Hedgehope Makarewa Catchment Group Project

Summary report of landscape data | Southern Dairy Hub

Executive Summary

Many farmers are actively seeking opportunities to reduce their environmental impact to meet their goals, regulations, consumer and community expectations.

Land and Water Science Ltd (LWS) have undertaken a new, high-resolution physiographic approach to mapping the inherent and varied susceptibility of the landscape to land use activities at property scales. Landscape variability has a significant role in governing the type and severity of water quality outcomes, even when land use is the same. Landscape variability also significantly affects soil greenhouse gas (GHG) production.

Linking the landscape susceptibility and farm system allows farmers to target mitigations and contaminant load reductions to reduce their environmental impact. This report summarises the datasets but does not deliver an integrated plan for mitigating environmental challenges. Instead, this data summary report seeks to *present* the key data and insights that can be used by the landowners and their farm systems specialists/advisors to apply mitigation opportunities to the identified areas.

Method

LWS, i. prepared the preliminary landscape data report which was supplied to the owners/key representatives of Southern Dairy Hub; ii. met with the key representatives on farm; iii. sought the representative's perspective on the environmental challenges they face, and; iv. discussed their preferred pathway for mitigating environmental risk.

The Farm

The property is located at 611 Ryal Bush-Wallacetown Road, Branxholme, Southland. The property is ~385 hectares in size, is owned by Southern Dairy Hub Limited Partnership, and has the Makarewa River running through the property and along the southeast boundary. The land is flat, with undulations occurring due to the historic passage of the Makarewa River, and has a mean slope of 5.0° with a range of 1 to 86° (reflecting steep sides of a drainage ditch) across the property. The low mean slope of 5.0° is consistent with what is a low relief property, with most of the land between 10m and 20m Relative to Sea Level (RSL).

Environment Southland designates the majority of the property within the Makarewa Groundwater Management Zone, with an area of ~13% along the north-western boundary falling within the Lower Oreti Groundwater Management Zone.

The Catchment

The Southern Dairy Hub property sits within the Lower Makarewa sub-catchment, which is located at the southern tip of the Hedgehop-Makarewa Catchment. The Hedgehope-Makarewa catchment is located within the greater Oreti catchment in Southland, New Zealand. It extends from the divide draining the southern side of the Hokonui Hills to the north of Invercargill. The total area of the catchment is approximately 111,940 hectares (ha).

The Lower Makarewa sub-catchment accounts for 11,401 ha of land, or 10% of the wider catchment, and is drained by the Makarewa River. This is fed by a diverse network of smaller streams, combining to run in a south-west direction through the sub-catchment. At the southern tip of the sub-catchment, the Makarewa River drains to the Ōreti River before discharging to the sea via the New River Estuary at Invercargill.

Landscape Susceptibility

The landscape datasets generated for the Southern Dairy Hub have been presented. The landscape package includes a farm-specific model of surface drainage, terrain ruggedness, and high-resolution (3 cm) drone captured photographic images. It is important to emphasise that the susceptibility models do not consider land use nor any existing management practices of physical mitigations (e.g., sediment traps, wetlands) already in place. As such, landscape susceptibility models only identify the inherent or natural susceptibility of the land, they do not indicate that the areas of elevated susceptibility are losing high rates of contaminants.

Within the context of the above paragraph, the main landscape susceptibilities associated with the property are thought to include:

i. High NNN loss via the surface water or any subsurface drainage network;

ii. Elevated susceptibilities to particulate and particle reactive contaminants in the vicinity of poorly drained mineral and organic soils (abandoned oxbow).

Our understanding, following the farm visit with representative of SDH, is that best practice management techniques are already being deployed on farm to manage nitrate-nitrite-nitrogen by reducing excess NNN in the soil before and during late autumn and early spring. Of the PP and TKN landscape susceptibilities, and a component of likely microbial losses; these could be mitigated through managing runoff and direct discharge to the Makarewa River.

1. Objective

In the following landscape data report, existing soil and geological datasets and the physiographic classification provided by LandscapeDNA are used to provide a generalised overview of the farm setting before the presentation of a high-resolution and data-driven assessment of landscape susceptibility. Here the objective is to move beyond the low resolution of historic soil and geological maps towards property, paddock, and sub-paddock scale assessment of landscape susceptibility. The aim is to provide landscape knowledge capable of supporting a spatially targeted and highly efficient approach to mitigating soil GHG and water quality-related losses.

2. The Farm Landscape

2.1 Site description

The property is located at 611 Ryal Bush-Wallacetown Road, Branxholme, Southland. The property is ~ 385 hectares in size, is owned by Southern Dairy Hub Limited Partnership, and has the Makarewa River running through the property and along the southeast boundary. The land is flat, with undulations occurring due to the historic passage of the Makarewa River.

From the LandscapeDNA website (www.landscapeDNA.org), the property staddles two dominant physiographic environments. Along the western side of the property is the 'Oxidising Soil and Aquifer', and along the eastern side the 'Reducing Soil and Aquifer' class or family (Fig. 1). These two broad classes are based on existing geological and soil surveys and knowledge of the factors that control the susceptibility of the land to contaminant loss. According to LandscapeDNA, the Oxidising Soil and Aquifer class has a greater susceptibility to the leaching of nitrate to the underlying aquifer due to a greater abundance of well-drained soils ('Waikiwi'). The Reducing Soil and Aquifer class has a lower susceptibility to the leaching of nitrate to the underlying aquifer due to poorly drained soils (Pukemutu and Makarewa soils). However, LandscapeDNA does identify that the Reducing Soil and Aquifer unit that occurs east of the Makarewa River is likely to have an elevated susceptibility to losses of nitrate via artificial drainage (mole-pipe). The same class also has a greater susceptibility to surface runoff of water and the entrainment of particulate and particle reactive (i.e., sediment (organic and inorganic), ammoniacal-N, organic-N, particulate phosphorus, and microbial pathogens) due to the fine texture of the soils and poor drainage.

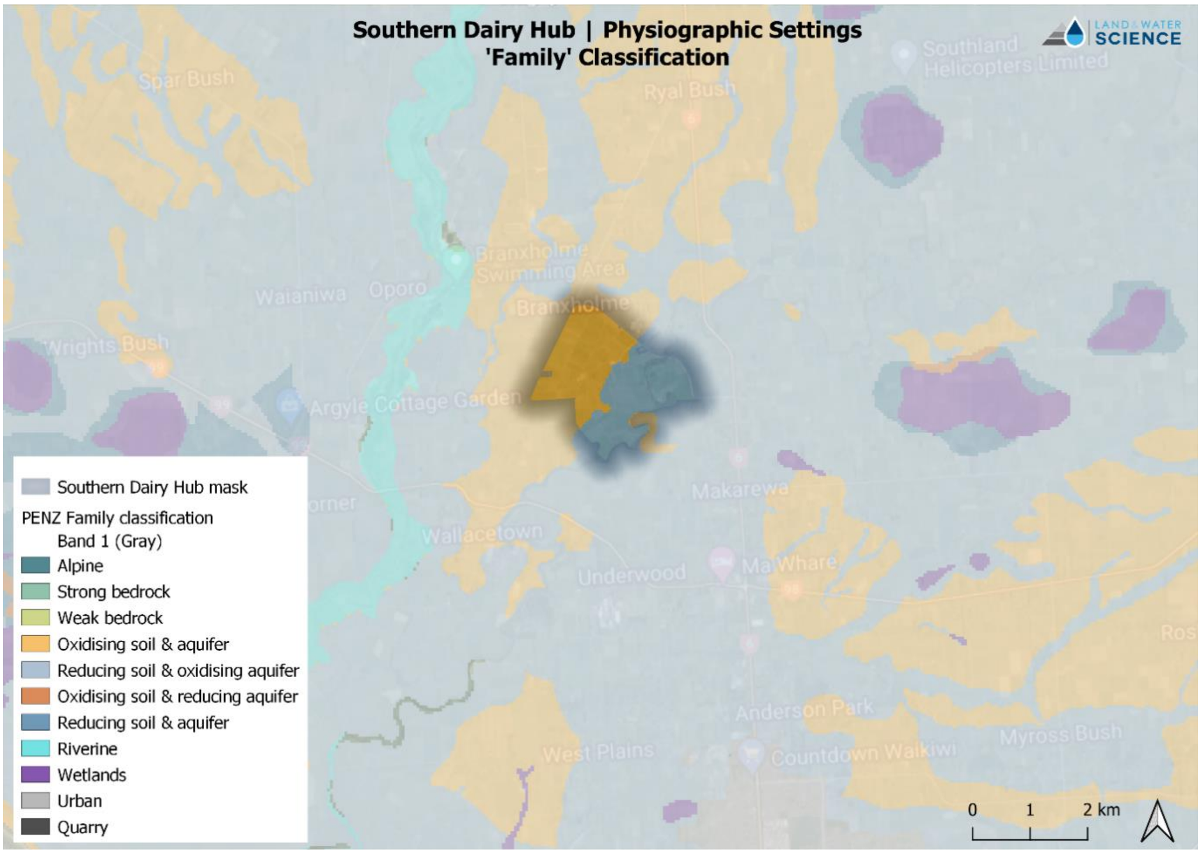

Figure 1. Case Study property – Southern Dairy Hub. Physiographic Families classification.

LandscapeDNA integrates geology, soil, and topographic variation to identify at a generalised broad level the susceptibility of the landscape to contaminant loss. The geological component identifies that the property resides within two different geological units (Fig. 2), with the historic stream bed of the Makarewa River forming the main divide between an older (western) and a younger (eastern) set of water-laid (alluvial) gravels. Specifically, the western part of the property is comprised of "sandy greywacke gravel overlain by loess", according to geological survey (Q-Map V3). The maximum age estimate of this landform is between 14 to 70 thousand years old. The younger, eastern part of the property is comprised of "unconsolidated gravel, sand, silt, clay and minor peat" that has an estimated maximum age of 14 thousand years old. These two distinct geological units are separated by the

Makarewa River, which forms the divide between the Lower Oreti and Makarewa Groundwater Management Zones, west and east of the river, respectively.

The soil component in LandscapeDNA is derived from Topoclimate South Soil Survey. The Topoclimate survey identifies three main soil series (siblings) across the property. The Waikiwi soil sibling is the largest and occupies the area of older alluvial gravels west of the old Makarewa streambed. Waikiwi soils are comprised of fine-textured materials, notably silt, and are described as being well-drained. The Pukemutu soil series is mapped as running north to south through the property in the vicinity of the old streambed of the Makarewa. Pukemutu soils are described as moderately deep, poorly drained, silt over clay. Makarewa soils occur along the eastern edge of the property and are described as moderately deep, poorly drained clay.

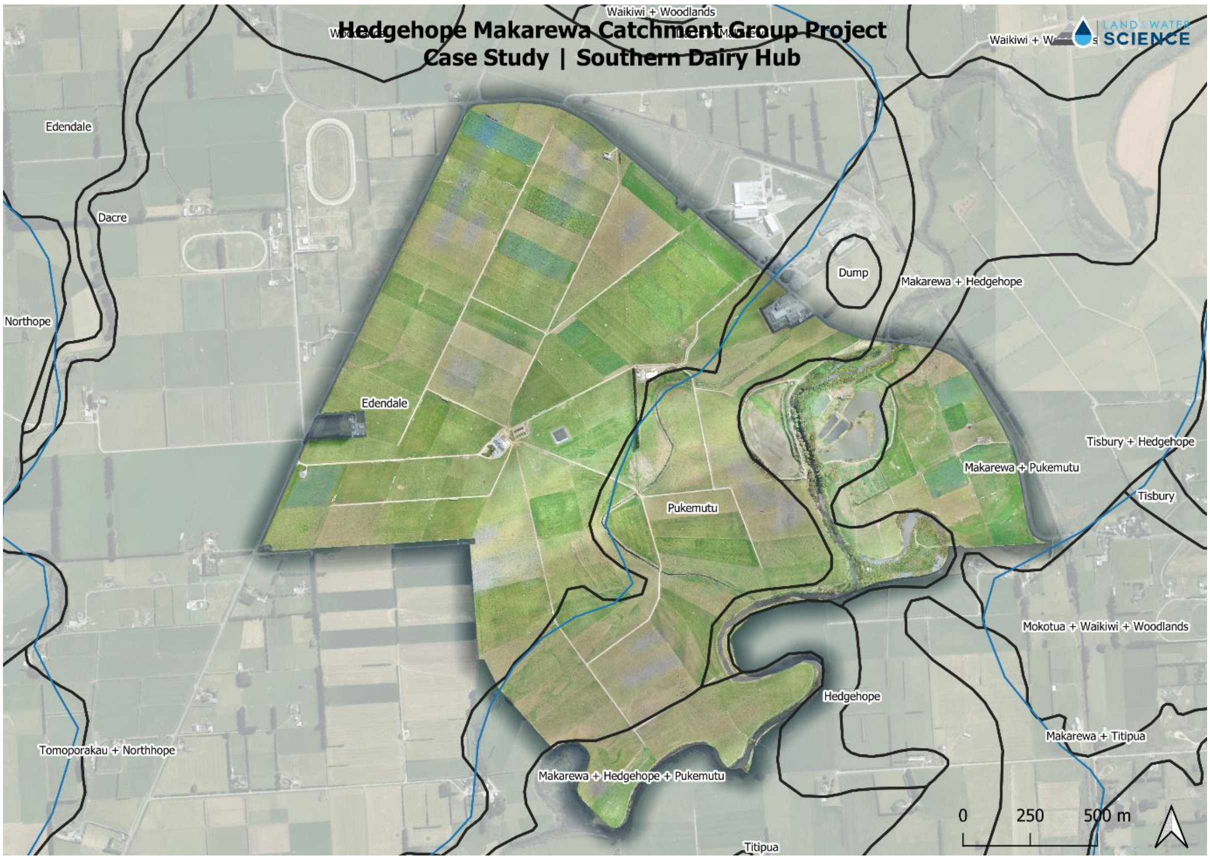

Figure 2. Case Study property – Southern Dairy Hub at a scale of 1:10,000. The Makarewa River runs through the eastern sector of the property. Blue lines denote the geological units (Q-Map V3; 1:250,000), with younger alluvium (Q1) occurring to the east and older (>Q2) alluvium to the west of the Makarewa River. Black lines and labels denote the soil series (TopoClimate South; 1:50,000). The old riverbed of the Makarewa River bisects the property, the current channel runs through the easternmost portion of the property.

3. New soil map

Although not presented here, a new soil map was developed for the Hedgehope Makarewa Catchment Group as part of the Thriving Southland funded project. The map is available for viewing online in the catchment group's StoryMap application. The soil map was developed as a key step towards a more refined soil resource for the catchment. Airborne radiometric survey data (resolution of 40 x 40 m), Sentinel-2 European Space Agency satellite (10 x 10 m) data and terrain measures (elevation, slope, ruggedness) were utilised to improve the resolution of soil drainage and soil parent materials across the Hedgehope Makarewa Catchment (Figs 3 and 4). Historic soil auger points from the TopoClimate

South project were digitised, and new soil pits were dug across the catchment group area (Figs 5 and 6). Radiometric survey is a geophysical method that measures the physical, chemical, and biological character of the uppermost surface of the land (300 mm to several meters in some settings) and has been widely used to inform soil and geological mapping. Sentinel-2 satellite measures the absorbance and reflectance of light across a variety of wavelengths to enable an assessment of the seasonality in soil moisture. Specifically, the magnitude of the difference in soil moisture between the wettest and driest times of the year.

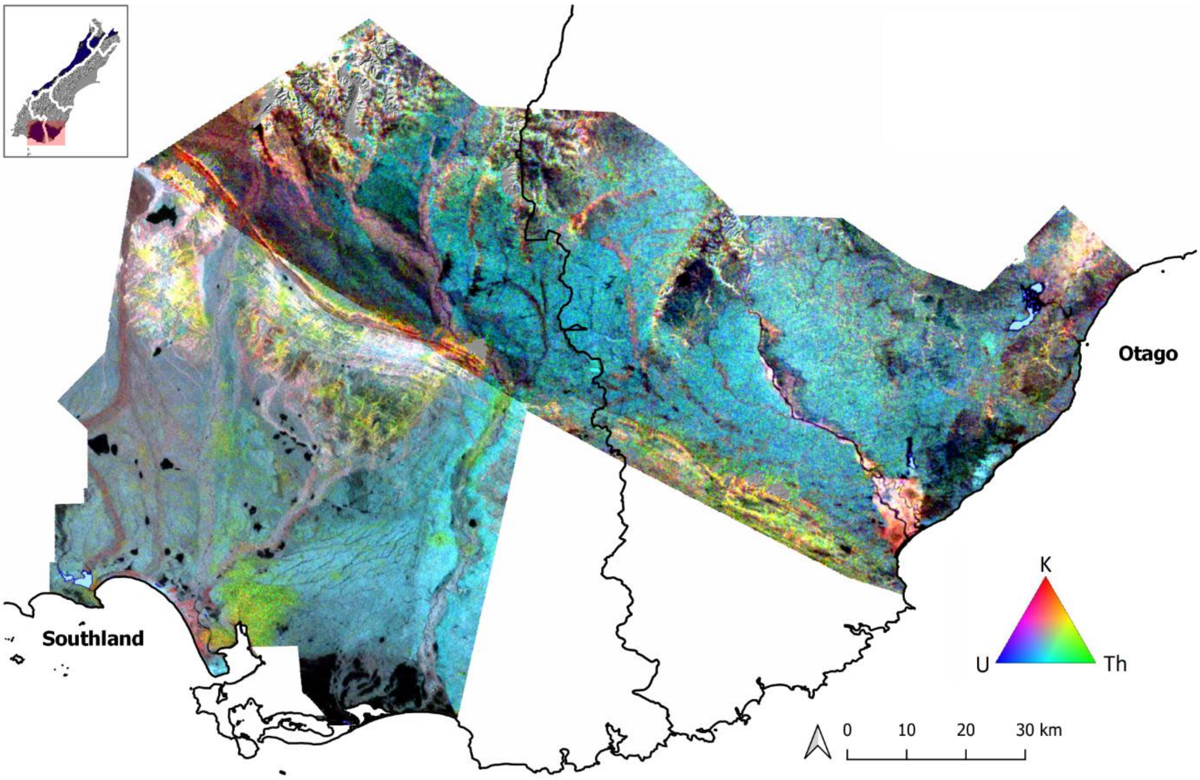

Figure 3. Extent of airborne radiometric survey across Southland and East Otago (40 x 40 m). Where K = potassium; U = uranium; Th = Thorium. Bright blue colours are associated with loess (silt) mantled landforms; magenta (red) with K-rich rocks and sediments; black areas are areas of peat and elevated water table; white areas are associated with erosion or active deposition of sediments. Yellow areas show a mix of K and Th in hill and high country, with cities and small towns also detected (concrete and paving signature).

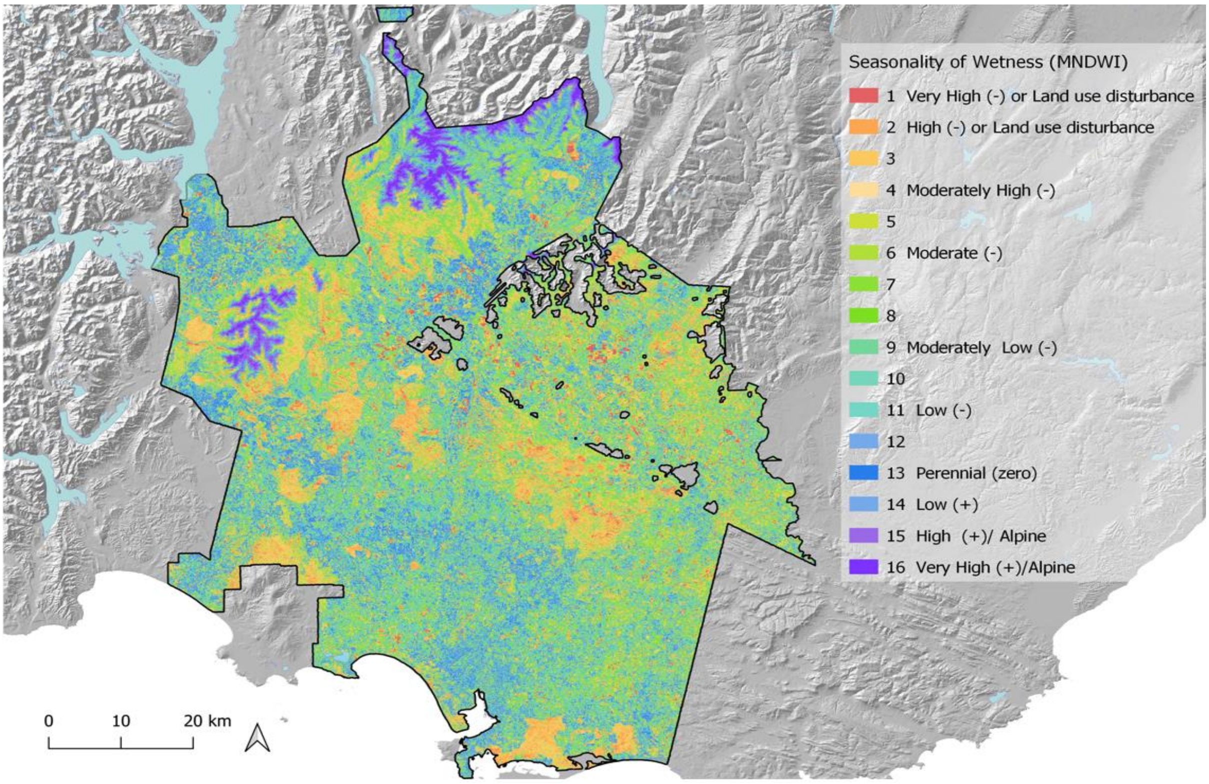

Figure 4. The seasonality of soil moisture derived from the Sentinel-2 satellite for the 2018 – 2021 calendar years (10 x 10 m).

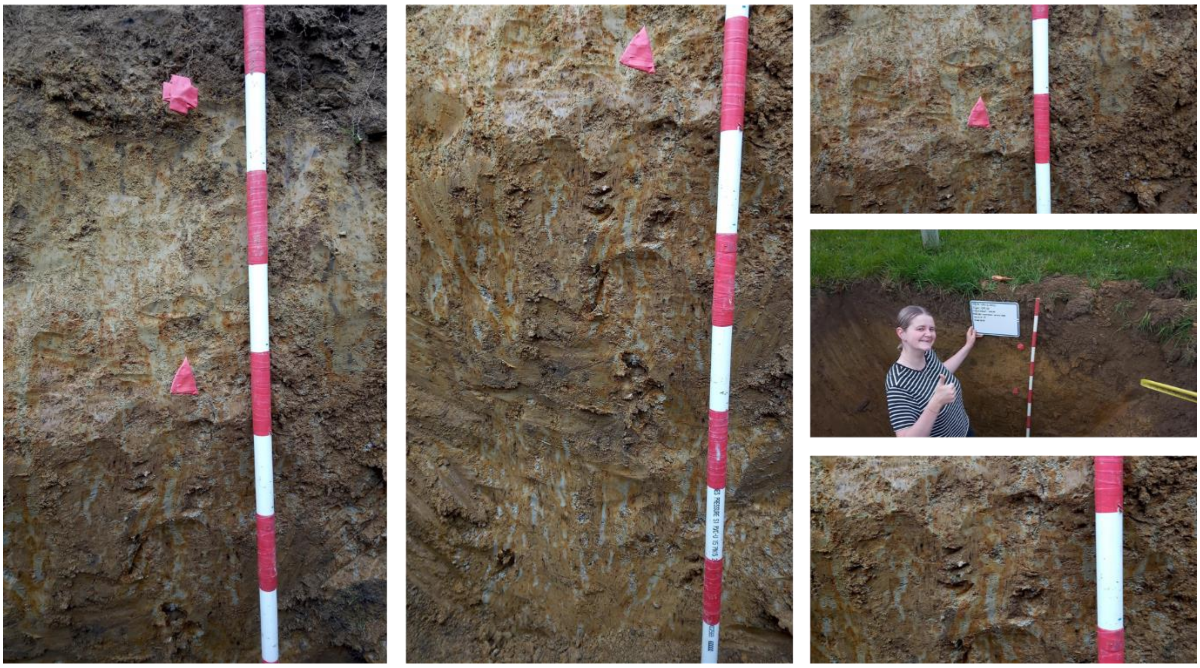

Figure 5. Soil pit 9 (see Figure 2 for location). The soil is relatively poorly drained despite being mapped as a well-drained Waikiwi soil.

Figure 6. Soil pit 10 (see Figure 2 for location). The soil is more consistent with a Waikiwi Soil, although there was evidence of minor mottling throughout the profile (rust and manganese concretions).

The new soil map is presented in Fig. 7 below. In conjunction with soil test pits, it suggests a different soil drainage pattern than provided by TopoClimate South. Specifically, there is evidence for organic soils associated with old oxbow (abandoned) channels of the ancestral Makarewa Stream. Soil pit data also support a transition from poorly drained mineral soils at pit 9 to moderately well-drained soils at pit 10. Better-drained soils are associated with the lightest colours and occur on both sides of the Makarewa River. Specifically, the new soil map suggests a greater proportion of moderately to well-drained soils east of the Makarewa River and south of the abandoned oxbows.

Importantly, further ground truthing would be helpful to substantiate the existence of better-drained soils across this part of the property. However, if valid, the new soil map suggests: i. a higher susceptibility to nitrate leaching across the south-eastern central portion of the property than previously identified by historic soil mapping; ii. a lower susceptibility to groundwater from the leaching of nitrate around the fringes of the western block, and; iii. a greater susceptibility to particulate and particle reactive contaminant loss, dissolved phosphorus, ammoniacal-N, organic-N, and microbial contaminant loss in the vicinity of wetland soils. The pathway taken by water over or through the soil, including the presence of sub-surface artificial drainage, also influences the type (e.g., nitrate leaching to an aquifer vs surface runoff of particulate and particle reactive contaminants) and magnitude of susceptibility to contaminant loss. The topography and hydrology of the site are discussed below.

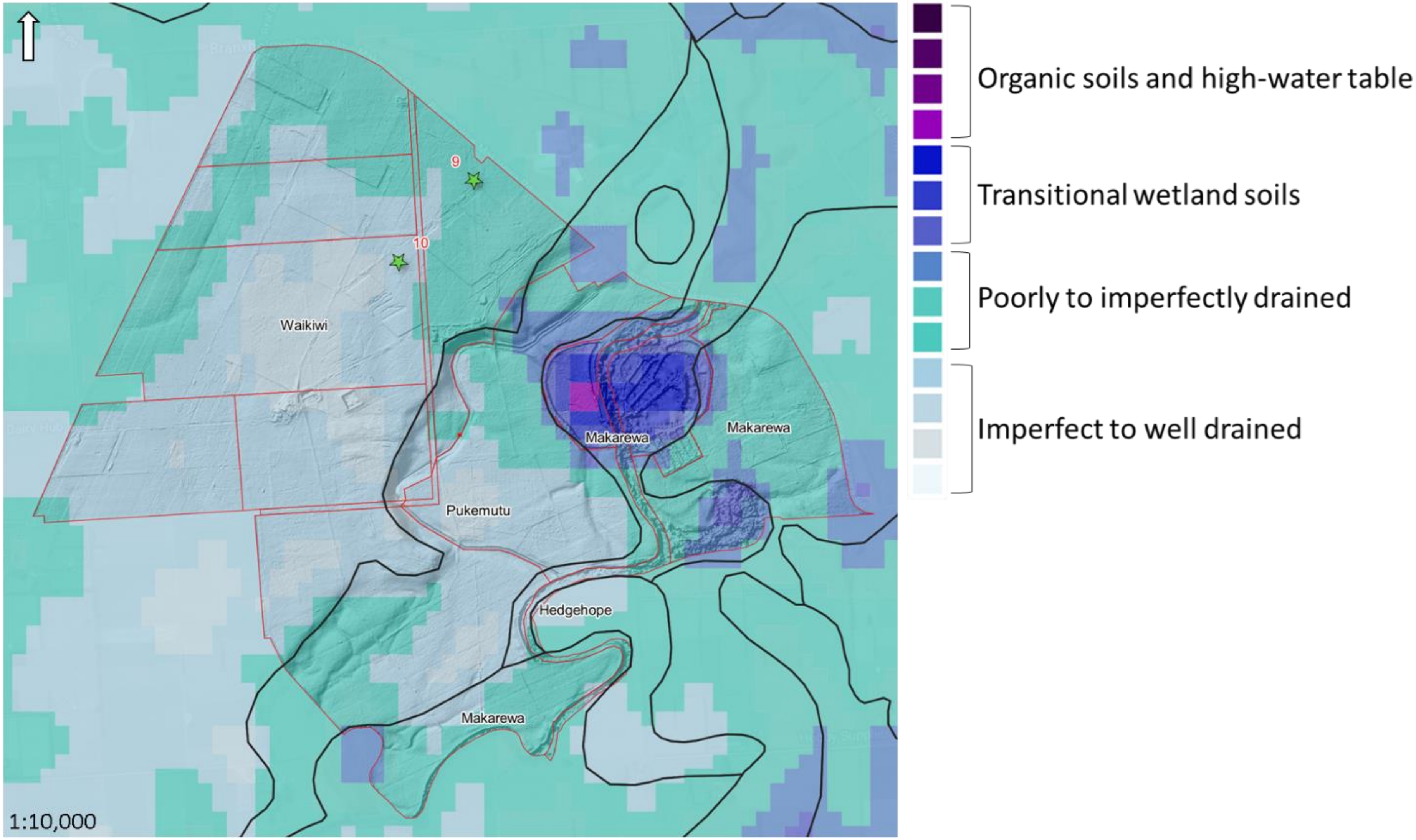

Figure 7. New soil map for the Hedgehope Makarewa Catchment displaying likely soil drainage. The lighter the colour, the better drained the soil. The darker the colour, the more likely the soil is to be poorly drained.

4. Digital Terrain Model (DTM)

The subject property was surveyed with a drone to develop a high-resolution Digital Terrain Model (DTM) with a horizontal resolution of 0.7m x 0. 7m and a vertical accuracy of 0.02 m. A DTM provides the basis for resolving in high-resolution the topographic variation across the property (Figs. 8 and 9). Topography is a dominant control over the movement of water across a property and as such the transport of contaminants from one area to another. The drone-derived digital terrain model (DTM) of the property was used to compute a mean slope of 5.0° with a range of 1 to 86° (reflecting steep sides of a drainage ditch) across the property. The low mean slope of 5.0° is consistent with what is a low relief property. Most of the property lies between 10m and 20m Relative to Sea Level (Fig. 9). The relief across the property is variable and reflects the historical passage of the Makarewa River across the site (Fig. 10).

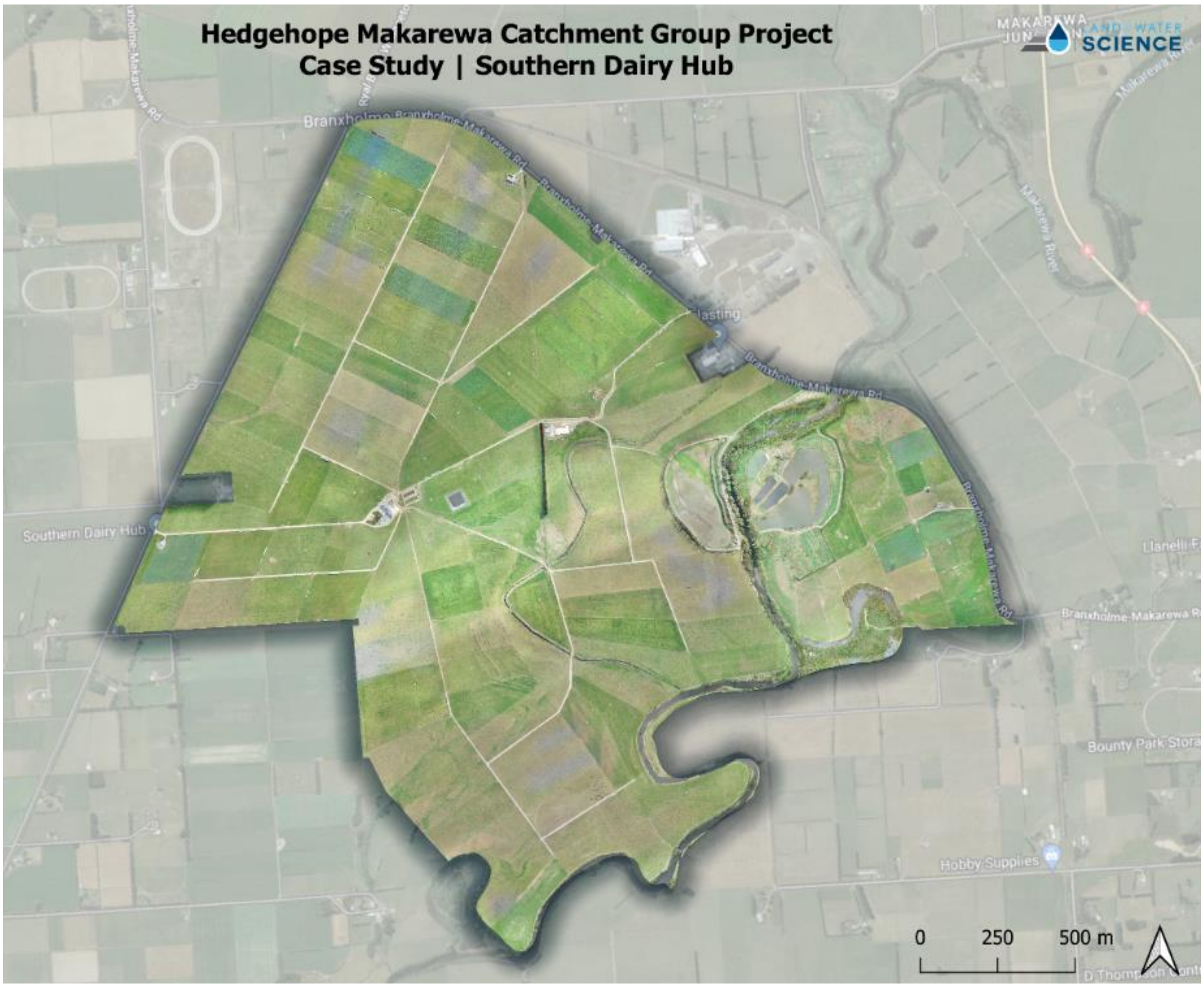

Figure 8. Southern Dairy Hub. The photogrammetry survey generates an orthomosaic output at 3cm resolution, producing a Digital Elevation Model of 12cm/pixel, with a vertical geolocation accuracy of 0.02 m.

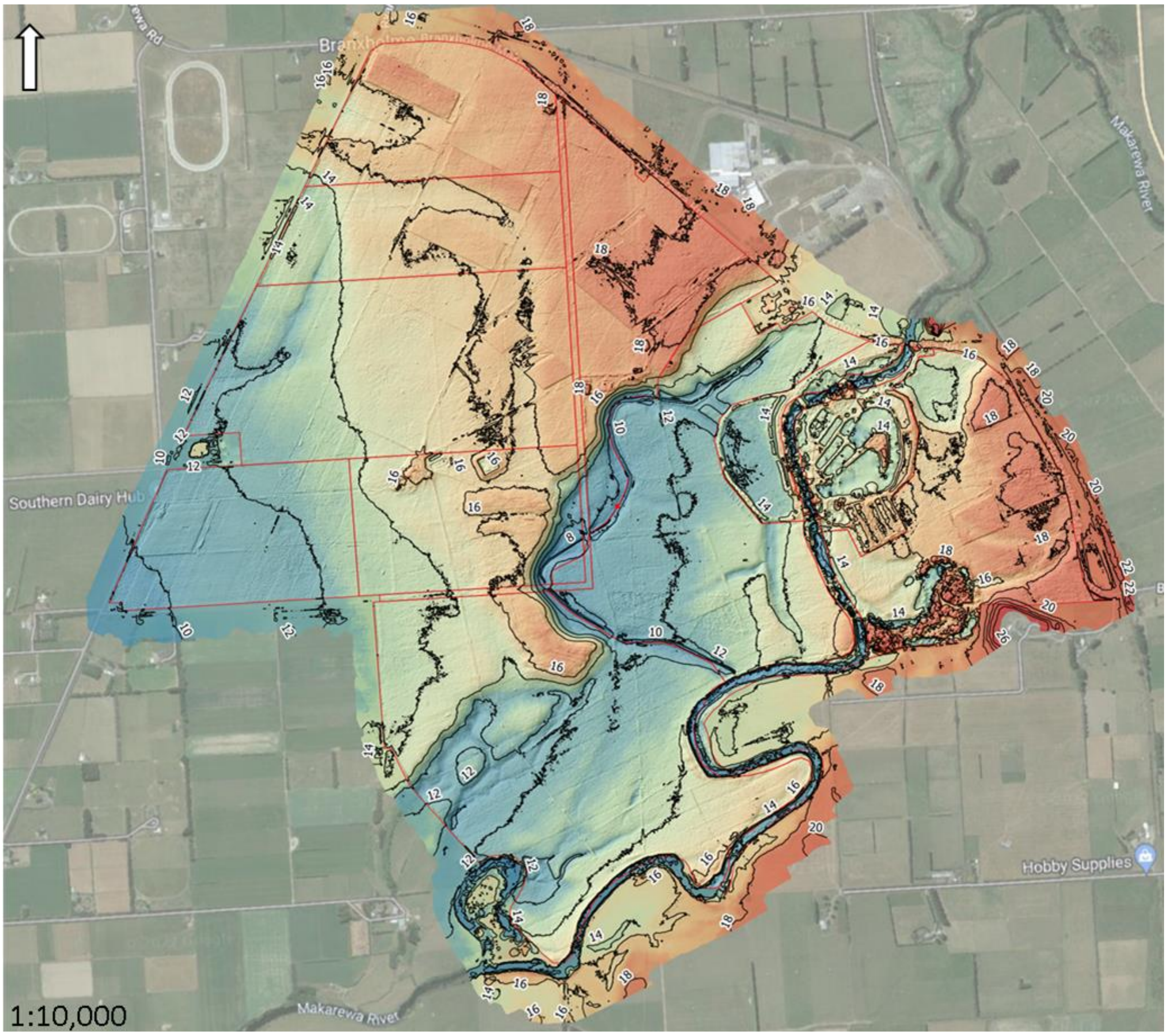

Figure 9. Southern Dairy Hub. Digital Elevation Model (DEM) overlaid with elevation contours (2m RSL) across the property. Warm colours (red) denote higher elevation areas, and cool colours (blue) lower elevation areas.

A transect across the property (6,000 lineal meters) is presented in Fig. 10. Except for the eastern margins of the site, the land falls away from the modern channel of the Makarewa River. However, the old riverbed of the Makarewa River forms a broad loop that connects to the river in the middle of the property. This old channel is referred to as a tributary of the Makarewa River and is hydrologically connected to the modern stream channel. Despite most of the property falling away from the modern river course the tributary directly connects the eastern side of the property to the Makarewa river.

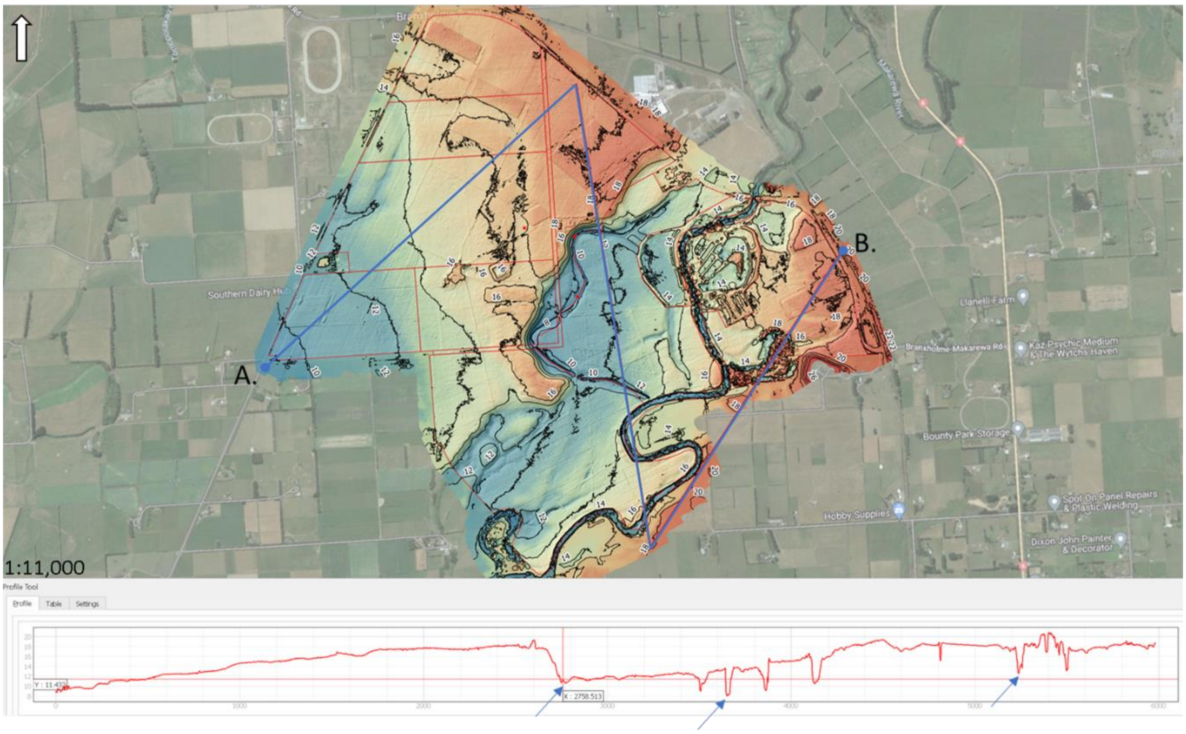

Figure 10. Transect A – B across the Southern Dairy Hub (6,000 lineal meters). Note the steep terrace west of the Makarewa River Channel and the inclination of the eastern portion of the property towards the river. The divide between the western and eastern areas of the property is identified by a steep terrace (first blue arrow); this arrow demarcates the old stream bed of the Makarewa River. The modern-day stream channel is intersected 3x (second blue arrow), and an abandoned oxbow is also intersected.

4.1 Hydrological network for Southern Dairy Hub

Following the survey, the DTM was utilised to build a digital model of the hydrology of the property, which includes the generation of watersheds, a digital drainage network, and nodes or junctions where drainage channels intersect or leave the property. The need to better define the hydrology of the property reflects the role of water in transporting contaminants from one area to another and at times, off-site.

Ultimately, water is the vehicle that transports contaminants from land to water. A better understanding of the area water collects from and drains to is a critical component of effective land management. Furthermore, soil moisture also tends to follow the drainage network, with higher soil moisture and greater incidences of saturation associated with low-lying areas that receive drainage from higher elevation parts of the property. The saturation of the soil with water also controls soil GHG generation (section 5.2).

Watersheds (Fig. 11), drainage network (Fig. 12), discharge nodes (Fig. 13), and priority nodes (Figs. 14 & 15) were generated for the property. Watersheds encompass the area that collects and drains water to a node. Water drains towards a common collection point, following the lowest-lying pathway to a drainage line. Hence the water that flows through a drainage channel during a runoff event is sourced from the entire area within the watershed.

Discharge nodes identify the location at which water leaves the property area, and priority nodes identify where small drainage channels connect to and feed into larger drainage channels. Each drainage line or 'channel' is ranked (ordered) according to its level of branching. A low-order drainage line, e.g., order 1, defines the smallest drainage features, whereas a high-order drainage network, e.g., order 5, defines the largest drainage features, such as broad or incised swales, drainage ditches, and in some instances, flowing stream channels. As a generalisation, higher-order drainage lines are more likely to contain water for extended periods, whereas low-order drainage lines may only channel water in response to wet conditions and associated surface runoff events.

Critically, the DTM does not detect nor consider any artificial drainage that has been undertaken. Where present, artificial drainage will significantly modify the hydrological properties and behaviour of water movement across or through the landscape. Accordingly, knowledge of artificial drainage is important given its role in water and contaminant export. Perhaps most critically, the unnamed tributary that occupies the former riverbed of the ancestral Makarewa River was not detected by the hydrological mapping algorithm. This tributary is recognised as draining historic offal pits, contributing a large load of ammoniacal nitrogen to the Makarewa[1].

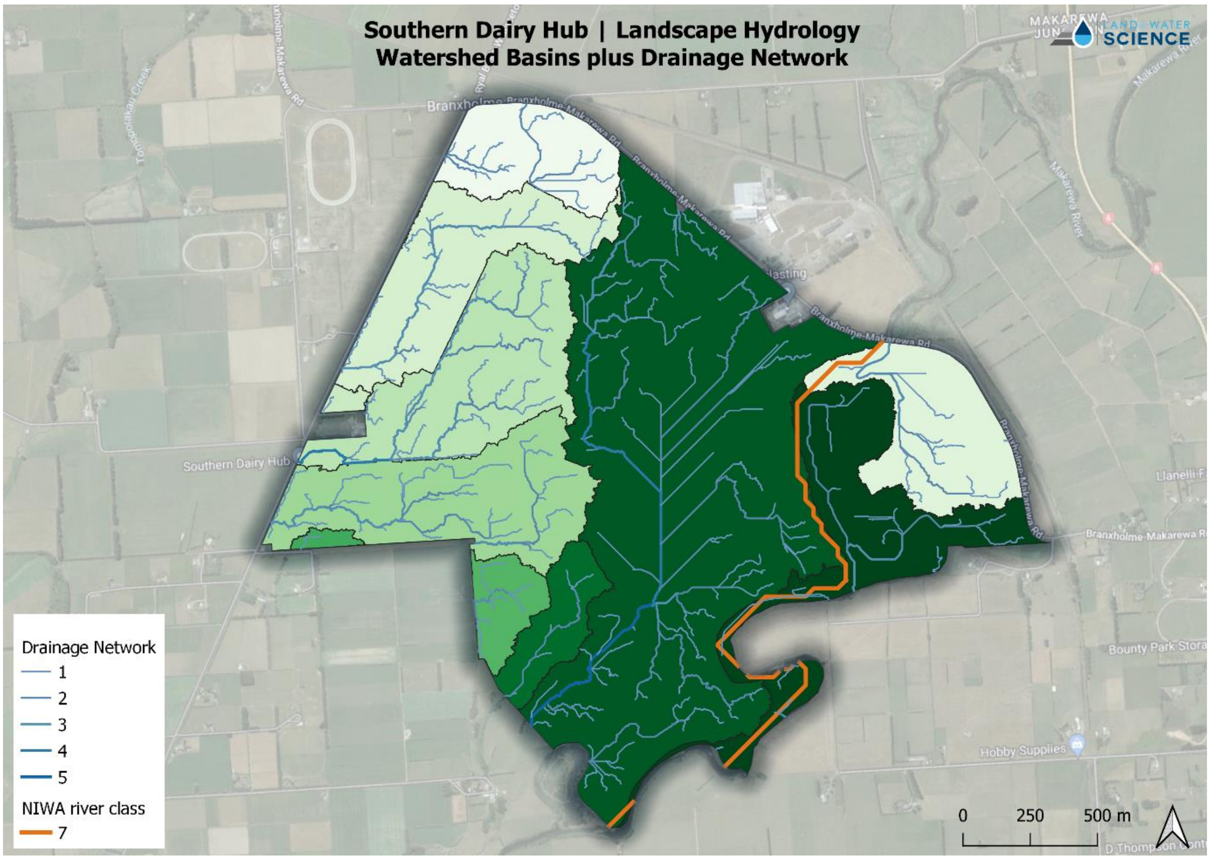

Figure 11. Southern Dairy Hub - landscape hydrology – watershed basins plus drainage order network. These watersheds can be further subdivided for each tributary. The network may be modified to account for artificial drainage (open ditch).

[1]Rissmann, (2018): Southern Dairy Hub: Contaminant Source Investigation. A report for Environment Southland.

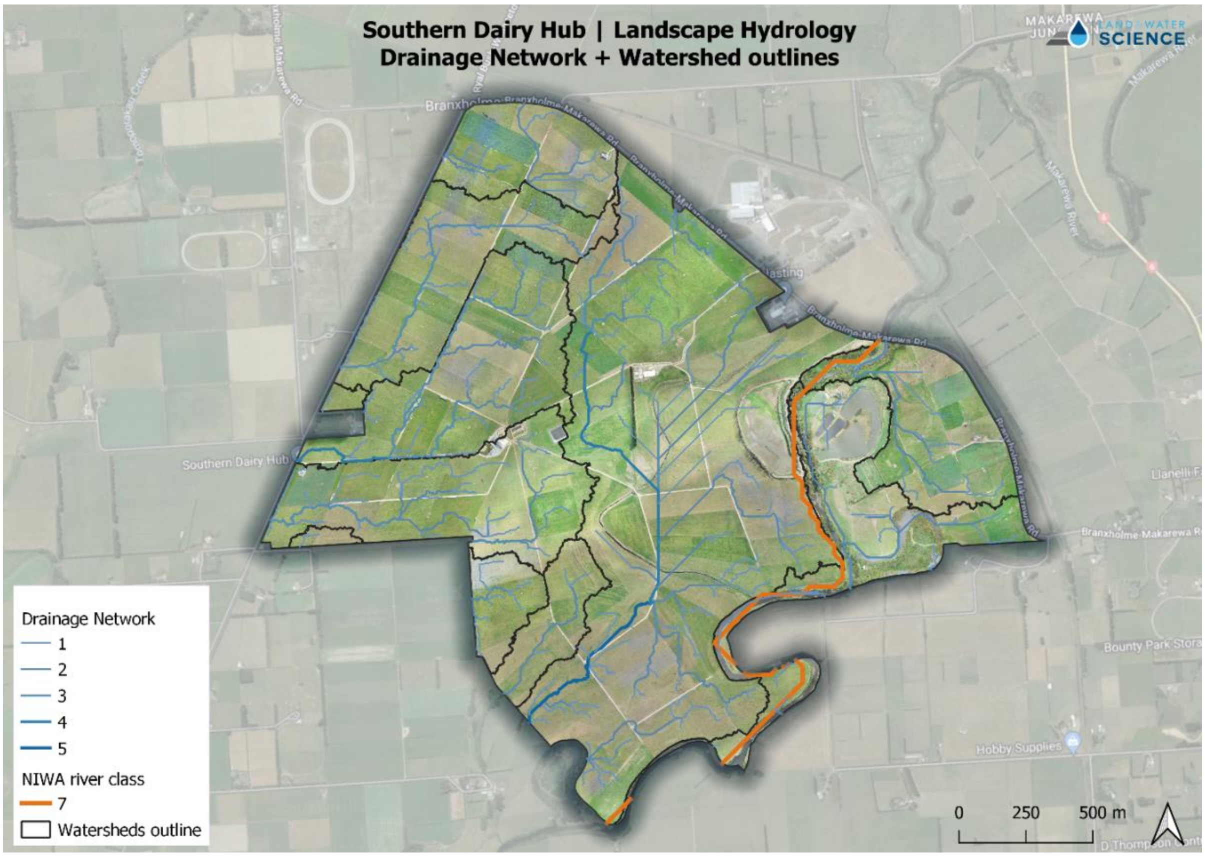

Figure 12. Southern Dairy Hub - landscape hydrology – drainage network. The legend denotes the 'order' of drainage lines, with low-order drainage connecting to generate higher-order drainage lines.

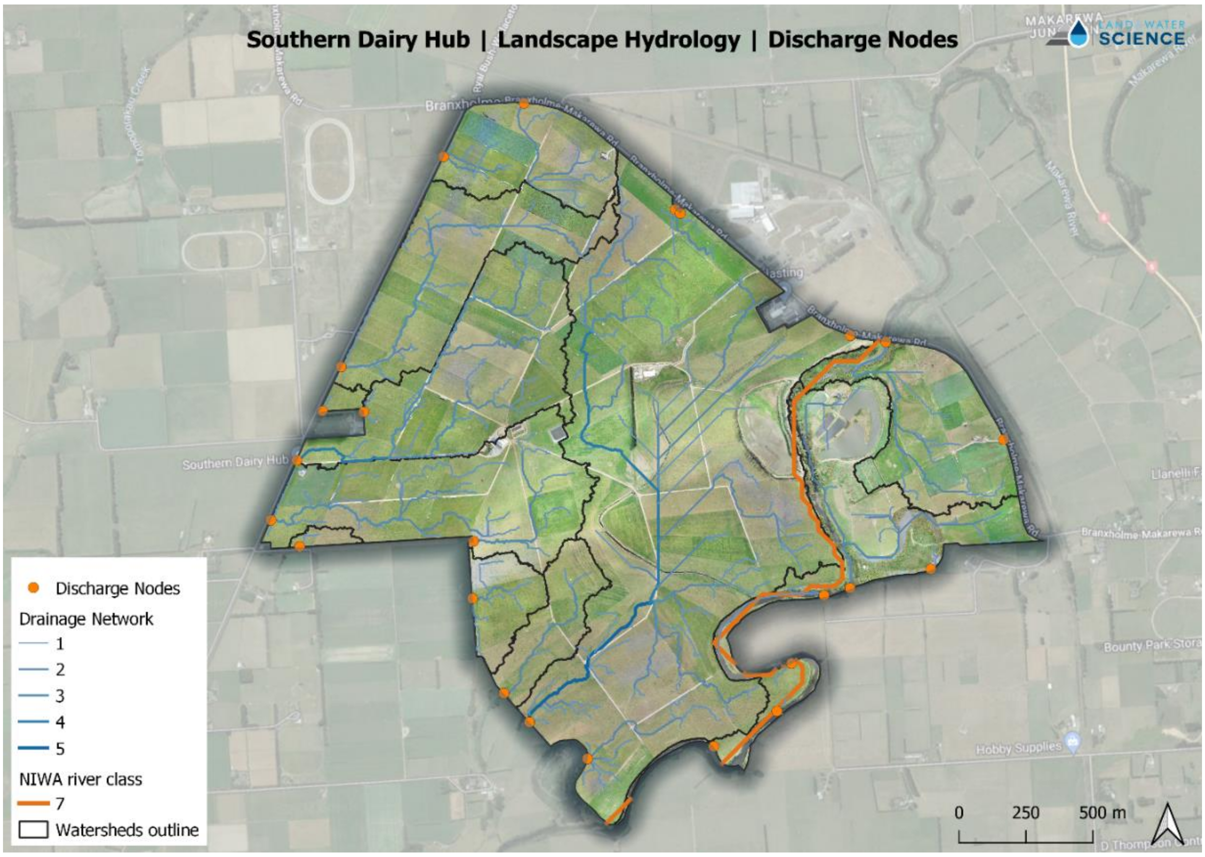

Figure 13. Southern Dairy Hub - landscape hydrology – 'discharge' nodes plus drainage network. Discharge nodes are the points where the water leaves the property.

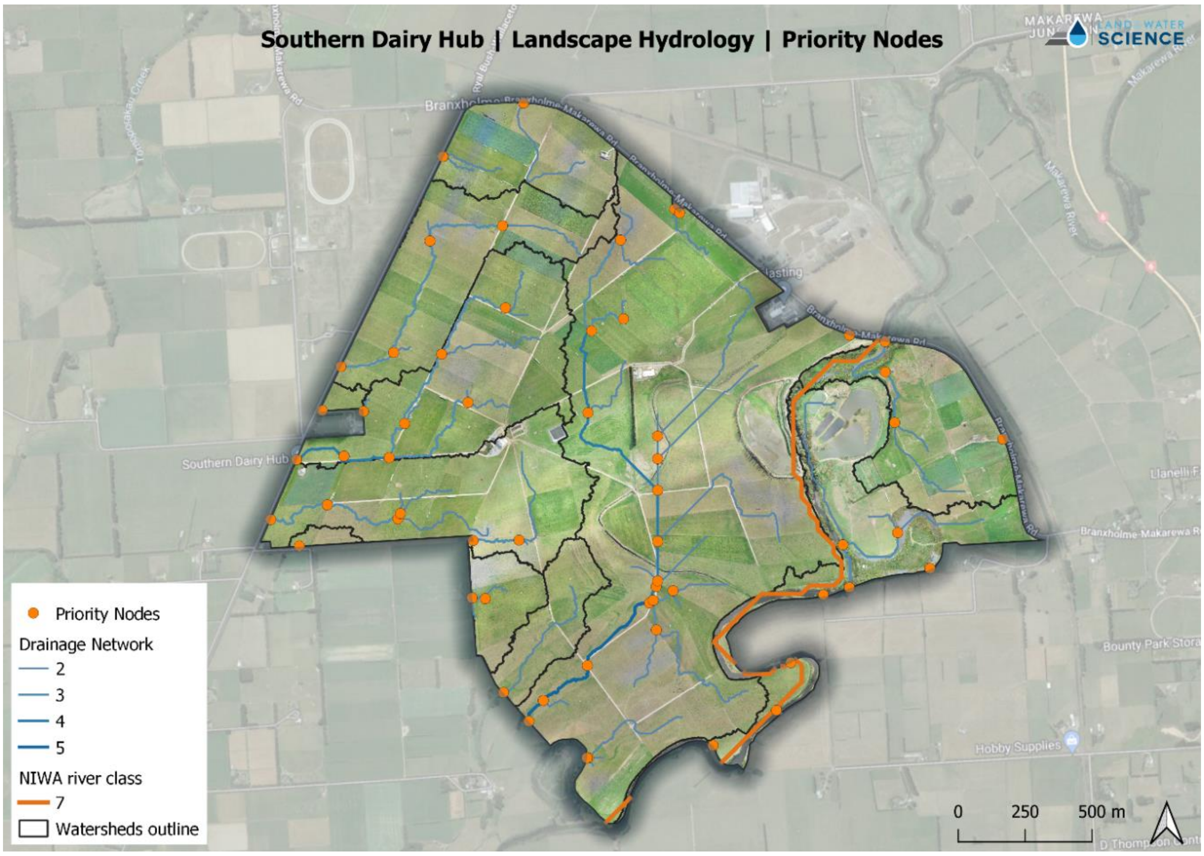

Figure 14. Southern Dairy Hub - landscape hydrology – drainage orders 2 - 5 only (i.e., the major drainage channels within the farm property), plus the related junctions and discharge nodes.

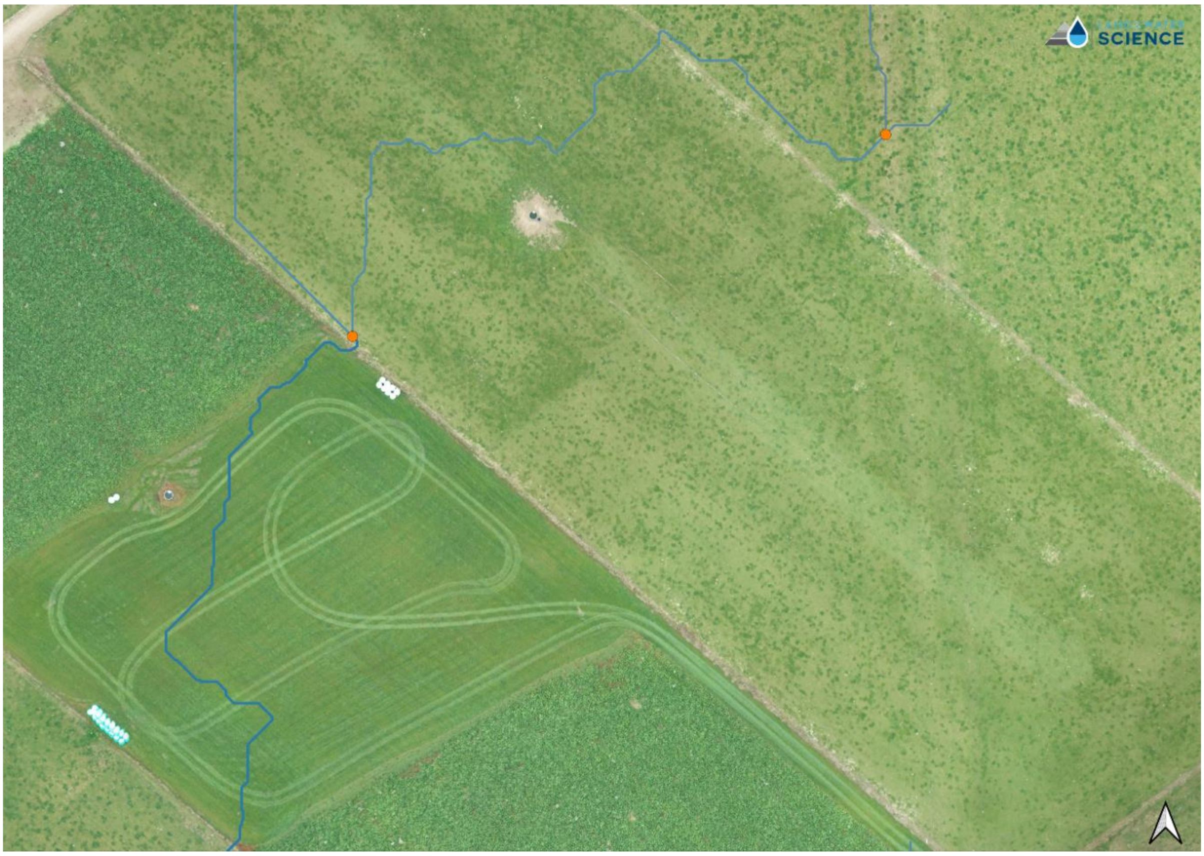

Figure 15. Southern Dairy Hub – zoomed-in view of several junction nodes (orange circles) identifies where drainage channels converge or join.

The spatial context provided with the hydrological mapping creates insights as to the source and movement of water across the property. Again, water is the dominant control over contaminant loss. As such, the hydrological network generated here is seen as a critical starting point for understanding and prioritising possible mitigations to support a more resilient farm system, e.g., sediment traps (‘Duck Ponds’), wetland areas etc. We recommend that the hydrological model of the property be used as a spatial framework through which the susceptibility of the farm landscape is viewed and ultimately managed.

5. Landscape Susceptibility for Southern Dairy Hub

Landscape variability is a major driver of variability in the type and severity of water quality and soil GHG loss, even when land use is the same. Land & Water Science Ltd (LWS) have generated a new, high-resolution approach to mapping the inherent and varied susceptibility of the landscape to land use activities at property scales (Figs. 16 - 23).

Each susceptibility model is informed by regional water quality data and utilises airborne radiometric survey and terrain measures to generalise the likely susceptibility of the landscape to contaminant loss. Critically, the method employed reveals only the ‘inherent susceptibility of the landscape’ by removing the effect of land use. As such, each model represents the likely role of the landscape in controlling contaminant loss. As such, it is important to note that the models do not represent the actual loss, nor do they consider any management practices or mitigations that are already in place. Simple, the models seek to reveal the susceptibility of the landscape on its own, independent of any existing land use.

The models of landscape susceptibility depict soil greenhouse gas (GHG) and water quality susceptibility as ‘very low’, ‘low’, ‘medium’, and ‘high’. As with any model, each model is only a guide, with ground truthing in partnership with land users an essential part of ensuring the relevance of the outputs.

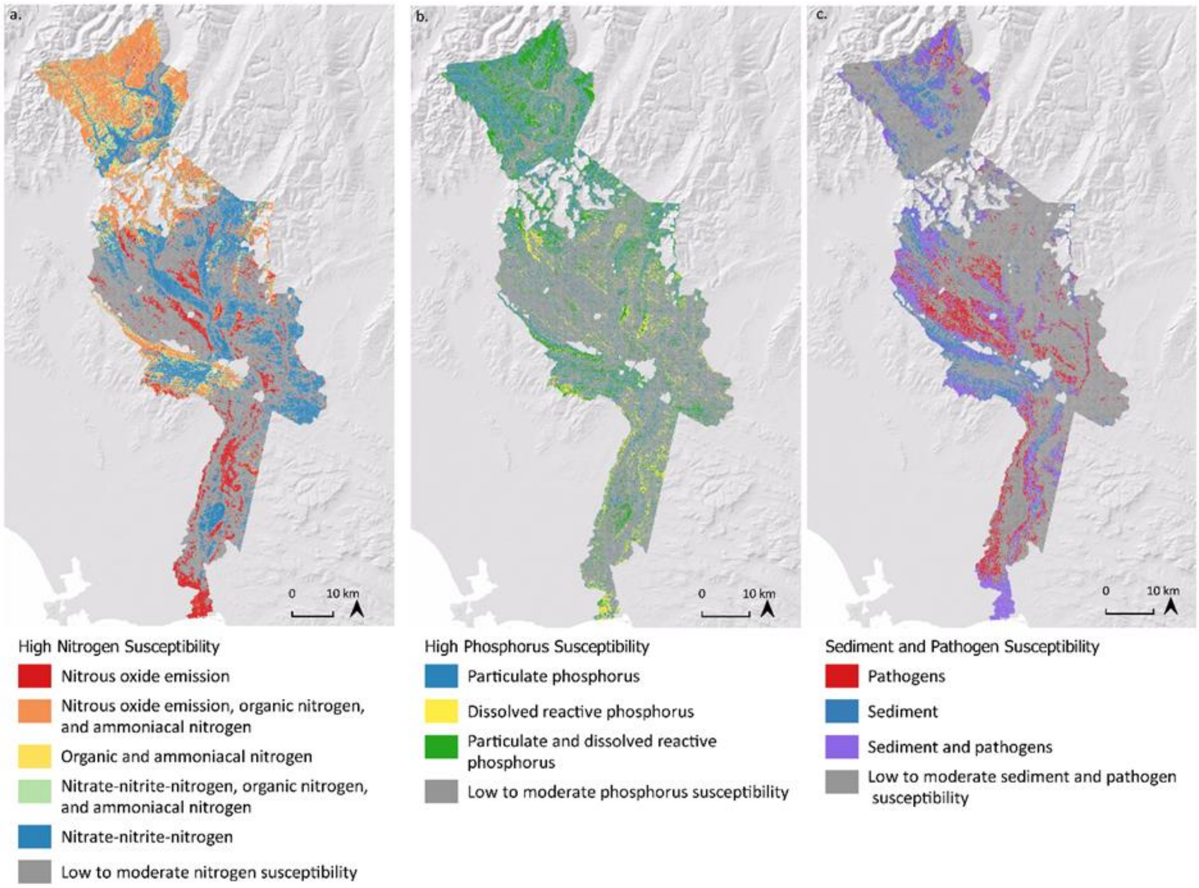

Figure 16. Example maps of landscape susceptibility (high) for the Mataura Catchment, Southland

Before reading any further, it is important to emphasise:

A. that the susceptibility models presented below do not take into account land use nor any existing management practices or physical mitigations (e.g., sediment traps, wetlands) that are already in place, and;

B. when reviewing the maps please note they are *not* identifying actual losses, rather they seek to identify the natural susceptibility of the landscape to inform land users of the risks and opportunities associated with their landscape.

5.1 Landscape Susceptibility to Erosion

The susceptibility of the property to erosion is overall very low relative to hill and high-country areas of Southland (Rissmann et al., 2020). To evaluate the fine-scale susceptibility of the Southern Dairy Hub to erosion a Terrain Ruggedness Index (TRI) was developed for the property using the newly acquired DTM (0.7m x 0. 7m) with a vertical resolution of 0.05 m (Fig. 17). The TRI has been widely used nationally and internationally to support identifying areas of active erosion. The new TRI layer can be utilised to identify in fine-scale erosional features not limited to gully erosion, sheet erosion, slips, slumps, and soil creep (terracettes). The TRI map, when used in combination with the digital drainage network and landscape susceptibility models, can be used to narrow down ('hone in') the areas of highest erosional susceptibility.

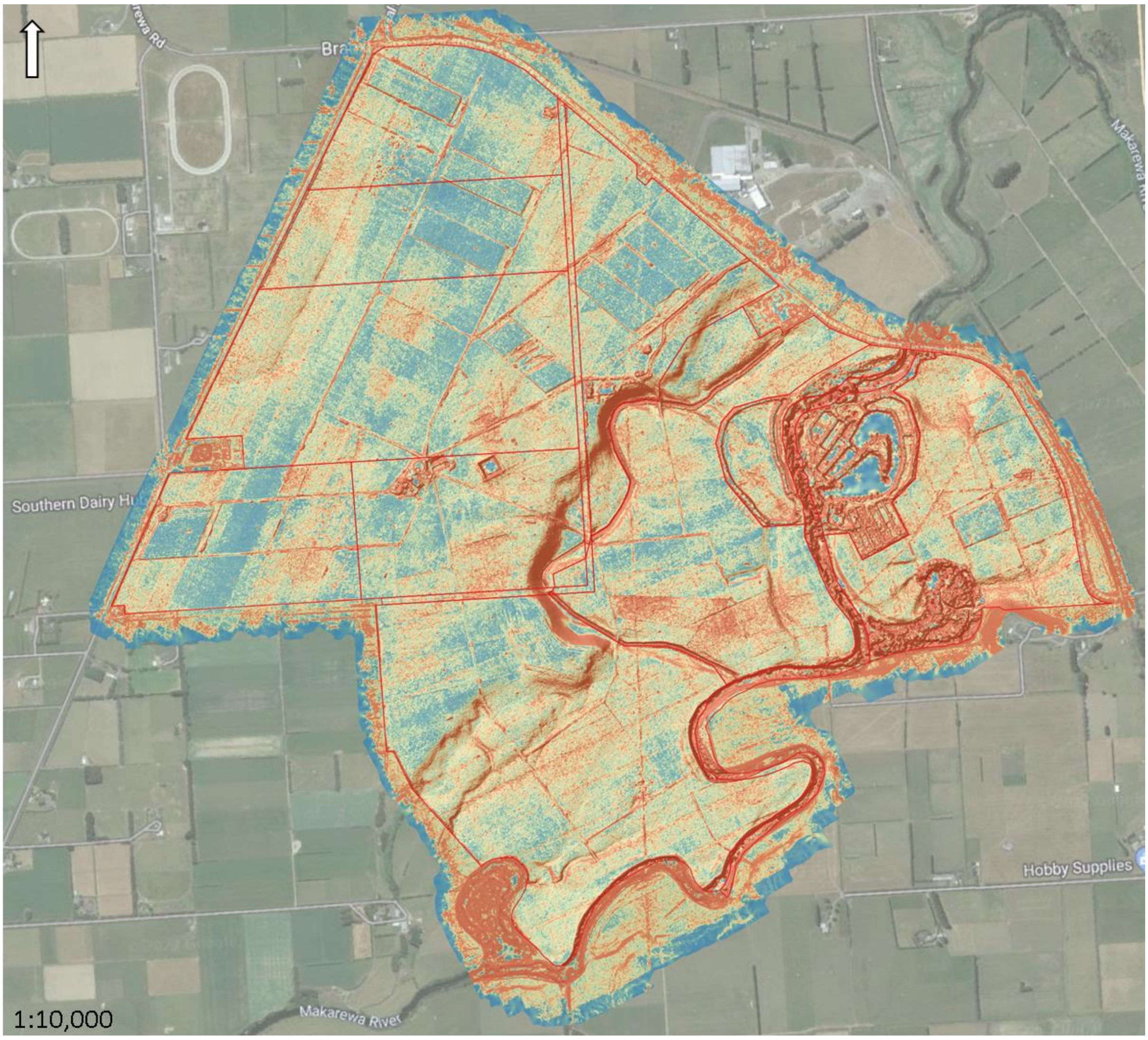

Figure 17. Southern Dairy Hub. Terrain Ruggedness Index (TRI), red colours are associated with the most rugged parts of the property.

With the property being relatively flat, elevated TRI is mainly associated with the terraces, stream channels and oxbows of the Makarewa River. Where high TRI coincides with slow permeable or poorly drained and slowly permeable soils, the risk of sediment entrainment in runoff is elevated. During a high-intensity rainfall event, e.g., a thunderstorm, runoff may result in these soils being incised and the eroded soil carried to the drainage network. This very high-resolution layer needs to be viewed at sub-paddock scales to extract the maximum value. Overall, the susceptibility of the property to mass wasting and erosion is considered low, but the susceptibility to sediment mobilisation in response to runoff is elevated in the vicinity of old channels, terraces, and remnant oxbows.

5.2 Landscape susceptibility to soil zone nitrous oxide loss

When soil becomes saturated with water, even for a short period, it may generate nitrous oxide. Nitrous oxide is a potent soil GHG with a warming potential of c. 273 times that of carbon dioxide[1]. It is produced from soils that saturate easily, either due to slowly permeable topsoil or imperfect to poor drainage. However, if the soil lacks nitrate, then very little nitrous oxide will be produced. Urine patches from livestock are a key source of urea that is rapidly converted to nitrate under the right conditions.

In brief, the mass of nitrous oxide produced is a factor of the surplus of nitrate in the soil, soil temperature, and the duration of saturation of the soil. Low volumes of nitrous oxide are generated when soil temperatures are low, soil nitrate concentrations are low, and the topsoil is not saturated. High volumes of nitrous oxide are generated when soil temperatures are elevated, soil nitrate concentrations are high, and topsoil becomes saturated. The soil nitrous oxide susceptibility model is derived from an assessment of the controls over soil reduction potential and, as such, does not consider the role of fine-textured soils in controlling soil nitrous oxide generation. Bearing this limitation in mind, the susceptibility model identifies areas of poorly drained mineral soils (green areas) and organic soils (orange and red) as having the highest susceptibility to soil nitrous oxide production. It makes sense that poorly drained mineral and organic soils are inherently more susceptible to nitrous oxide production. Further work is required to evaluate the relationship between fine-textured soils (even those that are well-drained) and soil nitrous oxide emissions.

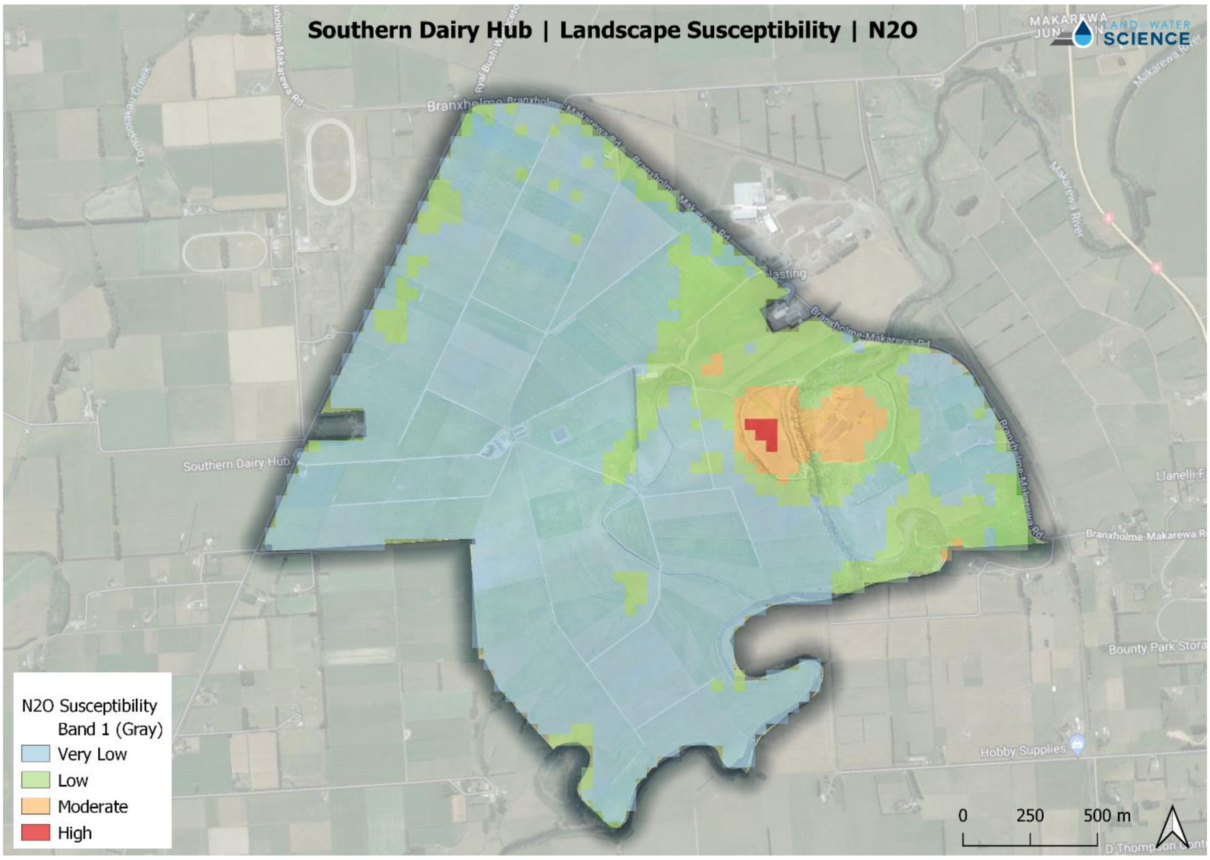

Figure 18. Southern Dairy Hub - landscape susceptibility to soil N_2O (Nitrous Oxide) emission.

5.3 Landscape susceptibility to nitrate-nitrite-nitrogen (NNN) loss

Nitrate and nitrite nitrogen (NNN) is highly soluble and is easily transported through the soil if not used by plants and microorganisms. NNN that moves below the root zone is at risk of being lost via lateral subsurface flow (including via mole-pipe drainage) and via vertical leaching to the underlying water table. Unlike organic or ammoniacal forms of nitrogen, NNN is not typically mobilised in surface runoff. Rather, it is 'rinsed' or leached from the soil and travels to the drainage network via subsurface flow paths.

NNN leaching losses to an underlying aquifer are often greatest where soils are permeable, well-drained, and deep. The oxygen concentration of the aquifer will then determine whether nitrate is able to build to high concentrations. Where oxygen is naturally low, leached NNN is often rapidly removed; where oxygen is naturally elevated, NNN may only be partially removed or not at all, enabling it to build to high concentrations. Nitrate may also be leached to the subsurface artificial drainage (mole-pipe) drainage network, where it is less likely to be attenuated, especially where a subsurface artificial drainage network discharges directly to the stream.

The NNN model indicates a large area of 'high' susceptibility to NNN leaching. The area of greatest susceptibility coincides with areas of relatively well-drained soils (Section 4.0). The areas of lower and lowest susceptibility coincide spatially with poorly drained mineral soils and organic soils (oxbow areas). Here, leached nitrate is likely to be removed in response to low oxygen conditions within the subsoil. There is little data on the groundwater beneath the property[1]. The limited information that is available suggests a moderate to low susceptibility to NNN accumulation due to weakly reducing conditions that favour the removal of NNN within the aquifer. However, where subsurface artificial drainage is present, the susceptibility of NNN leaching losses is elevated. In summary, the susceptibility model and the general setting of the Southern Dairy Hub suggest that NNN loss, especially via subsurface artificial drainage and hydrologically connected tributary, is an important management consideration for the Southern Dairy Hub.

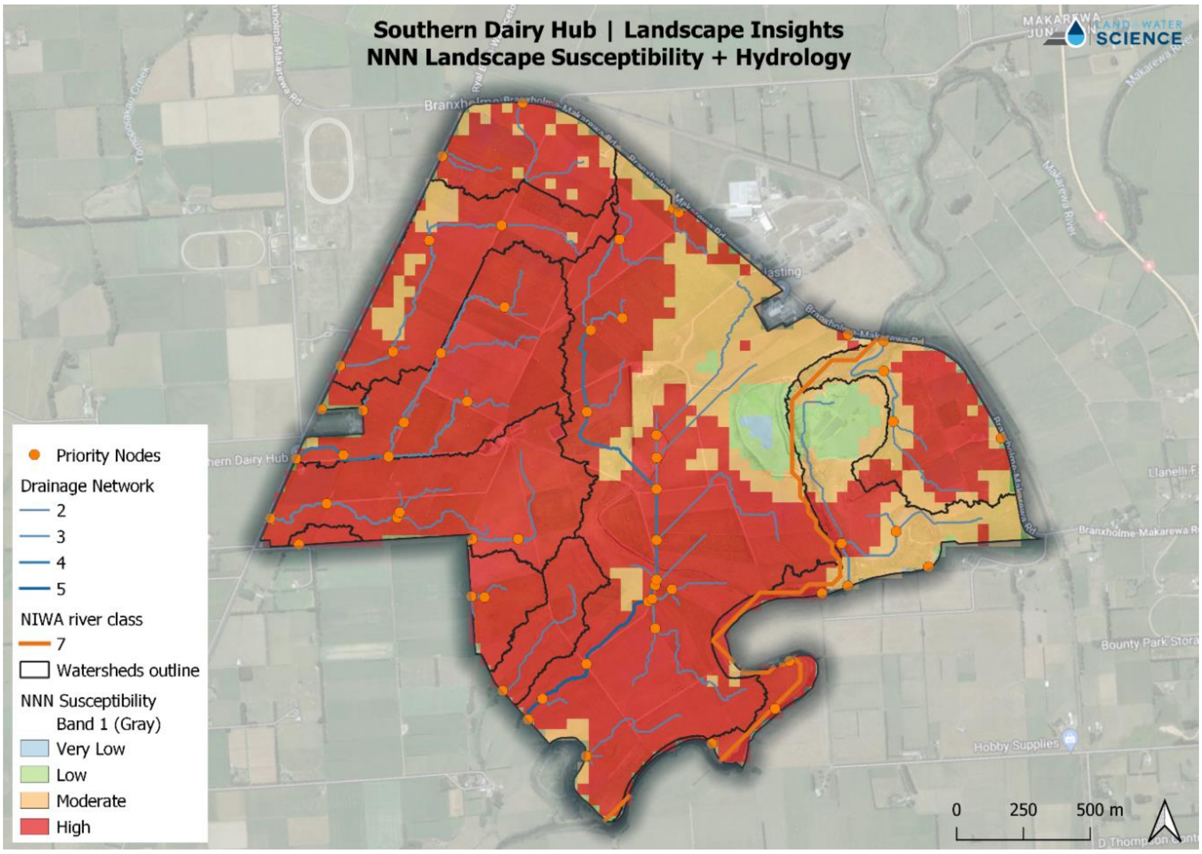

Figure 19. Southern Dairy Hub - landscape susceptibility to NNN (Nitrate-Nitrite Nitrogen) contaminants, overlaid with the hydrology.

5.4 Landscape susceptibility to Dissolved Reactive (DRP) and Particulate Phosphorus (PP) loss

When lost from a farm at high rates, P as dissolved (DRP) or particulate (PP) can impact on the health of freshwater ecosystems. Dissolved reactive phosphorus refers to dissolved or very small particles of P that may be mobile under specific conditions. However, DRP is typically very sticky, adhering to soil particles, and typically occurs in very low concentrations in most waters. However, if sediment that contains abundant P is mobilised, it is said to occur in particulate form (PP).

Dissolved and particulate forms of P include organic and inorganic phosphorus from natural rock weathering, animal manures, and fertiliser. Soils with high Olsen-P values can produce large quantities of PP if eroded. As with sediment, PP is transported by water across the land to the drainage network. Particulate P may also be elevated in subsurface artificial drainage, especially where macropores (large pores or cracks in the soil) enable water to bypass the soil matrix.

Dissolved reactive phosphorus may be leached from the soil under specific conditions. Most notably from mineral soils that are poorly drained and from organic soils. The greater tendency to lose dissolved and particulate phosphorus from these soil types reflects a lower capacity to retain P (lower anion exchange capacity) and, in some instances, greater susceptibility to structural damage. In brief, poorly drained soils have a lesser capacity to retain phosphorus and are more prone to runoff.

Referring to the model below, most of the subject property has low susceptibility to DRP and PP loss, with lesser areas of moderate to high susceptibility. Areas of elevated susceptibility coincide with poorly drained mineral and organic soils. Areas surrounding and adjacent to the abandoned oxbows are especially susceptible to DRP and PP loss. The new soil map (Section 4.0 above) for the catchment may help better support the identification of key management areas for DRP and PP.

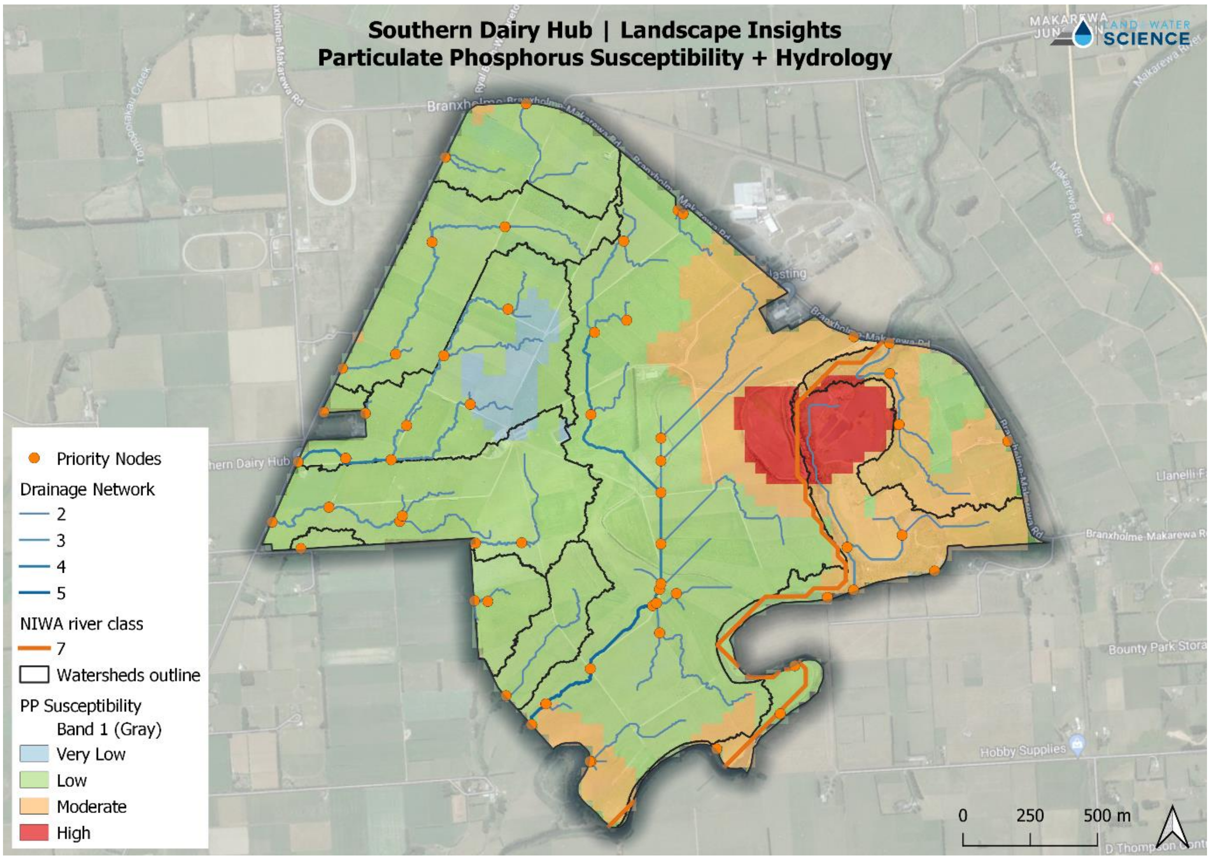

Figure 20. Southern Dairy Hub - landscape susceptibility to PP (Particulate Phosphorus) and DRP.

5.5 Landscape Organic and Ammoniacal Nitrogen (TKN) Susceptibility

Total Kjeldahl Nitrogen (TKN) is a measure of organic and ammoniacal N. Organic and ammoniacal nitrogen are derived from the breakdown of organic matter, soil organic matter, manure, and animal urine. Organic nitrogen is mineralised to ammoniacal N, ammoniacal N is oxidised to nitrite and, ultimately, nitrate. The loss of excessive TKN from land, e.g., from a recently cultivated paddock, is, therefore, an important factor controlling stream health. However, it is important to note that all natural systems generate TKN, with TKN loss occurring from natural state landscapes as well as farmed land. The main difference between the natural state and any developed landscape is the magnitude of losses.

Commonly, natural TKN losses are elevated for soils that are imperfect to poorly drained or prone to saturation for extended periods of the year. The TKN susceptibility map for Southern Dairy Hub (Fig. 21) indicates low susceptibility to TKN loss across most of the property and some moderate to high susceptibility that coincides with the poorly drained mineral and organic soils. The new soil map (Section 4.0 above) for the catchment may help better support the identification of key management areas for TKN.

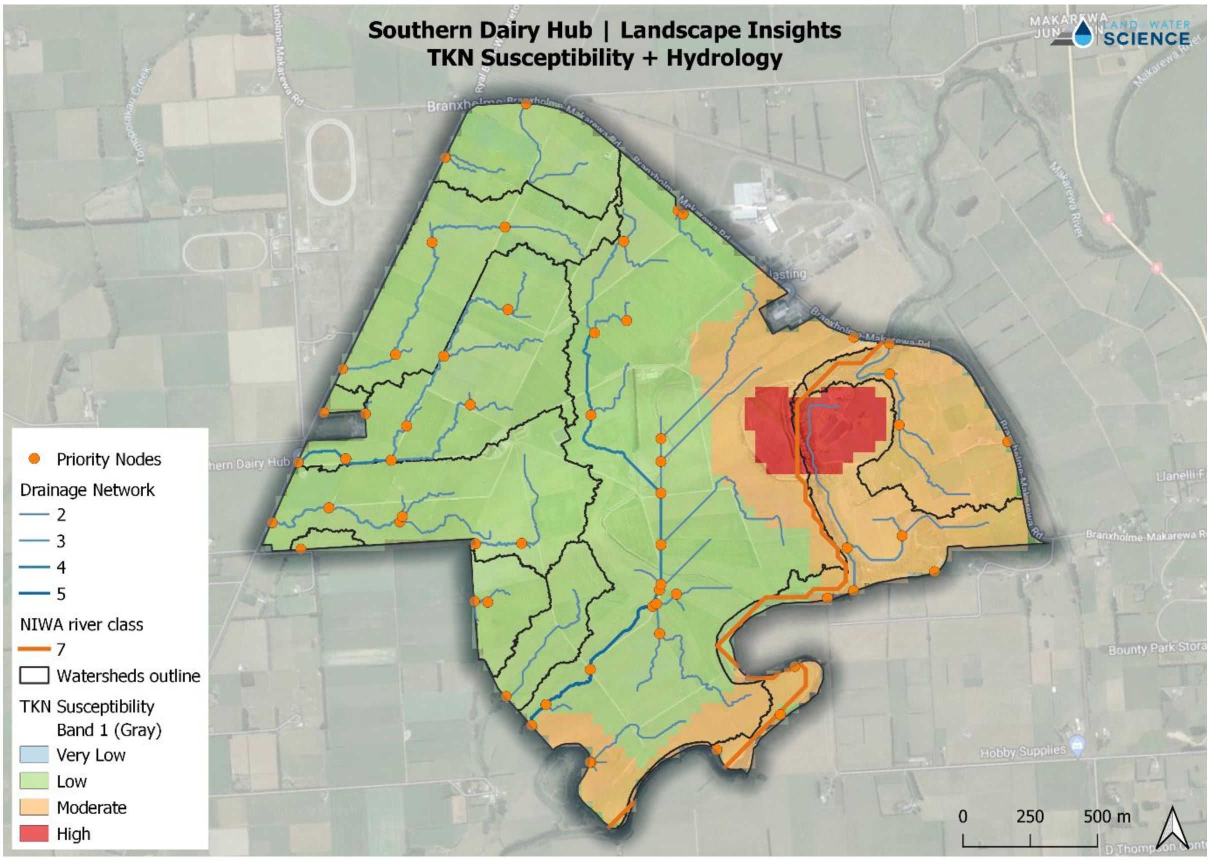

Figure 21. Southern Dairy Hub - landscape susceptibility to TKN (total Kjeldahl nitrogen – being organic and ammoniacal nitrogen) contaminants, overlaid with the hydrology.

6. Next steps

This report introduces the landscape datasets available for the Southern Dairy Hub and provides an assessment of the susceptibility of the farm's landscape. We hope that the datasets presented here provide some helpful insights that can be used to support aligning the farm system with the landscape variability through input from specialist farm systems experts, and feedback from other farmers during the planned field day.