4a.1 soil sibling which correlates with the Waenga (W5) soil map unit, the following soil characteristics are noted:

The topsoil typically has loam texture and is stoneless. The subsoil has dominantly loam textures, with gravel content of > 3% but < 35% for most of the

[16] Pers. Comm. Sam Carrick, 2019.
[17] McCraw JD. (1964) Soils of Alexandra District. Soil Bureau Bulletin 24. DSIR, Wellington.
[18] Hewitt AE. (1978) Soils of Cromwell Gorge, Central Otago, New Zealand. New Zealand Soil Survey Report 41. DSIR, Wellington.
[19] https://lris.scinfo.org.nz/layer/48137-fsl-south-island-all-attributes/
[20] https://smap.landcareresearch.co.nz/support/faq/#definitions

soil. The plant rooting depth is 35 - 65 (cm) due to densely packed gravels that mechanically impedes root growth. Generally, the soil is imperfectly drained with high vulnerability of water logging in non-irrigated conditions and has moderate to high soil water holding capacity. Inherently, these soils have a very high structural vulnerability (prone to soil compaction and structure degradation when grazed or cultivated when wet) and a moderate N leaching potential, which should be accounted for when making land management decisions.

*Limitations of current map information*

49 A soil map shows the spatial distribution of soils for an area. Maps are usually based on field soil observations and the assessment of other related environmental data such as topography, geology, geomorphology, vegetation, land cover, and climate (Grealish, 2017)[21].

50 Map scale is the ratio of the size of a feature on a map compared with the size of the feature on the ground. For example, at 1:20,000, 1 cm on the map represents 200 m on the ground. A detailed scale map (e.g. 1:500 to 1:15,000) enables identification of short-range spatial changes in soils, whereas a broad-scale map shows less detail (i.e. > 1:25,000 scale) and can used for catchment and regional planning but cannot be used for site specific (property scale) management. This is primarily because the density of observations is not sufficient to delineate the soil map unit areas[22].

51 Maps are usually drawn at specific scale depending on the smallest area of interest for a particular use and the density of field observations. For example, a 1:5,000 scale map requires on average four observation/ha while a 1:50,000 scale map requires 0.04 observation/ha (four observations per 100 ha)[23].

52 Enlarging maps from their original scale will not provide the same accuracy or contain more detail then a broad scale map. Inaccuracies, such as the location of boundary lines, will be magnified. The increase in scale will not capture the effect of different parameters or factors that control the distribution of soil types[24].

53 The LUC classification can be applied and mapped at any scale. Property scale mapping is typically mapped at a scale between 1:5,000 and 1:15,000 for detailed

[21] Grealish G. 2017. New Zealand soil mapping protocols and guidelines. Envirolink Grant: C09X1606. Manaaki Whenua – Landcare Research.

[22] Grealish G. 2017. New Zealand soil mapping protocols and guidelines. Envirolink Grant: C09X1606. Manaaki Whenua – Landcare Research.

[23] Grealish G. 2017. New Zealand soil mapping protocols and guidelines. Envirolink Grant: C09X1606. Manaaki Whenua – Landcare Research.

[24] Hewitt A, Lilburne L. 2003. The effect of scale on the information content of soil maps. Soil News Vol. 51 No. 4. NZSSS.

farm planning and smaller properties while for farm planning for larger properties, catchments and regional maps are mapped at 1:15,000 to 1:50,000 scale[25,26].

54 To the best of my knowledge, a property scale field assessment of the soil and LUC classification have not been completed for the site in question.

55 The Leamy and Saunders (1967) soil survey is at a more detailed scale (1:31,680 scale) that the other available map information (1:50,000 scale).

56 The Leamy and Saunders (1967) map scale could be considered adequate for indicating the soils present for a property the size of the area in question (244 ha) as soil and LUC assessments for farms of similar size and larger are undertaken at scales between 1:15,000 to 1:25,000 scale. However, there will be limitations when applying these maps at a finer scale as I mention in my evidence above.

57 The limitations of applying the available soil and LUC map information to the site in question are that map unit boundaries and areal extent of soils identified may not be accurate, and that areas of modified soil are most likely not identified. There is potential that the soils on the site may differ from those identified in the mapping, however, given the scale of the Leamy and Saunders (1967) survey (1:31, 680 scale) this is less likely.

58 I have undertaken a desktop visual assessment of the map information for the area which indicated some areas where soil map boundaries (and therefore LUC classes) are likely to be inaccurate.

59 A detailed slope map of the mapped Waenga (W5) soils provided to be by the Applicant (**Appendix 5**) indicates where there is a change in slope, the existing soil map unit boundaries are likely overestimating of their extent.

60 Based on the topography and the mapped adjoining soil map units these areas are likely not Waenga (W5) soil. The general area affected is shown by the area identified as “7° +” in the map legend and is estimated at five (5) ha.

61 In addition to these map unit boundary inaccuracies, unless field soil observations were made as part of the original soil survey by Leamy and Saunders (1967) the delineation of the smaller areas of Lowburn very shallow sandy loam, rolling phase (L2) cannot be confirmed, and other soil map unit areas may be affected.

### *Modified soil areas*

[25] Grealish G. 2017. New Zealand soil mapping protocols and guidelines. Envirolink Grant: C09X1606. Manaaki Whenua – Landcare Research.

[26] Lynn, IH, Manderson, AK, Harmsworth, GR, Eyles, GO, Douglas, GB, Mackay, AD, Newsome, PJF (2009) Land Use Capability Handbook - a New Zealand handbook for the classification of land 3rd Ed. Hamilton, AgResearch; Lincoln, Landcare Research; Lower Hutt, GNS Science 163pp.

62 For an accurate assessment of LUC Classification for a property, the assessment should be based on the current condition of the area. This is important because some land management practices (e.g. the placement of tracks, excavation for buildings, excavation of drains and soil remediation for soil contamination) can irreversibly change the soil and land. These areas are defined as Modified soils. In essence these are soil are classified as Anthropic Soils[27] and can no longer be considered high class soils.

63 I have undertaken an assessment of the area of Waenga (W5/b and W3+W5/c) soils based on the Leamy and Saunders (1967) soil map unit in the area in question using available aerial photography and information provided in the report provided by WSP Opus for the Applicant (PPC14 – Appendix K). A map of the modified soil areas identified is provided in **Appendix 6**.

64 Based on my initial desktop assessment using aerial photography of the site areas of likely modified soils were identified and estimated to occupy ~5.4 ha of the Waenga (W5/b and W3+W5/c) soil area.

65 My analysis identified similar areas to those presented as ineffective areas in Figure 1 of evidence provided by Mr Edwards and the excluded areas in the evidence of Mr Dicey[28].

66 I do note that these are desktop based estimates, in respect of both the underlying soil classification and the modified areas.

67 In combination the areas of inaccurate soil map boundaries and modified soils could reduce the mapped Waenga (W5) soil area by as much as 10.4 ha.

**Definitions of high class soil for the Otago region.**

## *"High Class soils of Otago " definition*

68 A definition of high class soils is provided in the (McIntosh (1993) report "High Class Soils in Otago" (McIntosh (1993) [29]. The definition states high class soils are:

*"soils that are capable of being used intensively to produce a wide variety of plants including horticultural crops".*

69 McIntosh (1993) describes the methods used to distinguish and calculate the area of high class soils of Otago Region. The method notes using map units distinguished in the New Zealand Land Resource Inventory (NZLRI) and,

[27] Anthropic soils – "Other soils that have been formed by the direct action of people by either truncation, drastic mixing or by deposition of material 30 cm or more thick" (Hewitt, 2010).
[28] Appendix 6 of Statement of evidence of James Dicey, 20 May 2020.
[29] McIntosh P.D. (1993) High Class Soils in Otago. Landcare Research Contract Report LC9293/85. p24.

specifically LUC Class I, Class II and Class III. Other criteria[30] are then applied to refine high class soils further.

70 The use of LUC classes 1 and 2 and some of LUC class 3 is consistent with that used to define high class soils (also termed highly versatile soils, highly productive soils) elsewhere in New Zealand in regional policy, however, the exact criteria used by McIntosh (1993) are not clearly defined in the available report, and in my opinion the criteria are more permissive for soil depth and climate, and for soil depth differ from the classes used in the LUC Survey Handbook 3rd Edition[31].

71 Of particular note are that high class soils include soils with a soil depth of <45 cm and that high class soils can have growing degree days (GGD10°C) as low as 400, well below the accepted minimum GDD for horticulture. Additionally, there is no consideration of frost.

72 Base on the Mcintosh (1993) classification for high class soils the Waenga (W5 and W3) and Ripponvale (R3) soils are classified as high class soils.

73 In my evidence presented for Private Plan Change 13 (PPC13) I concluded that based solely on the McIntosh (1993) classification similar classed soils (LUC 3s6) were high class soils. In my PPC13 evidence I did not specifically consider the RPS definitions.

74 However, on subsequent examination of the individual criteria used by McIntosh (1993), I consider the criteria for soil depth and climate to be too broad and not in alignment with the LUC Survey Handbook 3rd Edition and other examples of criteria used to identify high class soil in New Zealand.

75 These broad criteria allow the inclusion of soils that under other classifications would not be considered high class soils due to soil and climate limitations reducing their capability *of being used intensively to produce a wide variety of plants including horticultural crops.*

## *Operative Otago Regional Policy Statement*

76 The definition for high class soil provided in the *Operative Otago* R*egional Policy Statement* (RPS) reads:

77 **High class soils** are "soils that are capable of being used intensively to produce a wide variety of plants including horticultural crops. The definition requires good soil and other resource features that in combination are capable of producing a wide

[30] Table 1. Properties of high class soils, page 5 in McIntosh (1993).

[31] Environment Canterbury Regional Policy Statement; Waikato Regional Policy Statement; Auckland 2050 Plan.

range of crops. It does not include areas that may be suited to one or two specialist crops, largely due to the climate rather than soil quality".

78 The definition provides no reference to the use of the Land Use Capability Classification for identifying areas of high class soils nor does it refer to report by McIntosh (1993) as a basis for defining high class soils.

79 Of importance in the definition are the statements "capable of being used intensively to produce a wide variety of plants including horticultural crops", "good soil and other resource features that in combination are capable of producing a wide range of crops", and "does not include areas that may be suited to one or two specialist crops, largely due to the climate rather than soil quality".

80 My interpretation of these statements are that they refer directly to highly versatile soils, that is, soils that have minimal limitations (including limitations other than soil limitations) that allows them to be used for a wide range of uses, including horticulture, intensive and arable cropping, intensive pasture, and dairy. The definition also states that it does not include areas that may be suited to one or two specialist crops, largely due to the climate rather than soil quality.

81 Aerial photo interpretation of the Cromwell area indicated this to be the case, with cherry orchards, viticulture, centre pivot dairy and low intensity pastoral farming occupying the land in the Cromwell area. Furthermore, the distribution of viticulture and orchards was across a range of soils, with varying soil limitations. Predominantly viticulture is on soils that are not high class (LUC units 4s9, 4s15 and 7s12). What was common was the presence of large irrigation storage ponds indicating irrigation was required for production, due to the low water holding capacity of the soils (which is low for shallow stony soils) and the low rainfall in the area (~400 mm MAR).

82 Additionally, the low frost free period[32] (i.e. frequent frosts) would allow for viticulture and cherry orchards in most areas but would be limiting for other horticulture such as kiwifruit, avocado, and cropping, including commercial vegetable growing and seed production.

83 Mr Edwards in his evidence notes the presence of decommissioned historical summer fruit orchards in differing states of repair on the site. He surmises that this presumably because this use is no longer viable. The Operative Central Otago District Plan identified the presence of apples, summer fruit, cherries in the district. However, Mr Edwards notes there are very few nearby summer fruit orchards, with

[32] Based on growOTAGO map information.

poor productivity from these fruits driving change to alternative crops, predominantly cherries and grapes in the local area.

84 Mr Edwards statements align with my opinion that due to climate limitations the site in question is only suited to one or two specialist crops, largely due to the climate rather than soil quality.

85 Applying this definition to the site in question which could support highly productive viticulture and cherry orchards (subject to permanent long term irrigation supply) would suggest the latter is applicable rather than the site being capable of producing a wide range of crops. My interpretation is that the soil and climate limitations of area are such that the soils and land on the site are only suited to one or two specialist crops, largely due to the climate rather than the soil.

86 Given the soil and climate limitations (shallow soils less than <45 cm depth, low to moderate water holding capacity, low rainfall and low frost free period) of the site in question, the soils would not meet the operative RPS definition for high class soils because they are not capable of being used intensively to produce a wide variety of plants including horticultural crops. Rather they are only suited to one or two specialist crops, largely due to the climate rather than soil quality. This would include viticulture and some orchards but exclude intensive cropping or intensive pastoral uses.

87 If high class soils are considered on a regional basis (for which the Otago RPS applies) the broad consideration of high class soils and the concept of soil versatility are important.

88 This importance was noted in Mr Lynn's report on the soils for the Applicant (PPC14 - Appendix L) where he stated that the soils cannot be considered "high class" if they are not suitable for "intensive arable cropping". Mr Lynn's assessment was based on more detailed soil profile data now available from national the S-Map database.

89 My conclusion is that based on the definition provided in the operative Regional Policy Statement the soils on the site in question do not meet the criteria for high class soils as both soil and climate limitations restrict the capability of the site to grow a wide range of plants, including some horticulture and arable crops.

### *Proposed Regional Policy Statement*

90 The Proposed Otago Regional Policy Statement (PRPS) does not provide a definition for high class soils. Instead the term "significant soils" is used and the following definition provided:

***Policy 3.2.17 Identifying significant soils*** *Identify areas of soil that are significant using the following criteria:*

*a) Land classified as land use capability I II and IIIe in accordance with the NZ Land Resource Inventory*

*b) Degree of significance for primary production*

*c) Significance for providing contaminant buffering or filtering services*

*d) Significance for providing water storage or flow retention services*

*e) Degree of rarity*

91 Applying the definition criteria to the soils of the site in question, criteria (a) is not met based on the LUC map information provided in my evidence as none of the LUC classes or subclasses are LUC class 1, 2 or subclass 3e.

92 Criteria (b) refers to the significance for primary production. Based on LUC Survey Handbook criteria[33] and the soil and LUC map information provided in my evidence, a proportion of the land and soils on the site in question (LUC units 3s6 and 3c3) are classed as Multiple use land with soil and climate limitations and moderate arable cropping suitability. The remainder of the land and soils are classed as low suitability for arable cropping (4s9) with soil limitations, or unsuitable for arable cropping (6e22 and 6e19) with erodibility limitations.

93 There is evidence to support the soils and land being capable of viticulture and orchard production, but these primary production land uses are not specifically limited to the soils and LUC classes on the site.

94 With the exception of the Waenga (W5) soil, the soils on the site in question are predominantly shallow with low water holding capacity and therefore do not meet the requirements for criteria (c) or (d). I would go further to say that with regard to criteria (c), the intensification of these soils is likely to increase losses of nutrients and other contaminants from the soil to the groundwater. The Waenga (W5) soil has moderate to very high profile available water but also high bypass flow, which reduces its provision of services for both criteria (c) and (d).

95 Criteria (e) is difficult to interpret from a soil perspective, without a spatial analysis of the region's soils and their distribution, and consideration of the remaining areas of primary production on the soils. Simply using the soil series name in a local context does show the soil to be of limited extent in the immediate Cromwell area, more common north of Lowburn, and more common again around Luggate and

[33] Lynn, IH, Manderson, AK, Harmsworth, GR, Eyles, GO, Douglas, GB, Mackay, AD, Newsome PJF. 2009. Land Use Capability Handbook - a New Zealand handbook for the classification of land 3rd Ed. Hamilton, AgResearch; Lincoln, Landcare Research; Lower Hutt, GNS Science 163pp.

Tarras[34]. However, because soil series names change across the region, soils with similar profiles and characteristics are difficult to identify to assessment the "rarity". for soils with similar profile characteristics this does not fully represent the "rarity" of the soils in question.

96 S-map soil siblings nationally group soils with similar soil profile characteristics and can be used to provide an indication of "rarity" of soils with common characteristics. The areas for each soil sibling can be estimated for Leamy and Saunders soil survey area (I refer you to **Appendix 7**). For the soil siblings identified on the site in question, the Ranf_4a.1 Sibling (correlated with the Waenga (W5) soil) was the seventh (of 77) most common soil sibling by area (1790 ha) for the soil survey area and represented ~14% of the total area (13,130 ha) of moderately deep soils in the soil survey area.

97 Based on my assessment against the PRPS significant soil criteria (a) through to (e) I do not considered the soils on the site in question to be significant soils because they fail to meet the requirements of criteria (a), (c) and (d), and there is doubt to whether they meet criteria (b) and (e).

**Interpretation of soil map information for Land use**

98 In addition to the land use suitability interpretations of Leamy and Saunders (1967) summarised in Mr Gibson's evidence, additional interpretations of land use suitability are provided in Hewitt (1978) for the soils of the Cromwell Gorge. This survey was a more detailed scale (based on 1:15,840 scale aerial photography) than that of Leamy and Saunders (1967). The relevance of this is that there were more soil observations made from which to interpret the soils suitability for land use.

99 Hewitt's interpretations are based on previously used land use interpretations of Cutler (1967)[35] and McCraw (1964). Based on the soil map information of Leamy and Saunders (1967), the following classes are assigned to the soils present on the site in question for orcharding, cropping and food production.

100 For orcharding the Waenga soils are classed as second class orchard soils. Second-class orchard soils typically have one or more impediments to tree growth including shallow and stony soils.

101 Lowburn soils are identified as third-class orchard soils with severe impediments which interfere with tree growth, typically they are extremely porous, stony, have

[34] Based on the soil map Sheets 2 and 3 in Leamy and Saunders (1967).

[35] Cutler EJB. (1967) Soils of the Otago Region. Pp. 35-51 in National Resources Survey, Part V – Otago Region. Compiled by Town and Country Planning Division, Ministry of Works and Development, Wellington.

uneven topography and soil horizons of low permeability. Letts soils are classed as unsuitable for orchards.

102 For cropping suitability, the interpretation follows that of Cutler (1967). It is noted that the suitability ratings are generalised as the suitability of the various soils will depend on the crop grown. Applying the classification, the Waenga soils and Lowburn soils are classed as having severe soil limitations for crop production with shallow and stony profiles and serious moisture deficiency. However, for the Waenga fine sandy loam (W5) on the site in question, shallow soils is unlikely to be a limitation.

103 The classification of soils for food production, classifies soils according to their actual and potential value for food production based on Cowie (1974), and was the basis for Section 2B(b) of the Town and Country Planning Act 1953 (1973 Amendment). Applying this classification, Waenga soils are classed as having moderate actual or potential value for food production with limitations of poor physical properties, or stoniness and droughtiness. Lowburn soils and Letts soils are classed as having low actual or potential value for food production.

104 The main point drawn from my interpretation of the soil information for land use suitability is that none of the soils on the site in question are classed as high for orchards, cropping or food production.

### *Suitability for horticulture based on growOTAGO climate data*

105 The growOTAGO climate data available for the site in question provides available climate data for assessment the site's suitability for horticulture in relation to climate. This data has been referred to and used by Mr Dicey and Mr Gibson in their evidence.

106 Ward and Clothier (2019) in their desktop study assessing the suitability of different horticultural and plant-based foods in selected areas of North Canterbury, provide general climate requirements for horticulture.

107 Their assessment of the general suitability for horticulture included Growing Degree Days base 10°C (GDD10) of at least 800 degree days and a Frost Free Period (FFP) of at least 200 days. For some crops such as kiwifruit, the GDD10 is greater.

108 Based on a the growOTAGO map information for the site in question, the annual GDD10 are sufficient for horticulture in general, however, the site is not likely to be suitable for all horticulture land uses.

109 The map information for FFP indicates that the FFP is below the minimum of 200 days (I refer you to **Appendix 8**).

110 This is a climate limitation. Both Gibson and Dicey acknowledge this limitation in their evidence when discussing site suitability for viticulture and orchards, stating that the limitation can be managed using wind machines. However, this management technique unlikely to be viable for lesser value cropping land uses.

111 Again, this suggests that the site in question, is suited to one or two specialist crops, largely due to the climate rather than soil.

### *Land use and soils on the PPC14 site*

112 In my opinion the revised structure plan (**Appendix 9**) has identified the soil areas where horticulture and viticulture is most suitable (given the soil depth and climate limitations of the soils).

113 The proposed establishment of cherry orchard (H horticulture area) and the location of the RLA6 makes the best use of the larger contiguous area of mostly Ripponvale (R3) and Waenga (W5 and W3) soils (presented to earlier in my evidence – **Appendix 4**).

114 Based on my assessment of the distribution of the modified soil areas (presented to earlier in my evidence – **Appendix 6**) the remaining Waenga (W5) soil area in RLA1 is broken up by the presence of modified soil areas reducing the productive capability of the area and likely to make the area difficult to establish in a way that is easy to manage.

115 The remaining area of Waenga (W3+W5/c) soils in RLA2 (and some of RLA4) are dominated by shallower Waenga (W3) soils with a soil limitations and is south facing which may also increase the severity of climate limitations present in the area as identified in the evidence of Mr Larsen and Mr Edwards.

## Further comments on evidence documents regarding soils

116 I have read the PPC14 evidence, supplementary evidence and reports by Mr Gibson, Mr Dicey, Mr Whitney and Mr Lynn. The following summarises my comments regarding soils in their PPC14 documents.

### *Soil map information*

117 With reference to the evidence of Mr Gibson. Mr Gibson provides a good overview of much the same soil map information sources as I have considered in my report. He has identified that the Leamy and Saunders (1967) soil map information provides the best soil map information available. I agree with his statement that the maps remain the best and most detailed spatial resource for soils of the area, subject to my comments above regarding the reliability of this information at a property scale.

## *High class soils*

118 Both Mr Gibson and Mr Whitney refer to the McIntosh report (High class soils of Otago)[36] stating that Waenga soils are identified as high class soils. This is true. However, McIntosh considered all LUC class 3 soils high class soils. This does not take into consideration limitations of soil depth and climate, identified by Lynn et al. (2009), nor the definition in the proposed RPS for significant soils which clearly only includes LUC sub-class 3e (3s and 3c are excluded).

119 There is a high reliance on the McIntosh report to support their statements that the Waenga fine sandy loam (W5) soil is a high class soil. As I have discussed in my evidence, this classification has very permissive soil depth and climate criteria that would allow soils with limitations for supporting a wide range of horticulture and cropping to be included.

120 The NZLRI LUC map information classifies this soil on the property as LUC unit 3c3 with a moderate climate limitation. Although Gibson and Dicey provide ample evidence that grapes and orchards can be successfully established on these soils (and the fact that the Applicant plans to establish these land uses on the soil supports this) the suitability of the soils and climate for the wider range of horticultural land uses, and intensive cropping is not discussed.

121 In my opinion using this to justify these soils as high class soils is not correct, rather, the soils are *suited to one or two specialist crops, largely due to the climate rather than soil.*

## *Viticulture suitability and high class soils*

122 In my opinion the presence of viticulture land use or suitability for viticulture does not indicate the presence of high class soils. Rather, it is more likely to indicate soils that have severe limitations that make it marginal or unsuitable for arable use. In the Cromwell area these limitations are likely to include very shallow or stony soils, very low moisture holding capacity, severe impediments to cultivation, severe climate limitations and salinity limitations.

123 Mr Dicey in his PPC14 evidence states that low to moderate water and nutrient holding capability and low to moderate fertility are common to soils in the Ripponvale Road area, and that these characteristics plus the other climatic conditions make them optimal to grow both grapes and cherries.

[36] McIntosh PD. (1993) High Class Soils in Otago. Landcare Research Contract Report LC9293/85. p24.

124 The soil characteristics noted by Mr Dicey would for most other horticultural and cropping land uses, be considered unfavourable and not characteristics of high class soils.

125 An aerial photography assessment of the Crowell area indicated that vines and orchards in the area are predominantly located on LUC units 4s9, 6e19, 3s6 and 7e15 with a small area on 3c3. From my interpretation of the aerial photography other land uses on these LUC units included low intensity pasture, lifestyle blocks, irrigated dairy, forestry, recreational and industrial uses, and urban subdivision.

126 The soils on LUC units 3s6 and 3c3 although suitable for viticulture and cherries are by no means unique or specifically required for the production of either viticulture or orchard land uses in the Cromwell area. Also, these soils do not seem to be utilised for any other significant areas of intensive land uses in the area.

127 Based on this, I suggest that that the presence of, or suitability for viticulture does not indicate the presence of high class soils, and that the likely capability of the soil to support a broader range of intensive land uses is restricted by soil limitations, most likely in combination with climate limitations.

### *Comments on raised organic matter*

128 Mr Gibson expressed the opinion (also referred to by Whitney) that the total organic matter component of the soils (resulting from previous irrigation) raises the value of these soils very significantly; to the extent that Mr Gibson is of the opinion that W5 soils are lifted from “high class” to “outstanding”. In my opinion this confuses soil quality (pertaining to how a land use is managed) and the concept of high class soils and is therefore not relevant to the argument of whether the soils are high class soils. The misinterpretation has arisen through the incorrect use of the term “soil quality” instead of “high class soils” in planning documents, such is the case with the operative Otago Regional Policy Statement. High class soils should be defined based on inherent soil characteristics as this avoids temporal variability in soil biological, chemical, and physical soil properties (soil quality) associated with different land use and land use management practices. Soil quality measures such as soil organic matter levels will vary for a given land use and management.

### *Comments on Lynn’s report*

129 Mr Lynn’s report on the soils for the applicant states the soils cannot be considered “high class” unless if they are not suitable for “intensive arable cropping”.

130 Mr Gibson disagrees with this stating that this “is simplistic and highly restrictive and is at odds with other classifications and does not recognise that soils can be extremely valuable and of high class to particular industry and yet still not ideally “arable”. It assumes arable farming is the ultimate use a soil can be put to. For our

much more sustainable horticultural and viticultural systems the soils we value the most might be the soils with just the right moisture release characteristics, soil chemistry, physics and biology to grow the highest quality fruit or make the best wines to be found in the world".

131 My opinion differs from Mr Gibson's interpretation, and aligns with Mr Lynn's on this matter. High class soils should be considered on a regional and national basis, and suitability for intensive arable cropping is part of soil being considered as high class soils. Mr Gibson's interpretation (referring to viticulture) is centred around "highly productive" but again does not consider soil versatility for a range of intensive land uses - a key concept of high class soils. Viticulture on the whole is most suited to soils that would not be considered high class soils (often soils with LUC classes 4s-7s).

**Conclusions**

132 Based on my assessment of the available soil map information, I conclude that the best available soil map information is provided by Leamy and Saunders (1967), however, the information should be treated with caution due to the scale, especially with regard to the accuracy of soil map unit boundaries.

133 Based on my assessment of the available LUC map information, I conclude that the best available soil map information is provided by the NZLRI (1:50,000 scale) LUC map information however, this information should also be treated with caution due to the scale, especially with regard to the accuracy of LUC map unit boundaries.

134 A property scale assessment of soils and LUC could confirm the soils and LUC classes, more accurately delineate map unit boundaries, and identify areas of modified soils, however, the general soil LUC classes, map units and modified soil area are unlikely to change the overall presence of the soils and LUC maps for the site in question.

135 Inaccurate soil map boundaries are likely to reduce the actual area of Waenga (W5) soils by about 5 ha, based on available slope map information.

136 Modified soils are estimated to occupy 5.4 ha of the Waenga (W5/b and W5+W3/c) soil area, reducing the productive capability of these soil areas.

137 Based on the Mcintosh (1993) classification for high class soils the Waenga (W5 and W3) and Ripponvale (R3) soils are classified as high class soils. However, I consider the criteria for soil depth and climate too broad and inconsistent with national criteria now provided in the LUC Survey Handbook 3rd Edition.

138 Under other classifications the soils on the site) would not be considered high class soils due to soil and climate limitations reducing their capability *of being used intensively to produce a wide variety of plants including horticultural crops.*

139 Based on the high class soils definition provided in the Operative Regional Policy Statement the soils on the site do not meet the criteria for high class soils as both soil and climate limitations restrict the capability of the site to grow a wide range of plants, including some horticulture and arable crops.

140 Based on my assessment against the Proposed Regional Policy Statement significant soil criteria (a) through to (e) I do not considered the soils on the site in question to be significant soils because they fail to meet the requirements of criteria (a), (c) and (d), and there is doubt to whether they meet criteria (b) and (e).

141 Based on my interpretation of the soil information for land use suitability provided by Hewitt (1978) none of the soils on the site in question are classed as high for orchards, cropping or food production.

142 Viticulture on the whole is most suited to soils that would not be considered high class soils (often soils with LUC classes 4s-7s) and does not indicate the presence of high class soils.

143 High class soils should be considered on a regional and national basis, and suitability for intensive arable cropping is part of soil being considered as high class soils. Defining high class soils based on “high productivity” does not consider soil versatility for a range of intensive land uses - a key concept of high class soils.

144 Although some of the soils on the site in question are capable of supporting one or two highly productive horticulture crops (cherry orchards and viticulture) their inherent soil and climate limitations are very likely to restrict their capability to support a wider range of horticulture and cropping land uses.

145 In my opinion the revised structure plan has identified the soil areas where horticulture and viticulture are most suitable given the limitations of soil depth and climate, and areas of modified soil.

Dated this 16 September 2020

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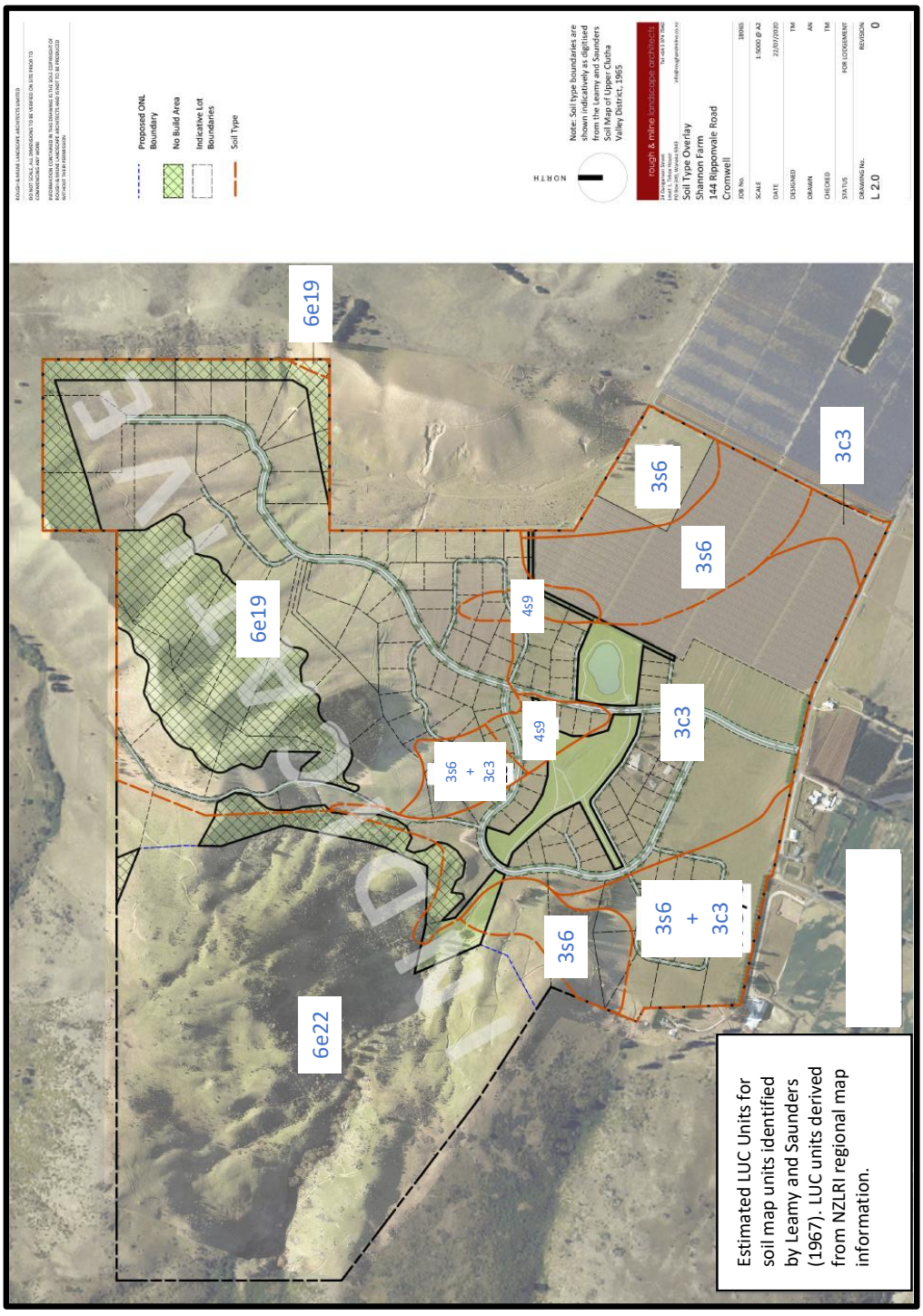
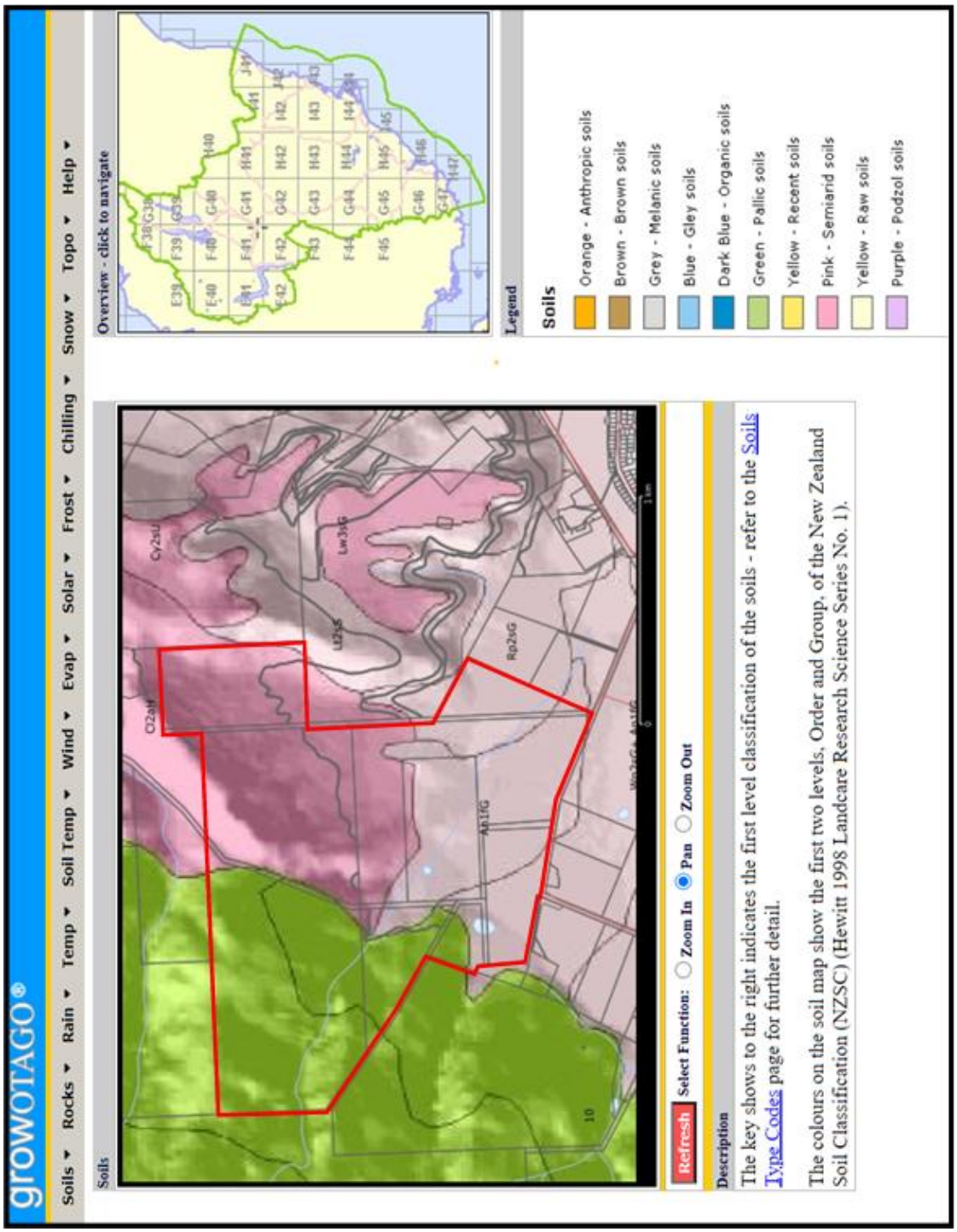
Reece Blackburn Hill

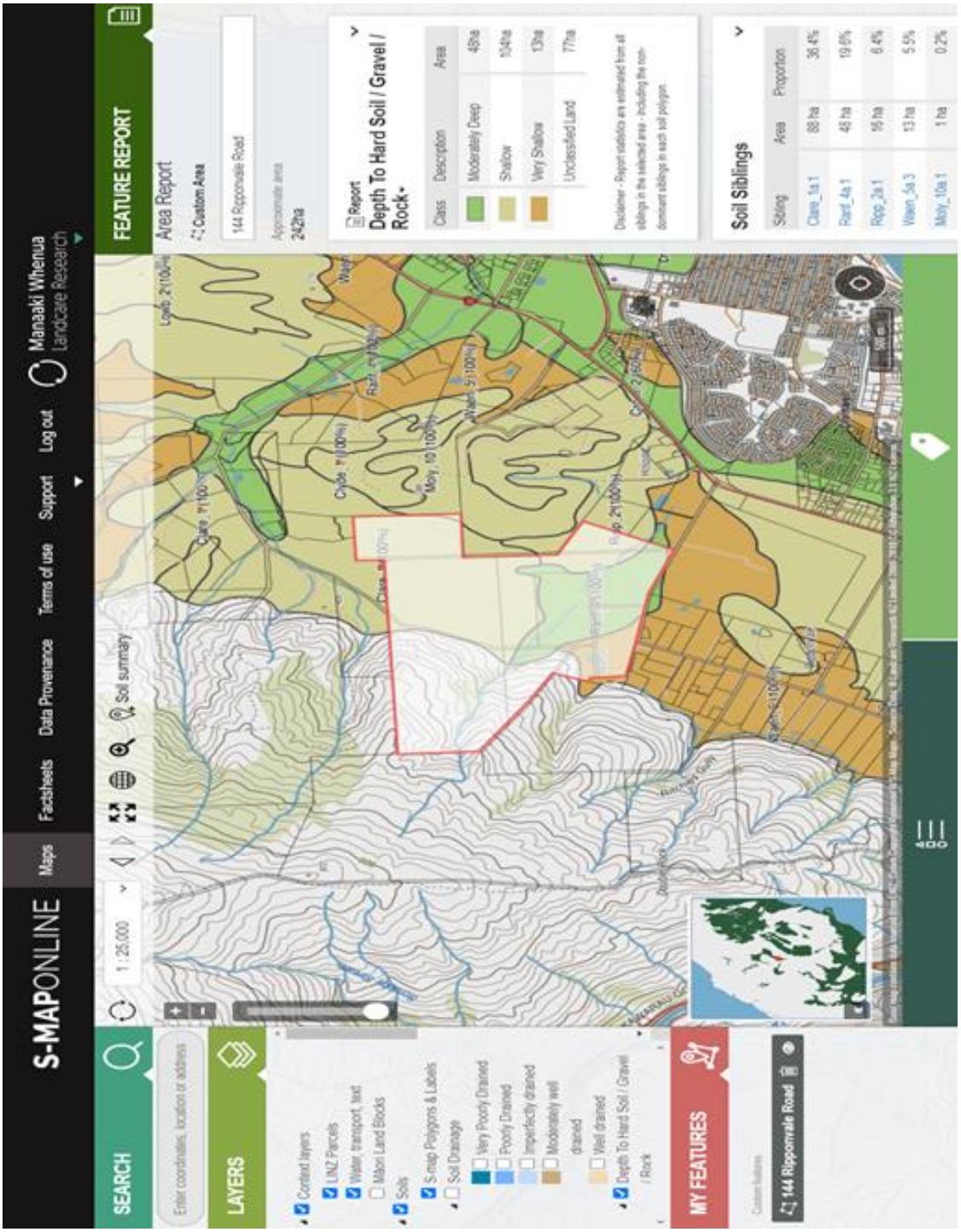
## Appendix 1. Map of estimated LUC Units for the PPC14 site.



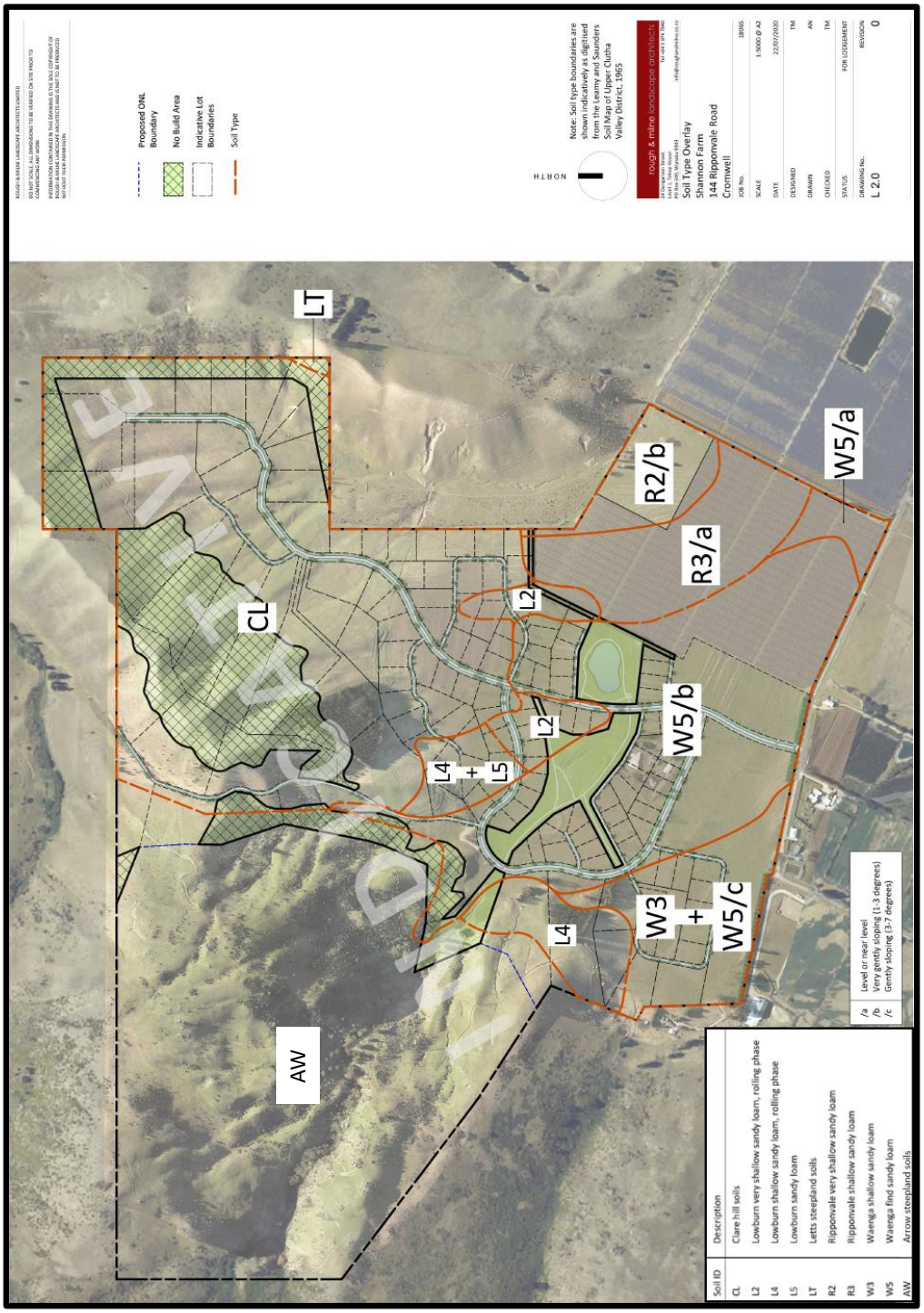
## Appendix 2. The growOTAGO soil map units for the PPC14 site.



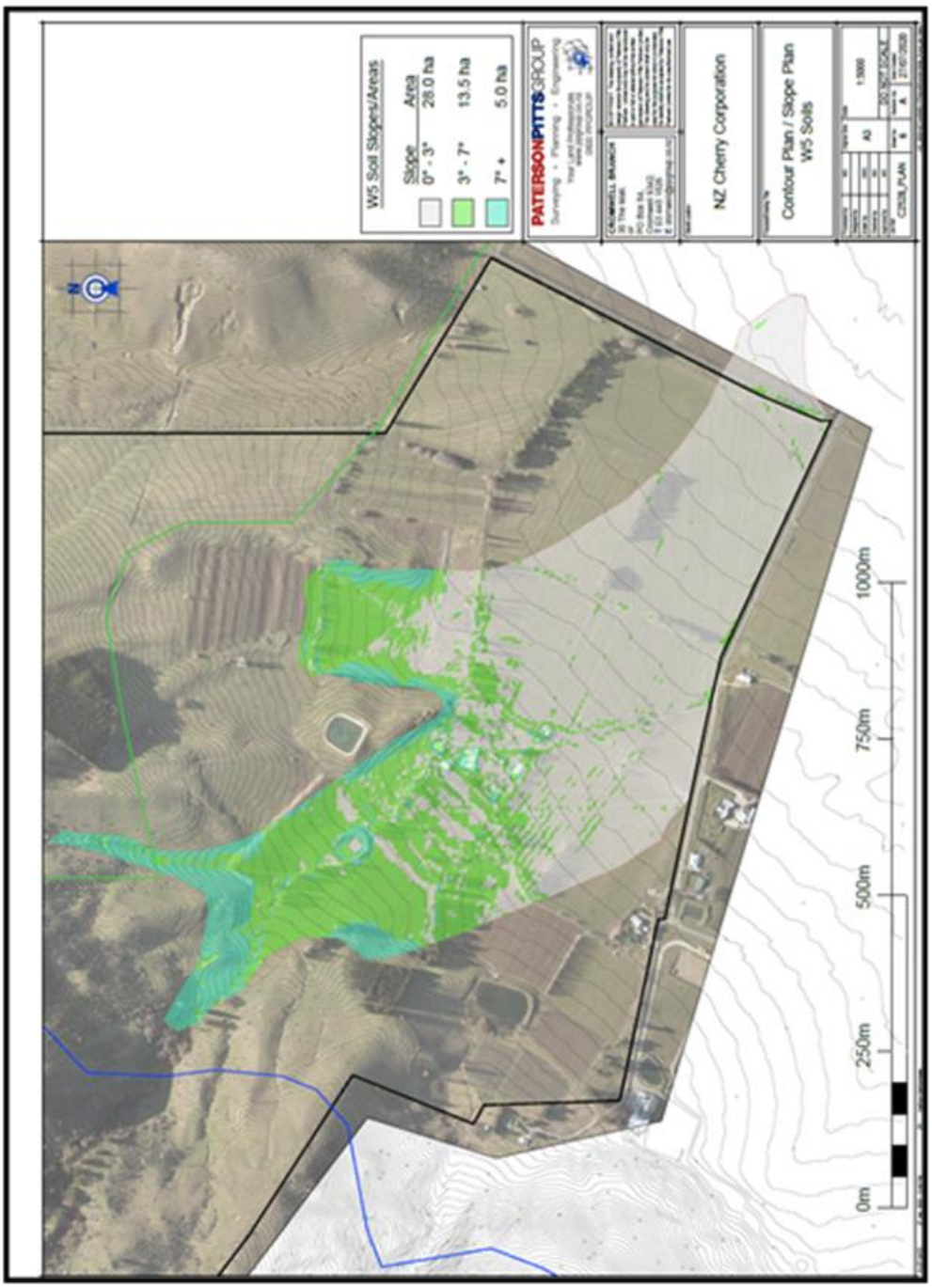
**Appendix 3. Map of the S-Map Online soil map units for the PPC14 site.**



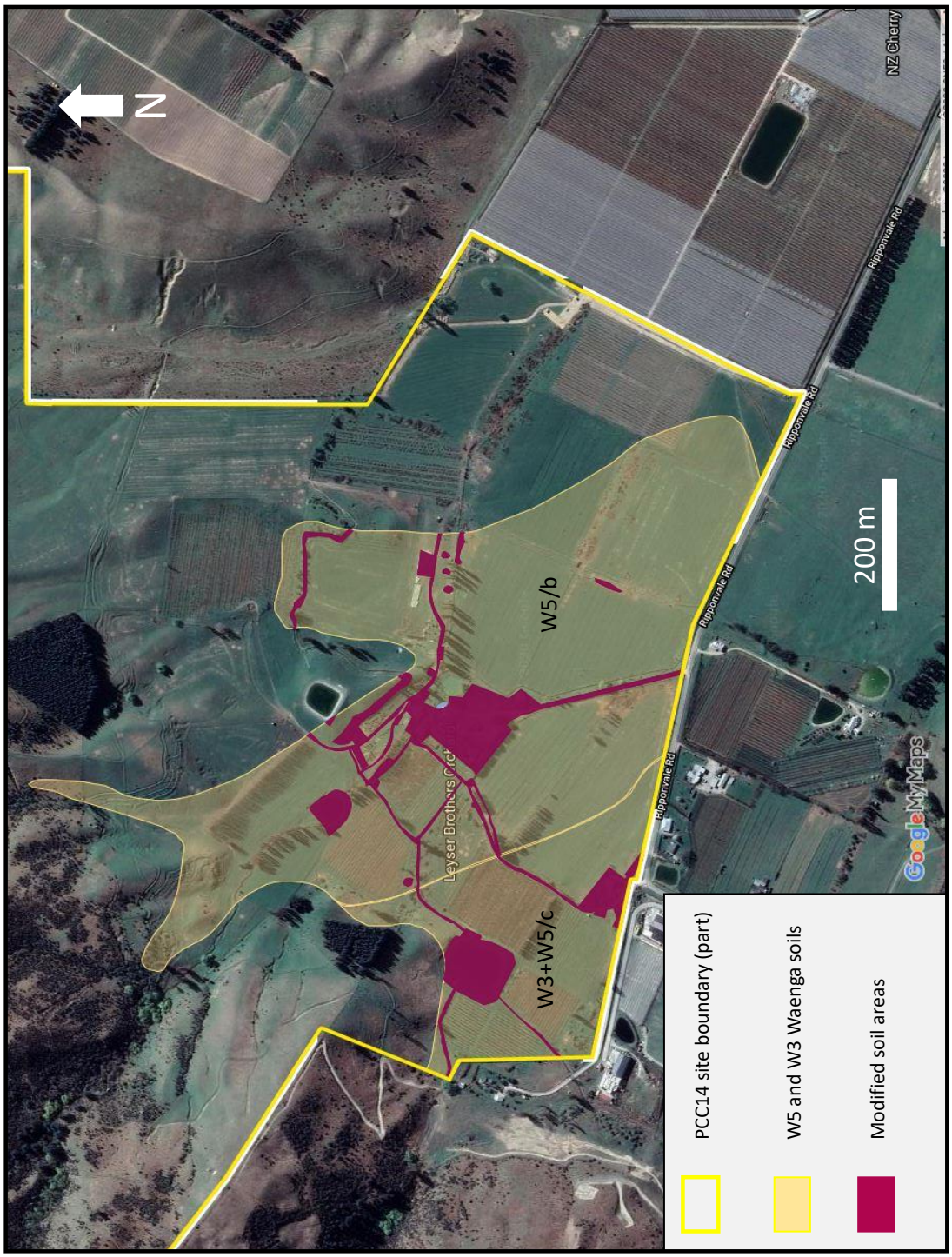
**Appendix 4. Map of estimated soil map units for the PPC14 site based on Leamy and Saunders (1967) and Fundamental Soil Layer soil information.**



**Appendix 5. Map showing where the soil map unit boundaries are likely to be inaccurate and not Waenga (W5) soils.**

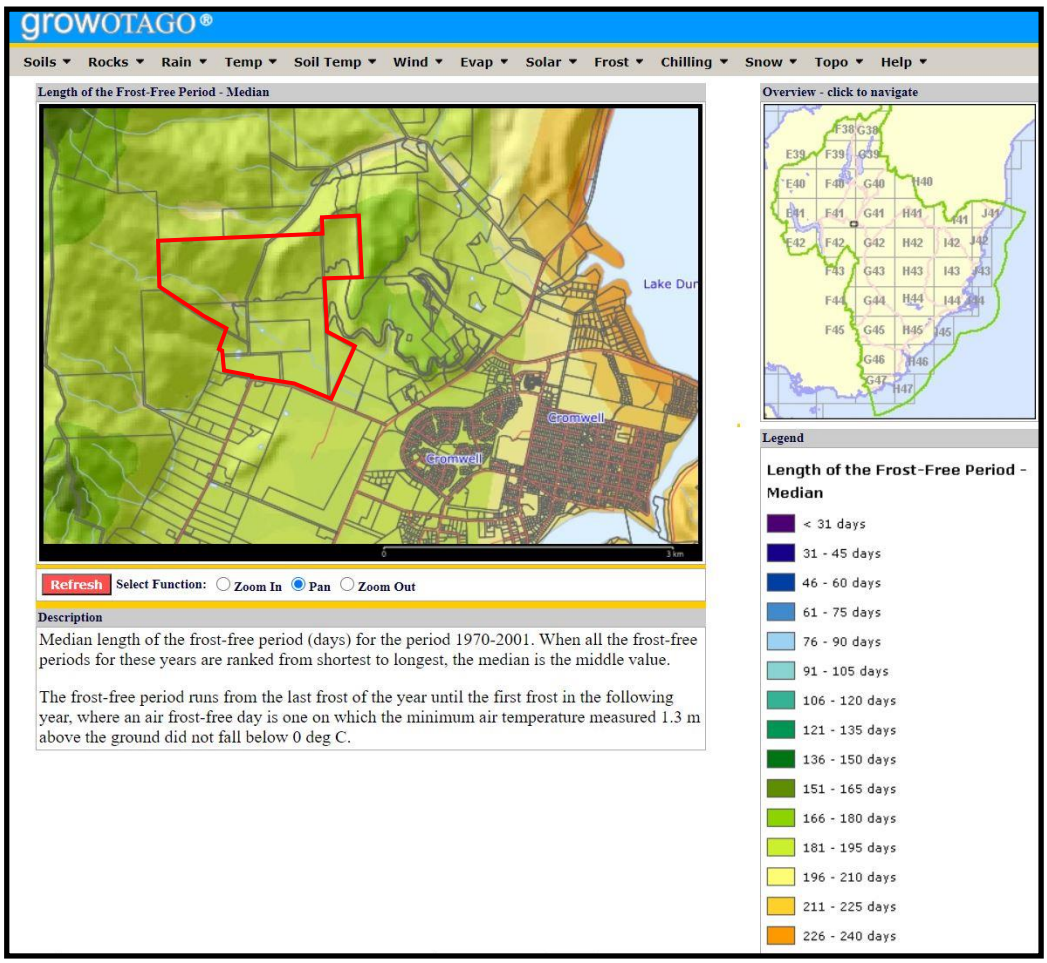


## Appendix 6. Map showing the areas of modified soils identified.



**Appendix 7. Estimated Soil Sibling and soil depth areas for Leamy and Saunders soil survey.**

## Appendix 8. Map of growOTAGO Frost Free Period (days) for the area in question.



## Appendix 9. Revised structure plan for the PPC14 area.