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Integrated Land Use and Farm Environment Plan

Molesworth Station

Prepared for Pāmu New Zealand

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Table of contents

I. Executive Summary

Molesworth is a special place with a significant role in New Zealand's history. It rests beneath the highest peak in the Kaikoura ranges, named Tapuae-o-Uenuku. It is the largest farm in the country and is owned by New Zealanders. It is administered by the Department of Conservation under the Recreation Reserves Act (1977) and leased to Pāmu New Zealand. Since Crown ownership, it has had just three farm managers and their families. As a farm, Pāmu strive to meet all of the values associated with Molesworth – including recreational use, conservation, farming, and the historic values it holds.

The environmental impacts from grazing on Molesworth have been reducing over time, and in many cases, farming may provide an ecological benefit. The actions to ensure progress continues which are recommended in this plan can be summarised as encouraging cattle away from waterways, weed and pest management, minimising fertiliser inputs, cultivation, and the use of cropping, managing high risk areas (yards), not overgrazing and ensuring useful, ongoing monitoring and data collection is occurring. These are largely already occurring and have been in place for a number of years.

Molesworth provides a unique window for New Zealanders and overseas visitors to visit an operational high country station. While access has been a point of contention over the years, this has been increasing and Pāmu are open to further access for recreational use providing this can be done safely for visitors, staff and animals. Some options for this include the addition of a mountain bike trail up the Severn River, and reinstating the Māori trails complete with historical accounts provided by tangata whenua. Further work should be done to ensure visitors are able to experience and understand station life, accurately built on Molesworth's rich history from pre-contact times through to modern day Māori relationships with its Crown owners. In some areas of the Station, direct access is not possible (e.g. Tarndale), but visitors could still be given insight into these areas. The use of virtual reality technology could be a valuable tool for this.

> "Pāmu has developed an integrated farm policy that works within the limits of the land and works with the rhythms of the seasons."

This report aims to bring the relevant values associated with Molesworth together to provide an integrated land use approach. This approach recognises that history, culture, place, people and the natural world are all connected and interrelated. This plan is an operational plan developed for Pāmu Farming Ltd and is not part of the Management Plan for the Molesworth Recreation Reserve. Farming on Molesworth is a privilege and being able to farm Molesworth on behalf of 4.8 million kiwis is a responsibility Pāmu don't take lightly. They seek to recognise all of the values associated with the land and demonstrate how farming can support these values being enhanced over time.

Section 1 of this report provides the overview and context, section 2 is a description of the resources present on Molesworth, section 3 covers the farm policies and section 4 looks at the relationship of farming to land, water and current compliance. More detail is then explored, including a risk assessment in the next sections which cover water, wetlands, biodiversity, greenhouse gases, climate resilience, soil health and management, animal health and welfare, waste, and heritage. Finally, section 14 discusses the relationship between the farm, people and environment. The appendices provide supporting information including data, maps and images which are referenced throughout the document.

While there is often tension between the values associated with Molesworth it is the view of Pāmu, which is supported by evidence, that farming has a place on the property which can support conservation values and positive environmental outcomes, a great recreational experience, and protect the history and culture associated with this special place. By taking an integrated approach to management and working with key stakeholders, this would provide a unique demonstration of integrated landscape management in the high country.

II. List of Maps

III. List of Figures

IV. List of Tables

v. Summary of Recommended Actions

Actions are a combination of ongoing management practices, and specific tasks and have been identified accordingly. In implementing the actions outlined in the Farm Environment Plan, where relevant, Pāmu will need to seek approval from DOC as per their obligations under the lease and management plan.

i. Management Practices - ongoing

MANAGEMENT PRACTICE	EXPLANATION
No nitrogen or phosphorus fertiliser used on pasture.	Reduces the risk of nutrient loss to waterways and supports a low-cost farming system.
Nitrogen and Phosphorus fertiliser use on crop is limited to crop requirements based on agronomic recommendations and soil test results.	Ensures the crops are only what they need to grow, reducing the risk of nutrient loss to waterways and supporting a low-cost farming system.
Direct drill standard practice. Minimum till only for light contouring when required.	Supports soil structure, minimises the risk of wind-blow, and reduces the risk of carbon and nitrogen loss.
Maintain grazing residuals at 50%.	Supports clover growth and the regeneration of native vegetation which is low to the ground, helps to maintain soil water holding capacity, builds soil organic matter and minimises risk of wind-blow from bare soil.
Lucerne all cut and carry for stockfeed.	Reduces risk of high intensity of animals creating soil damage, supports soil structure.
Block grazing of ryecorn rather than strip-grazing.	Reduces risk of high intensity of animals creating soil damage, supports soil structure.
Continued use of salt, ensuring salt site is located at least 30m away from waterway and any run-off from salt site not likely to reach waterway. *(Reference: Figure 16 and Figure 17).*	Attracts cattle away from waterways.
Self-imposed stocking rate limit maintained.	Ensures impact from cattle to waterways remains low.
Sulphur and lime use remains below 1400m, and pasture management practices maintained.	Discourages stock from venturing into high country, supporting native and woody vegetation recovery, and reduces risk of erosion on steeper slopes.
Maintain yard sites, including reticulated water supplies, and drainage to paddock rather than waterways. *(Reference: Figure 23 and Figure 24)*	Reduces risk of faecal bacteria entering waterways via run-off.

MANAGEMENT PRACTICE	EXPLANATION
Maintain small mob sizes to reduce pressure on sensitive areas (e.g. wetlands) when mustering stock.	If stock are moving through sensitive areas (which is minimised), smaller mobs do less damage.
Work with DOC to maintain fences on existing wetlands.	Ensures cattle are not able to damage the wetland areas.
Continue access to native woody vegetation only when mustering stock between blocks, no long-term access. Where possible, avoid access. *(Reference: Figure 25)*	Cattle can damage the understory of native woody vegetation if given the opportunity to graze. By only using these areas to move stock through, this damage is minimised.
Work with DOC and the Ministry for Primary Industries on the coordinated wilding pine control programme. Annual spend is ~$50,000. *(Reference: Figure 27 and Figure 28)*	Wilding pines pose a significant threat to grazing areas, as well as areas under conservation management.
Maintain stocking rate at or below current levels to support native vegetation recovery.	This may need to be reduced over time as conservation values are enhanced and overall land use evolves.
Work with DOC and others on continuing active, targeted pest management.	Pests will impact native flora and can also be vectors for disease.
Work with DOC to maintain culverts on high value native streams (e.g. Camp Stream).	Perched culverts are preventing introduced fish species predating on non-migratory native fish.
Model greenhouse gas emissions and sinks on Molesworth annually.	Using Overseer (best tool available currently), modelling emissions helps to understand where they are at and inform any mitigation options as they arise.
Review options to mitigate emissions annually.	Options are evolving as the science continues and moves to commercialisation.
Stock moved off crops when wet, vehicle movements managed to avoid soil compaction.	Soil structure can be impacted by heavy stock or machinery.
Grazing management ensures there is no need for over-sowing of seed.	The reduced stocking rate, large area, and management focused on high residuals and clover ensures there is adequate feed for the cattle on Molesworth without the need for more.
Continue with current waste management practices.	Waste is reused or recycled where possible, and carefully managed away from waterways otherwise.

ii. New Actions

In implementing the actions outlined in the Farm Environment Plan, where relevant, Pāmu will need to seek approval from DOC as per their obligations under the lease and management plan. In addition, some actions are being considered as part of the review of the management plan and therefore Pāmu will be advocating for these actions to be included.

ACTION	EXPLANATION	TIMEFRAME
Advocate in management plan review for willow management plan to remove willows in or close to stream and river. *(Reference: Figure 20 and Figure 21)*	Willows are causing streambank erosion as the waterway scours out around the root systems. Not all willows should be removed as those further out from the waterways will be providing shade benefit and not causing impacts to the waterways.	Over next 3 years.
Encourage cattle away from waterway where possible in Northern Awatere through increased use of salt, provision of water reticulation throughout the block, and protection of seeps. Temporary fences (such as hot-wires with battery pack) could also be considered.	This area has been identified as a risk for reduced water quality due to sediment likely caused by farming practices. Removal of cattle from the waterway would be most beneficial in this part of the property as it is the most intensive. However, fencing is impractical at the scale required. Alternative methods to attract cattle away from waterways therefore need to be used.	By end of 2020.
Divert race at Molesworth Stream stock yards to avoid run-off from yards reaching stream. *(Reference: Figure 30)*	The race is open and runs through the yards from a small dam just above the yards. To avoid any runoff from yards entering the Molesworth Stream, this small race needs to be diverted over the neighbouring paddock.	By end of 2020.
Increase stock water reticulation and provision of shade.	Both troughed water, and shade help attract cattle away from waterways. Both also support positive animal welfare benefits.	Over next 5 years.
Advocate in management plan review for the state of all wetlands (including seeps, flushes, ephemeral tarns) to be identified and establish time-series monitoring. Key areas to focus are Lake McRae, and Sedgemere-Tarndale. Identify management actions from the monitoring.	Be able to measure the impact of conservation and farm management practices on wetlands.	June 2021
Work with DOC to fence seeps/soaks (45 identified). *(Reference: Figure 18 and Figure 19)*	These seeps/soaks are ephemeral wetlands which should be protected from cattle to enhance their value. Very few of these remain in New Zealand.	Over the next 5 years.

ACTION	EXPLANATION	TIMEFRAME
Produce and introduce cyanobacteria training materials for Pāmu and DOC staff. Develop protocols for Molesworth Station involving Pāmu and DOC staff to limit risk to the public and animals. Cyanobacteria should be monitored by both Pāmu and DOC staff through a system of shared recorded observations.		By June 2021
Consistent with the management plan, work with DOC, to establish and maintain a three-yearly monitoring programme in order to track changes over time. Each round of monitoring should result in a substantive report monitoring should include E. coli, deposited sediment, conductivity, clarity, MCI, temperature, shade, periphyton, macrophytes, and substrate composition.		By end of 2020
In order to respond to localised concerns for waterways on the station in terms of ecosystem health, a conductivity meter can be purchased for the station as a first indicator in cases where nutrient contamination may be suspected.		By end of 2020
In order to respond to localised concerns of the suitability of waterways for recreation, human and stock drinking water, a guide to E. coli sampling and testing should be produced and made available to Pāmu and DOC staff.		By end of 2020
Advocate in management plan review for time-series monitoring of fish to be established to monitor fish species in key areas, or of key species to measure the impact of conservation, recreation and farm management practice and target further protection or enhancement work.		June 2021
Identify representative sites to carry-out the Freshwater Quick Assessments at least annually. Record results and monitor trends over-time. Respond as needed to declining scores or to scores not improving which are not showing 'excellent' water quality outcomes. Teach farm staff how to carry-out assessments.		Every summer (early at median flow).

ACTION	EXPLANATION	TIMEFRAME
Advocate in management plan review to identify streams free of salmonids where protection would be beneficial.	Provides barriers to sports fish (predators of native fish) access.	June 2021
Stock-take of all exclusion fences to ensure functioning. Undertake maintenance as required. *(Reference: Figure 29)*	Some of the research suggests these have not been adequately maintained to protect biodiversity outcomes.	By end of 2020
Advocate in management plan review to ensure ongoing, time-series monitoring of native vegetation, terrestrial biodiversity, and aquatic biodiversity.	Monitoring is required to ensure conservation and farm management practices are achieving positive, measurable outcomes for biodiversity values.	June 2021
Advocate in management plan review for sweet briar removal from areas where no or low impact to native vegetation. Start with the Alma, then the Awatere, then the Guide. *(Reference: Figure 26)*		Over next 3 years.
Undertake an annual visual soil assessment in each Land Management Unit (ideally), and at least in the Awatere block.	Visual soil assessment is a valuable tool to assess the long-term health of soils.	Annually in late winter or early Spring.
Begin household recycling of waste.		Immediately.
Advocate in management plan review to investigate the development of a mountain bike trail in the Severn through to tarns at Tarndale.		June 2021
Advocate in management plan review to investigate reinstating Māori trails working with tangata whenua.		June 2021
Provide current information for interpretation panels and DOC website for existing visitors to Molesworth.		By October 2020
Investigate opportunity for agri-tourism venture on Molesworth.		Over next 2 years
Investigate provision of virtual reality experiences for visitors to Molesworth to experience areas with restricted access and participate in farming activities such as mustering.		By end of 2020

Molesworth Integrated Land Use and Farm Environment Plan

1. Introduction and Context

Molesworth is New Zealand's largest farm at 180,470ha and is proudly leased by Pāmu New Zealand (Landcorp Farming Ltd), who have held the lease since 1990, but have been farming Molesworth since 1987. The property has been in Crown ownership for nearly 80 years. As with all farms in New Zealand, the management has evolved as the land managers' knowledge and understanding of the landscape and how it interacts with animals, has developed.

Molesworth is administered by the Department of Conservation under the Reserves Act 1977. The Department produces a Molesworth Management Plan at least every 10 years which outlines the vision of a high country reserve that supports a broad range of values including recreation, biodiversity, cultural, historical and farming, and how these values will be met. The Management Plan sits alongside a farming lease and grazing licence which outline the parameters for the farming lease. At the time of writing, a new management plan is being developed. The current Management Plan was produced in 2013. Farming on Molesworth is controlled by the Management Plan and the Lease Agreement.

Molesworth is a special place. Māori established trails through Molesworth for food gathering and access between the west and east coasts. Māori communicated about these routes to early European settlers, who then used them to move stock from Marlborough and Nelson through to Canterbury. This happened well into the 20th century. The Molesworth of today is an amalgamation of four separate pastoral leases, Molesworth, Tarndale, St Helens and Dillon which were all abandoned to the Crown between 1938 and 1949 due to rabbit infestation, huge stock losses due to snow, and economic recession. The old cob cottages on the property remain as a reminder of these tough times. Crown ownership has supported the gradual recovery of the land, while protecting its historic significance and enhancing environmental outcomes. In the past 70 years, the property has been managed by just three families, illustrating just how special the place is.

An Integrated Land Use and Farm Environment Plan brings together all of the elements that contribute to the landscape and the use of that landscape. It considers how these elements interact with each other, the risks created by this interaction, and identifies how these risks can be managed to maximise the beneficial interactions. For Molesworth, the elements include land and water, animals and people.

1.1 Pāmu's Strategic Goals for Molesworth

- Implementing a values-based approach for future management focused on long-term outcomes.
    - Responsible management demonstrating balance between livestock farming, recreational values and environmental enhancement.
    - Annual water quality monitoring.
    - Investigating new technology around virtual fencing.
- Further enhance recreational access.
    - Increase recreational access where public entry can be made safe and the welfare of DOC and Pāmu Staff, and animals is protected.
    - Explore opportunities for third party commercial tourism input, particularly incorporating farming aspects.

- Support biodiversity outcomes, particularly for dryland vegetation restoration.
    - Reduced stocking rate maintained while minimising fire risk in the highly traversed areas for recreation.
    - Investment into eradication programmes for broom, wilding pines and pests including a permanent staff member for this.
- Create better linkages with adjacent public conservation land for recreation and tourism and collaboration with local iwi.
- Integrate farming with biodiversity and recreation, recognising farming as part of the visitor experience and protecting the station and its history.

1.2 Development of the plan

This plan has been developed as an Integrated Land Use and Farm Environment Plan for Molesworth Station, leased and managed by Pāmu New Zealand. The plan has been developed to help ensure Pāmu are doing the absolute best by Molesworth and the diverse range of values associated with this unique part of the world. The plan recognises the interrelatedness of these values and reflects both the requirements Pāmu has within the Molesworth Management Plan, as lessees of a Recreational Reserve, and Pāmu's overall objectives.

Pāmu see themselves as Kaitiakitanga, guardians of nature. The care and respect of nature's lands, animals and people come first in everything Pāmu does. They recognise that people are intrinsically connected to place, and through time, historic and cultural values are of significance to their guardianship.

Molesworth is unique in many ways. It is a commercial farm operating in a Recreational Reserve. As such, there is a need to meet environmental, economic and recreational goals, which can often conflict. This plan provides an approach to bring these goals together, reflect on where things have been, and plan for what might be ahead to ensure the sustainable use of Molesworth as a farm.

Sustainable development is defined as *'Development that meets the needs of the present, without compromising the needs of future generations to meet their own needs.'* (Brundtland, 1987). Molesworth management historically did not meet this definition. Under current management, this definition is intrinsic to the decisions made in the farm business. Sustainable farming practices are therefore defined by Pāmu as '*Farming practices which restore and enhance our natural environment, promote stewardship of our human resources, and utilise a systems approach to recognise the interconnectedness of people, animals and the natural world which can be maintained for the long-term.'*

The Integrated Land Use and Farm Environment Plan documents how this is being achieved and can be further enhanced on Molesworth Station. It considers the base resources – natural, human and animal, how these are currently being managed, and the sustainability of that management. Actions are identified which will further enhance long-term outcomes for Molesworth. The plan is unapologetically focused from a farm perspective, with the intention to enable farming to continue at Molesworth. However, the farm management practices are scrutinised in relation to the base resources to ensure that they are meeting all of the values associated with the property.

2. Description of Resources

2.1 Climate

Rainfall on Molesworth ranges from 750mm per year average at the homestead to 1500mm per year average in the head of the Wairau Catchment.

Hot and generally dry summers are followed by harsh winters. Snow may fall at any time of the year, sometimes covering the entire property for up to eight weeks in the winter.

2.2 Land and Water

2.2.1 *Geology and land system*

Source: Molesworth and Upper Clarence Catchment Land Resources Inventory, 1988

The Molesworth geology is formed from a combination of tectonic, glaciation and erosion events. Molesworth was a historically glaciated landscape as evidenced by the presence of terminal and lateral moraines, glacial outwash plains, hanging valleys and waterfalls, cirque basins, tarns and arêtes, primarily on the western side of the property. The eastern side of the property has greater influence from tectonic uplift and erosion is prominent across the entire landscape. The altitude ranges from 549 to over 2100 metres.

Erosion is one of the defining, natural geological features of Molesworth with significant areas of the station being classified as 'extreme', 'very severe' or 'severe'. The factors which contribute to this are the underlying geology and soil types, the tectonic activity, climatic influences (including frost-heave), type of vegetation cover, lack of suitable stabilising vegetation, as well as pest and stock disturbance (Department of Conservation, 2013). Types of erosion present on Molesworth include wind, frost-heave, sheet, gully, soil slip, debris avalanche, and scree.

Molesworth is part of the Marlborough-Wellington Shear Fault Zone which is bounded by the mountainous land south of the Wairau River, and the Seaward/Kaikoura Range. Within this zone, the major faults are the Awatere Fault Zone, Clarence/Elliott Fault System, Fowlers Fault and the Hope Fault. Other fault traces have also been observed.

Molesworth is dominated by the Torlesse Supergroup rocks, ranging from poorly sorted thin bedded greywacke and argillite, to massive beds of better sorted sandstone and occasional argillite. Rocks and lava beds are also interspersed with tuffaceous sediments, limestones and chert.

There are three categories of land systems defined for Molesworth:

- High relief mountain slope macro landforms with minor terrace and fan elements within them.
- Low relief, hard rock, hillslope.
- Low relief flat to undulating basins, terraces and fans.

2.2.2 *Soils*

Soils on Molesworth are influenced by climate, elevation, and landforms, as well as variation in parent material, drainage, erosion and soil age. Soil types are outlined according to this split in Table 20. Table 21 outlines some descriptions of soils in relation to Land Use Capability units discussed below. The fundamental soils layer is shown in Map 4.

On the hill and mountain slopes, the low rainfall zone (east) is predominantly Muller and Benmore soils, the medium rainfall zone is predominantly Tekoa and Kaikoura Soils, and the high rainfall zone (west) is predominantly the Bealey and Spenser Soils. On the terraces, fans and moraines, the Acheron and Molesworth soils dominate the low rainfall zone, with the Craigieburn and Cass in the medium rainfall zone and the Katrine soils in the high rainfall zone.

The higher rainfall soils are more weathered with poor water holding capacity. The eastern side of the property is naturally moderately fertile, while the west is naturally moderately infertile.

2.2.3 *Land Use Capability*

The Land Use Capability (LUC) system has two key components. Firstly, Land Resource Inventory (LRI) is compiled as an assessment of physical factors considered to be critical for long-term land use and management. The LRI system involves mapping landscape units according to five inventory factors (rock type, soil unit, slope class, erosion type and severity, and vegetation). Secondly, the inventory is used for LUC classification, whereby land is categorised into eight classes according to its long-term capability to sustain one or more productive uses. Within these eight classes, the main limiting factor for that area of land is identified (erosion, water, climate, or soil), and then a final classification is made based on specific characteristics of the land, such as erosion type. The assessment is made by specialists who are trained in this type of land assessment.

Molesworth has been mapped at 1:50,000 scale. Given the size of Molesworth, this is an appropriate scale to help inform long-term land use and management decisions.

Map 5 shows the LUC classes for Molesworth. It is made up of 3 main classes, Class 6 (41,508ha), Class 7 (74,968ha) and Class 8 (63,240ha). The majority of grazed land is Class 6, there is a small amount of Class 7 land grazed, and no Class 8 land is grazed. The predominant limiting factor for land on Molesworth is erosion (90%), with the remaining land being either soil or climate limited. There is a small area (~260ha) with a wetness limitation.

The sub-classes are wide-ranging in area and land type as observed on the map and summarised in Table 21. Class 6 land is on the undulated, rolling terraces and fans, and the strongly rolling to steep slopes. This land is relatively stable, but the 6e22 land is prone to wind erosion. The variation between the sub-classes for the Class 6 land is based on rainfall and soil type.

The Class 7 land ranges from moderately steep to very steep hill country which is prone to erosion of varying types and is dominated by yellow-brown earth soils.

2.2.4 *Land Management Units*

The station is separated into Land Management Units which recognise the different characteristics of the natural resources in those areas such as soil, geology, water, topography, aspect, climate and vegetation cover. The Land Use Capability informs the Land Management Units. The stocking policies, including type of stock, number and timing of stock in each area, as well as consideration of management, are then defined based on the understanding of the natural resource characteristics. Table 22, Table 23 (in Appendix 18.3) and Map 2 show the Land Management Units and timing of grazing in the grazed area for Molesworth Station.

Within each grazing block there is a fertilised area on a 3-year rotation. These areas are fertilised with lime and sulphur. The majority of the grazing areas include the valley floors, and easier contour alluvial fans and ridges. Above the 'fertiliser line' (at about 1400m altitude), land is steeper and largely un-grazed. While not prevented by fences, cattle are much less likely to venture into higher altitude areas as the feed quality is poor here. This has the added advantage of supporting the native regeneration which is occurring in the higher altitude areas of Molesworth.

Within the grazed area, there is a mixture of tussock/natives and forage species such as clover, brown-top, timothy, cocksfoot, yorkshire fog, and fescues. In the past 15-years there has been no over-sowing[1]. However, it was common practice prior to this.

The ryecorn and lucerne crops receive fertiliser based on their agronomic requirements supported by soil test results, and no more.

2.2.5 *Waterways, wetlands, tarns*

Molesworth Station has a stream and river network of approximately 2,672km across three major catchments, Waiau Toa (Clarence), Wairau and Awatere. Major wetlands are shown on Map 1 in Appendix 18.2. The Clarence and Wairau rivers sit in the western part of Molesworth, driven by westerly rains from the St Arnaud and St James Ranges, while the Awatere starts in the Rachel and Inland Kaikoura Ranges and is much drier. Many of the rivers on Molesworth are braided, making them nationally significant ecosystems.

Lakes, tarns and wetlands are a dominant feature of Molesworth. The Sedgemere tarns are some of the richest and most diverse freshwater communities in Marlborough. Lake McRae is also significant in that it lacks introduced fish, as do some of the smaller tarns on Molesworth. Most of the lakes on Molesworth are free from introduced aquatic weeds and are home to several species of threatened aquatic plants.

2.3 Protected Areas

2.3.1 *Areas of High Natural Value (AHNV)*

Areas were identified on Molesworth in 1987/88 by the Department of Conservation. The areas assessed were the Balaclava, Dillon, Sedgemere and part of the Miromiro Ecological Districts with the intent of identifying areas to become Protected Natural Areas, now called Areas of High Natural Value. Vegetation in these areas within Molesworth was predominantly gravelfield and tussockland followed by shrubland and scrub. Wetland vegetation is a minor component on Molesworth. The survey recognised significant modification from agriculture of the valley floors, riverbeds, terraces, fans, and foot-slopes resulting in vegetation with a significant exotic component.

The areas recommended for protection were done primarily on their ecological values. These are shown in Map 3. Selection criteria included naturalness, representativeness, diversity, special features, cultural influences, other values, and management issues. Scale was identified as important to achieve viable outcomes. Where practical, boundaries were identified as ridges or waterways to provide natural limits rather than fences. The areas identified were not mutually exclusive of other areas of ecological significance on Molesworth. Areas that were excluded still have varying degrees of ecological value. In addition, there are areas within the Areas of High Natural Value where grazing is allowed.

2.3.2 *Pāmu*

Pāmu initiated the protection of Island Lake from grazing with fences. Other areas have been looked after by reducing grazing time in each area, reducing stocking rates, and leaving a high grazing residual. Mob sizes have also been reduced to minimise their impact on sensitive areas during mustering. Some fences have been put in place to protect AHNV's from grazing, these work with natural boundaries to prevent stock access.

1 Over-sowing in this environment involves spreading seed from a plane, usually in conjunction with fertiliser.

2.4 Animals

2.4.1 *Farm*

The current lease agreement sets a limit of 10,000 head of cattle on Molesworth. However, Pāmu have a self-imposed limit of 6,000 head, believing this to be a more sustainable number to meet all of the values associated with Molesworth. As such, in the past financial year there were 5,500 head of cattle wintered on Molesworth. 50 station horses and around 40 working dogs are also run on the property.

Animal welfare is a high priority on Molesworth and has largely driven the policy to reduce stock numbers to ensure animals are well-fed and able to perform, even in climatically challenging seasons. All staff are highly trained in cattle management, with expert dog training and horse training. Animal health policies are regularly reviewed by a veterinarian and proactive animal health plans are developed and implemented annually. Animal performance is monitored annually, and changes made to overall policies when needed in response to this information.

The farm policy is discussed in more detail in section 3, including why there are no sheep on the property.

2.4.2 *Introduced species*

Many of the streams on Molesworth are a spawning ground for rainbow trout, brown trout and Chinook salmon spawn in the Upper Clarence and Acheron River catchments.

2.5 Indigenous Biodiversity

Molesworth is a biodiversity hotspot for both flora and fauna with a number of rare and threatened species found there. Given the vastness of the property, there are likely to be more species present which are yet to be found. Appendix 18.5 lists the indigenous and introduced species known to occur on Molesworth sourced from the current (2013) Molesworth Management Plan. Map 10, Map 11, Map 12, and Map 13 show the national status of biodiversity assessed on Molesworth.

2.5.1 *Native fauna*

Molesworth is host to a wide range of native fish, invertebrates and birdlife.

There are a diverse range of native fish species present on Molesworth, some of which are unique to Molesworth such as the endemic Tarndale bully (*Gobiomorphus alpinus*) in the Sedgemere tarns. Others include the Northern Flathead Galaxias (*Galaxias vulgaris*), endemic to the top of the South Island and the Alpine galaxias.

Many of the rivers and lakes host longfin eels/tuna (*Anguilla dieffenbachii*). Dwarf Galaxias (*Galaxias divergens*) are present in many of the rivers and streams. Surveys of Island Lake have also recorded the presence of shortfin eels/tuna (*Anguilla australis*). Koaro (*Galaxias brevipennis*), torrent fish (*Cheimarrichtys forsteri*), Canterbury galaxis (*Galaxias vulgaris*) and the upland bully (*Gobiomorphus breviceps*) are also all present on Molesworth.

The majority of the fish species found on Molesworth are nationally declining and at risk. There is limited time-series data available to determine their status on Molesworth itself. This would be a very valuable investment to help conservation, recreation and farm managers understand the impacts of their management.

There are a number of native bird species found on Molesworth including nationally critical black-billed gull, grey duck and Australian bittern; nationally endangered black-fronted tern and kea; nationally vulnerable banded dotterel and southern crested grebe; nationally declining South Island robin, South

Island pied oystercatcher, New Zealand pipit, and marsh crake; and the Eastern falcon which is nationally recovering. Some of these species breed on Molesworth, some use it for feeding, and others are observed passing through or on the periphery.

Lizards are also a distinctive feature of Molesworth with the nationally vulnerable Marlborough spotted skink, the Northern long-toed skink, and the scree skink; the nationally declining Southern grass skink; and the pygmy gecko and Southern Alps gecko which are not threatened.

2.5.2 *Native flora*

Molesworth boasts a significant and diverse range of native flora thought to be due to the combination of the dry climate and mixed geography (Department of Conservation, 2005). Appendix 18.5.1 lists the native vegetation known to occur on Molesworth. A substantial portion of the endemic plants on the property are only found in South Marlborough (80 species).

There are 620 species and sub-species of indigenous vascular plants, around 15% of the NZ flora; 112 of the indigenous vegetation species and sub-species are nationally threatened or are at-risk; the tarn wollyhead appears to be endemic to Molesworth; some species have the majority or all of their populations on Molesworth (Courtney, 2018).

The natural vegetation of Molesworth was probably a montane forested zone and a subalpine and alpine tall tussock grassland zone, although it is less clear in the eastern parts of Molesworth. The suggestion is that it was most likely forested in totara forest (Sutherland, 1988). A brief history of vegetation cover on Molesworth is presented below from Husheer, 2018, which includes references for the information presented:

- *Post glacial pre-human 14,000 yr BP-1,400AD*
    - Drought tolerant forests including species such as *Fuscospora cliffortioides, Hoheria lyallii, Phyllocladus alpinus, Podocarpus laetus* and *Prumnopitys taxifolia*.
    - Smaller areas of shrub- and grass-land where forests could not be sustained, including *Dracophyllum, Helichrysum, Leptospermum* and *Ozothamnus* species.
- *Māori impacts on Molesworth Vegetation: Destruction of forest- 1350-1850 AD*
    - Repeated fires.
        - Forest cover nearly eliminated.
    - Most forests destroyed by 1,500.
    - Māori left Molesworth area due to shortage of food.
        - Slow vegetation recovery began.
        - Vegetation had still not completely recovered by the time Europeans arrived, highlighting how long the recovery process is.
- *European impacts on Molesworth vegetation: Destruction of forest, scrub and tussock grasslands- 1850-1940*
    - High intensity sheep grazing and burning and commonly annual burning of tussock.
    - Competition from invasive weeds and exotic pasture grasses.
    - Vegetation damage by rabbits, pigs, goats and deer.
    - By 1930's, sheep farming had become uneconomical.
        - 1938, government began taking up leases, removed sheep and stocked Molesworth with very low stocking rates of cattle.

- *The modern era- Cattle and exotic plant introduction- 1940-2016*
    - From late 1940's, pasture management rationalised, intensive rabbit control introduced, stocking rates reduced and aerial over-sowing of exotic plants such as *Agrostis* and *Trifolium*.
    - Weeds such as *Rumex*, *Hieracium* and *Hypocheoeris radicata* have contaminated some of the seed sow resulting in wide dispersal of these weeds with over-sowing.
    - Burning stopped.
    - Over-sowing ceased in late 1990's.
    - Stocking rate reduced by 40% since mid-2000's.

Native vegetation cover changes with altitude as identified in the Protected Natural Areas report and outlined below (Courtney & Arand, 1994).

- Manuka-kanuka scrub 600-1250m.
- Matagouri and briar scrub 700-1200m.
- Mixed scrub and tussock-shrubland 800-1600m.
- Flaxland 900-1550m.
- Broadleaved snow tussockland 1000-1650m.
- Broadleaved snow tussock gravelfield and loamfield 100-1650m.

Aquatic vegetation is also predominantly native for both macrophytes and algae in the lakes. Good monitoring is required to ensure this situation is maintained and that management can be adjusted if evidence suggests otherwise.

2.6 People

2.6.1 *Farm and customers*

Pāmu employ 4 full-time staff on Molesworth who live on the property full-time. They also employ 4 shepherds each year who start in September and finish in May. On average one or two of these shepherds will return the following season. A number of contractors are employed on an as-required basis. This includes for weed and pest control, pilots, vets, agents, and numerous other professionals. The farm team take pride in supporting all users of, and visitors to Molesworth, frequently being called on to respond to vehicle challenges, and medical emergency. They also work closely with Department of Conservation staff to ensure they are able to carry out their work on the property.

Beef produced on the farm goes to discerning markets all over the world. There has been 'Molesworth' branded beef produced on the property. It was processed by Harris Meats and sold in local restaurants. Unfortunately, the value-return was not adequate to cover the increased costs of production, a common challenge for developing brands. However, this may be considered again in future. Pāmu's vision is to become the premium supplier of meat, milk and fibre for niche markets globally. Molesworth creates a compelling marketing story which could be capitalised on.

2.6.2 *Department of Conservation*

Molesworth falls within the administration of the Department of Conservation (DOC) who undertake conservation work on the property. They also oversee the recreational use of the property. A number of DOC staff have been working on Molesworth for several years and have a close connection to the property. There are also volunteers who support this work.

2.6.3 *Public*

Molesworth is managed and treated as a farm for 4.8 million New Zealanders given it is in Crown ownership. Around 10,000 people visit Molesworth each year. The majority are through travellers who are driving or cycling through when the road is open. Users also include trampers and hikers, mountain bikers, horse trekkers and hunters. There are a number of commercial operators running activities on Molesworth including rafting and fishing. They have a permit to operate on Molesworth.

Access is managed to ensure the safety of the public, farm staff, and animals. This means there are areas which are not open to public access on the property.

Pāmu are very open to increasing access and recreational use of Molesworth. Where restrictions are in place, this is for good reason. Table 25 and Map 8 show the risk areas, time of year, and an explanation as to why access is limited in these areas. Map 6 shows the current public access and timing.

2.6.4 *Māori*

Molesworth is culturally significant to Māori. The property was originally covered in significant forest area which was repeatedly burned by Māori, and again by Europeans. Māori frequently moved through the main river valleys and over saddles to reach what is now Canterbury, and the West Coast for pounamu. One trail followed the Wairau River, over Island Pass to Lake Tennyson, and then either down the Waiau Toa (Clarence River) to Jollies Pass, or over Malings Pass to the Waiau Uwha (Waiau River), then on to the West Coast. Another was over Acheron Saddle (from the Waihopai River) and then down the Acheron River.

Molesworth also provided a food source for Māori with hunting parties likely using it for weka, New Zealand quail, paradise shelduck, whio, and eels in the lakes and rivers.

In modern times, this history remains significant to local iwi and hapu. Protecting values of indigenous biodiversity, resting places, burial sites and Mahinga kai in particular are very important. Further work is required to better understand the history of the relevant iwi communities, so that their statutory interests are accurately reflected in the future landscape management of Molesworth.

2.7 Infrastructure

Farm staff pride themselves on maintaining infrastructure on Molesworth. Key infrastructure includes yards and buildings, roads and tracks, and fences. These are identified on Map 7, including key locations for health and safety.

Maintaining infrastructure to a high standard is important to the Molesworth team for the safety of farm staff, DOC staff and visitors to the property. It is also important to ensure when stock are being moved that this can be done safely and efficiently.

From an environmental perspective, a key risk with infrastructure is run-off to waterways from tracks and yards. Yards are well-positioned on the property with reticulated water into the yards, and trees for shade. They are all located at least one terrace above waterways and are on flat areas ensuring no run-off going to the nearby waterway. The yards by the Molesworth Stream have a small, open drain running through them which only flows in winter. This will be moved in the coming year to ensure there is no risk of run-off to the stream.

3. Farm Policies, Performance and Goals

The farm system at Molesworth has evolved significantly over time as knowledge of the interaction of different farming practices with the landscape has changed, and societal values and knowledge have advanced. The farm policies today have several drivers and have been designed to best match the resources available, and the values associated with Molesworth. Drivers include:

- Animal health and welfare
- Environmental enhancement
- Climate resilience
- Supporting recreational use of Molesworth
- Safe and healthy staff and visitors
- Economic sustainability

3.1 History

Farming began on Molesworth in the mid-1850's and the property changed hands numerous times. In the early 1900's a decision to farm sheep only had disastrous consequences. In 1900, there were 40,000 sheep and 10,000 lambs. Between 1911 and 1913 severe rainstorms and snowstorms killed 39,000 sheep. By 1936, ewe numbers had dropped to 22,000. Landowners were not generating enough money to invest in pest control, and the property was over-run with rabbits. It was abandoned in 1937 and purchased by the Crown in 1938 under the administration of the Lands and Survey Department.

With Crown ownership came a substantial shift in investment in rabbit control, over-sowing with improved pasture species, upgrades of infrastructure, investment into sweet briar and broom control, and a policy for cattle only. Cattle didn't graze as close to the ground as sheep and had much greater resilience to the harsh climate experienced on Molesworth. With the cattle, also came an investment in genetics.

The number of cattle increased over time, with 9,000 head in 1968, and 10,000 head in 1974. In 1982 cattle numbers were capped at 10,000 head and this cap remains today. Pāmu have a self-imposed cap of 6,000 head. Figure 1 shows the number of cattle wintered on Molesworth since 1990. Note: Between 1990 and 1998 numbers are estimates only as records for this period were unreliable.

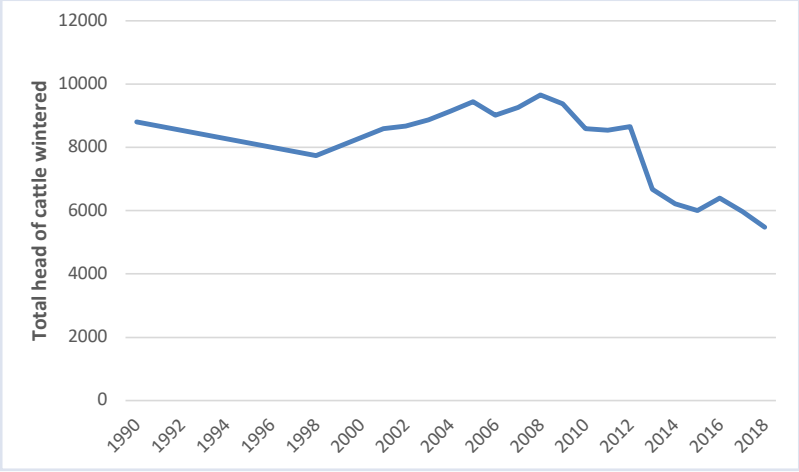

Figure 1 Change in total head of cattle wintered over time at Molesworth Station.

3.2 Current

There are currently just under 6,000 head of cattle run on Molesworth. The policy is for breeding cows to produce a calf each year. Calves are weaned at around 6 months of age and taken to the Hanmer properties for finishing. Replacement females are raised on Molesworth.

Animal performance is important to ensure resources are used as efficiently as possible. That means ensuring animals are fit-for-purpose for the environment and are producing a calf each year.

The Molesworth system is primarily pasture based with the exception of lucerne, which is harvested each year, and renewed every 6-8 years, and the ryecorn which is grown and harvested each year. The lucerne and ryecorn are used in winter to provide additional stock nutrition. Pastures are managed with high grazing residuals to encourage pasture growth and avoid over-grazing a sensitive landscape. Cattle are only farmed on land which can support cattle grazing.

Benchmarking the performance of the last 3 years of Molesworth against industry averages for South Island high country shows strong results. Production per hectare (grazed) is over double, 55.41kg/ha compared to 21.6kg/ha. Production per stock unit is slightly below average at 15.25kg/stock unit compared to 16.6kg/stock unit industry average. Calving percentage is 91% compared to the industry average of 84%. Losses are also well below industry average at less than 1% compared to industry at 2.1%.

Financially, Molesworth performs better than the industry average, despite having much greater farm operating expenses per hectare due to the significant spend on weed and pest management.

Molesworth supports one apiarist with a total of 1,300 to 1,500 hives. This is a symbiotic relationship where the bees provide pollination services in exchange for the sites.

3.3 Future

The future of Molesworth as a farming entity lies outside of Pāmu's hands. Pāmu strongly support the view that farming can sit alongside conservation, cultural and recreational values to provide mutual benefit and hope to be able to continue demonstrating this on Molesworth.

Pāmu are future-focused when it comes to production systems. They have a strong focus on market-driven food and fibre production and are investing in technology to help them lead the way. Molesworth is no exception to this and Pāmu are looking at how Molesworth can be used as a leading example of achieving multiple values on a high country property without compromise using sound scientific analysis, and a long-term, values-based approach to farming. For example, they are investing in fenceless technology, which has potential to be employed on properties like Molesworth to ensure stock are not accessing waterways.

4. Relationship Between Farm Policy, Land and Water

Stock are part of an integrated landscape that enhances recreational values and the existence of permanent staff to take care of a recreation reserve for the access of naturalists, scientists, recreationalists and those that wish to explore New Zealand's wild places.

Present farming stewards of Molesworth have learned from the past. The stock run on Molesworth now are kinder to the lowlands and ensure high country is not over-grazed. Only farming 38% of the station ensures Pāmu can support the recreational and ecological values of the land while maintaining a profitable farm system. This system allows Pāmu to invest in pest and weed control, to support travellers in the Recreation Reserve, to maintain the infrastructure, and to ensure the fire risk is minimised.

Pāmu has developed an integrated farm policy that works within the limits of the land and works with the rhythms of the seasons to minimise the impact of animals in sensitive areas while enabling a protective focus for the reserve – fire and pest-risk minimisation, infrastructure maintenance and integration of social, recreational and farming values.

The cattle generate income which supports ongoing weed and pest management in excess of $200,000 per year by Pāmu leveraging work done by OSPRI and DOC. This enhances the investment by all parties to achieve good biosecurity and environmental outcomes for all stakeholders protecting people and animals, including native flora and fauna, within the landscape.

> The cattle are farmed to match the land class suitable for supporting them and at low stock densities, this ensures productive, healthy cattle, and low environmental impact. Over the past two decades, stocking rate has been decreased by 40%, phosphorus applications have halved, and are only applied to cropped areas now (80ha) and total nitrogen loss has reduced by 9% (on a per hectare basis, nitrogen loss is the same as in native forest land as modelled in Overseer). Greenhouse gas emissions have dropped by nearly 40%.

Climate resilience and waterway enhancement has been achieved by utilising land in Hanmer. This land has enabled the reduction in stocking rate on Molesworth meaning the property is far less vulnerable to extremes of climate. It has also allowed for continued protection of the sensitive areas, while maintaining pest control work.

Water quality is being annually monitored by Marnie Prickett, following on from regular water quality monitoring which was done by the Cawthron Institute. Monitoring from March 2019 shows Macroinvertebrate Community Index (MCI) scores averaging 118, indicating good water quality, with only 3 of 19 sites below 100, and half of the sites exceeding 119 indicating excellent quality. While Pāmu recognise that cattle on lowlands can be a risk, they are responding with a 40% lower stocking rate, fencing off seeps, and using management techniques such as the use of salt to attract cattle away from flowing waterways. Pāmu are also exploring the role of technology in protecting these areas (e.g. virtual fencing).

4.1 Land use suitability

The focus of management is to ensure that feed quality is high in areas where cattle should be, and this acts as an effective, natural deterrent from other areas (i.e. cattle are likely to stay in areas where the feed is sufficient and palatable).

To maintain pasture quality in a very low input system, the focus is on the clover. The management philosophy at Molesworth is to eat 50% and leave 50%. This ensures the clover is well looked after, in turn, producing high quality feed for cattle. This also means there is a high level of organic matter break-down in the system which will be enhancing soil health, and water conservation of the soil.

No class 8 land is grazed, and class 7 land is grazed minimally at times of year when risk to this land is low.

The stocking rate at 0.3SU/ha (a fifth of the industry average for this class of land) provides a resilient system to climatic variation without the need to import feed or export stock off the property. It also generates sufficient income to support investment into maintaining other values associated with Molesworth such as recreation and weed control. Finally, many of those who interact with, and value Molesworth, talk about the 'wide open landscape' as a key value. While some areas of the landscape would benefit from further reversion to native, woody vegetation, the cattle support the maintenance of this unique landscape which can be shared with all New Zealanders.

4.2 Current compliance

Pāmu have a strong emphasis on ensuring that compliance is met on Molesworth across health and safety, environmental regulations, and animal welfare. Wherever possible, compliance is exceeded and there is a focus on best practice. The VHF radio system is a good example of this. Every evening, the farm manager makes contact with any DOC staff on Molesworth, and any staff or contractors who are using the camps or huts. This is a general check-in and provides an opportunity for any issues to be raised which require remediation the next day or in the coming days. It is highly valued by all of the users and demonstrates a high-level of care for people. The radio can be used at any other time for operational and/or urgent requirements.

At the time of writing, new policy is pending surrounding water quality regulations across New Zealand. It is not anticipated that this will have a significant impact on the current management of Molesworth as a farm. However, the rules will be reviewed at the appropriate time, and action taken to ensure this is the case.

There is also policy pending surrounding agricultural greenhouse gas emissions. This is likely to have an impact on Molesworth but is not likely to be significant in the short-term. With limited options to reduce emissions on the property, a whole of business approach by Pāmu is more likely to provide offsets for emissions from Molesworth. Pāmu will assess any technological solutions that may materialise in the coming years and consider their application to the property.

5. Water

5.1 Situation

A survey undertaken in March 2018 (Prickett, 2018) of microbiological, biological, and physiochemical parameters of 19 sites on rivers and streams on Molesworth Station indicated that water quality on the station is generally good. Sites assessed are shown in Figure 2.

No sites breached primary contact (i.e. swimming) standards for *Escherichia coli (E. coli)* and conductivity (used to indicate nutrient enrichment) was low across most sites. Low nutrient levels are consistent with the findings of three Cawthron studies conducted in 2007, 2009 and 2011.

Macroinvertebrate Community Index (MCI) samples show most sites have scores that indicate either excellent or good water quality, with three sites which are fair.

Cyanobacteria was observed at the Tarndale Brook site and reported due to the potential serious risk it poses to human and animal health.

Water clarity guidelines (measured in centimetres) for in-stream biodiversity were breached at seven sites and fine deposited sediment was above 20% cover at 10 sites. This is of concern for macroinvertebrate and fish communities as sediment deposited on stream and riverbeds degrades habitat.

Due to the detrimental effects of fine deposited sediment on ecological health of streams and rivers Prickett recommends that sedimentation of waterways on Molesworth Station should be a focus for land management.

The March 2018 survey did not include lakes and tarns. Survey results are summarised in Appendix 18.1.

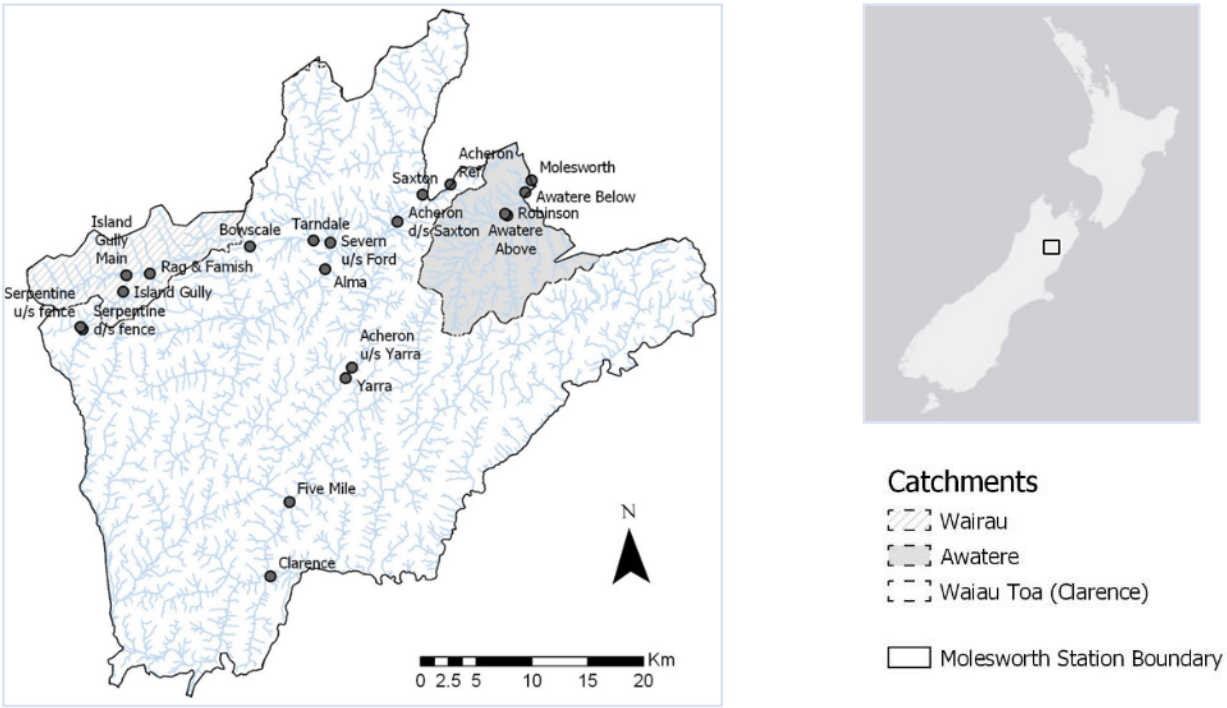

Figure 2 Monitoring sites for Prickett Survey, 2018

To provide a comparison from 10 years ago, in 2009, the Cawthron Institute (Holmes, 2009) conducted monitoring on 10 sites to examine the effects of cattle grazing on water quality. Sampling was taken after stock had been excluded for 6 months, and again after stock had been included for 5 months.

Water quality remained good in all surveys with faecal bacteria indicators never breaching guidelines for swimming or drinking. There were some increases in phosphorus, nitrogen and organic carbon when stock were grazing, but these were not statistically significant. The moderate elevation of E. coli in some of the samples was considered episodic. Overall, there was no difference in E. coli between the areas above and below the stock exclusion fence. There were no significant differences in taxonomic richness or macroinvertebrate indices.

The report didn't address the issue of potential cumulative effects from diffuse inputs of sediments and nutrients from stock activity in the monitored sites. This was explored in more detail in the Prickett work and will be continued annually.

The report concluded that there was no indication that the cattle grazing regime adversely affected water quality in the streams tested, that farming practices have a negligible impact on aquatic invertebrate communities, and that it is possible current farming practices are having a positive influence on the productivity and diversity of the streams through moderate increases in nutrients. It also suggested that some waterways are more erosion prone so stock can cause some sediment problems, and these may be worth focusing on. This has been done via Prickett's work.

5.2 Risk Assessment – Water Quality

5.2.1 *Nutrients*

Nutrient management is important as it impacts the ability to grow feed and subsequently, the animals. It also impacts on soil health and can impact on waterways. Nutrient sources include the natural levels that exist in the environment from parent material or the atmosphere, nutrient recycling from animals, and nutrients applied. Very few nutrients are applied to land on Molesworth, the vast majority comes from natural levels and the contribution from cattle. A risk assessment of nutrients on Molesworth is presented in Table 1.

NUTRIENT	RISK FACTOR	DESCRIPTION	RISK RATING (H, M, L)	RISK MITIGATION
Phosphorus	Soil type	Molesworth soils hold a degree of natural fertility (phosphorus), but do not create an undue risk of loss.	**L**	
	Topography	Grazed areas are on easy to moderate contour. The steeper the land grazed, the greater the phosphorus loss risk.	**M**	No cattle grazed above 1400m altitude, managed by providing plentiful, palatable feed at lower altitudes.

NUTRIENT	RISK FACTOR	DESCRIPTION	RISK RATING	RISK MITIGATION
	Fertiliser use	Phosphorus fertiliser is only used on the lucerne and ryecorn which are very small areas of the property.	**L**	Fertiliser application is based on regular soil test results and crop needs and does not exceed recommended maximums. No phosphorus fertiliser applied to remainder of property.
	Cropping practices	Direct drilling and minimum tillage practices are used to protect soils. Lucerne is all cut-and-carry with no grazing. Ryecorn is block-grazed rather than strip-grazed.	**L**	Continue with direct-drilling and minimum till only when necessary and conditions are appropriate to prevent wind-blow. Continue block grazing ryecorn and cut-and-carry lucerne.
	Olsen P levels	Phosphorus loss risk increases if optimum Olsen P levels are exceeded.	**L**	Maintain crop blocks at or below agronomic optimum for Olsen P.
Nitrogen	Soil drainage characteristics	Nitrogen loss risk increases as the drainage capability of soil increases. Soil on Molesworth has moderate natural drainage.	**M**	Ensure stocking rates are lower on free-draining soils.
	Rainfall	Increased rainfall increases drainage events. There is higher rainfall in the west on Molesworth.	**M**	
	Stock type	Cattle have a greater nitrogen concentration than other stock types (e.g. sheep, deer).	**H**	Ensure stocking rates are maintained at or below current and that non-performing stock are removed from the property.
	Stocking rate	The greater the stocking rate, the greater the nitrogen loss risk. Molesworth stocking rate is 0.3 SU/ha[2] for most of the year.	**L**	Maintain or reduce current stocking rate.
	Fertiliser use	Nitrogen fertiliser use increases the risk. Nitrogen fertiliser is only used on the ryecorn crop.	**L**	Nitrogen fertiliser only used on crops as agronomically required.

2 A Stock Unit (SU) is defined as the consumption of 550kgDM eaten per year, or 6,000 MJME consumed, this is roughly equivalent to a 55kg ewe with a lamb at foot.

NUTRIENT	RISK FACTOR	DESCRIPTION	RISK RATING	RISK MITIGATION
	Cropping practices	Direct drilling and minimum tillage practices are used to protect soils and reduce nitrogen loss. Lucerne is all cut-and-carry with no grazing. Ryecorn is block-grazed rather than strip-grazed.	**L**	Continue with direct-drilling and minimum till only when necessary and conditions are appropriate. Continue block grazing ryecorn and cut-and-carry lucerne.
	Supplementary feed use	Supplementary feed purchased brings additional nitrogen into the system. No supplementary feed is purchased on Molesworth. Lucerne baleage is made and fed in winter.	**L**	All cut and carry lucerne baleage, no supplement bought in.
Other nutrients	Nutrient application	Other nutrients are applied based on soil test results on a three-year rotation.	**L**	Lime and sulphur applications three-yearly as determined by soil test results.

5.2.1.1 *Overseer*[3]

Table 2 below shows the output from modelling in Overseer for Molesworth Station.

Table 2 Nutrients applied, and nutrient losses modelled in Overseer for Molesworth Station based on the 2018 year.

ATTRIBUTE MODELLED [4]	OUTPUT (2018) OVER 120,000HA
Nitrogen (N) Applied (actual)	35kg/ha/yr on 50ha
Phosphorus (P) Applied (actual)	28kg/ha/yr to 58ha + 30kg/ha/yr to 50ha Total = 3 Tonnes P
Nitrogen loss (Kg N/ha/yr) (modelled)	4kg N/ha/year[5]
Total Farm N Loss Kg N/Yr (modelled)	708,361
Phosphorus loss (Kg P/ha/yr) (modelled)	1.4kg P/ha/year
Total Farm P Loss Kg/Yr (modelled)	254,914

The Overseer output models nutrient losses on the property and shows that nitrogen loss does not exceed base levels seen in native bush or forestry (4kgN/ha/year). Phosphorus loss in Overseer is a risk-based approach, and at 1.4kgP/ha/year, this is relatively high. However, as phosphorus fertiliser is only used on the crop, this is due to natural conditions of topography, soil type and rainfall.

The overall risk of nutrient losses on Molesworth is low to medium. In general, the greater risk comes from the natural characteristics of the land – topography, rainfall and soil types. These are largely mitigated by having a low stocking rate and avoiding applications of nitrogen and phosphorus fertiliser across all of the pastoral area. Lime and sulphur are applied every 3-years which does not create an environmental risk.

3 Overseer is a scientific model which calculates the flow of seven major farm nutrients – Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S), Calcium (Ca), Magnesium (Mg), and Sodium (Na) and greenhouse gases.

4 Modelled in version 6.3.1

5 Base levels of N loss from native bush are 4kgN/ha/year.

5.2.2 *Erosion and sediment loss*

While a lot of the erosion on Molesworth is natural, some areas of erosion can be negatively or positively influenced by farm activity. It is therefore difficult to conduct a risk assessment of erosion per se. It is possible to use a risk approach to assess activity that may increase the risk of erosion, and this is considered in Table 3 below.

Table 3 Risk assessment for sediment and erosion influenced by farm activity on Molesworth Station.

RISK FACTOR	DESCRIPTION	RISK RATING (H, M, L)	RISK MITIGATION
Over-grazing	Over-grazing results in bare soil being exposed which then can be lost via run-off or wind blow.	**L**	Stock management policies minimise risk. In particular, aim for 50% residuals post-grazing.
Willows planted in waterways	Scouring around willow roots creates stream bank erosion. Observed particularly in the Awatere.	**H**	Remove willows planted in stream or right on waterway banks. Note that this is likely to increase sediment erosion in the short-term. Replace with native vegetation. Maintain willows further out from waterways.
Stock access to waterways	Cattle have access to most of the waterways on Molesworth, although monitoring has shown low impact of this.	**L**	Very little streambank erosion observed caused by hooves.
Cultivation	Conventional cultivation practices increase the risk of sediment loss due to bare soil being exposed.	**L**	All crops are direct drilled, or minimum tillage used rarely and for contouring only. Any tillage is done when there is no wind to avoid wind blow.
Stock camps/salt licks exposing soil	Soil is exposed in some stock camps, and where salt licks are placed. Only small area of soil exposed due to low stocking rates.	**M**	Continue careful placement of salt away from waterways where vegetated buffer exists to prevent sediment run-off.
Cattle on steep slopes	Heavy cattle on erosion-prone slopes can cause slipping.	**L**	Grazing is focused below 1400m using management to avoid cattle needing to move into steeper slopes to graze.

An alternative to the risk-based approach is to consider whether erosion is 'more or less likely to be influenced by farm activity' using deposited sediment as a proxy for, but not exactly the same as, erosion. The impact on the Macro Community Index (MCI) can also be considered to further inform sites to target. This approach was used and is recommended by Marnie Prickett in her master's research on sediment loss mitigation for Molesworth (Prickett, 2018). The report defines 'more/less' likely using an observed/expected ratio where:

> >1 means that the amount of deposited sediment is **more likely to be influenced by farm activity** (i.e. there is more deposited sediment in a stream or river than is expected under natural conditions).
>
> <1 means that the amount of deposited sediment is **less likely to be influenced by farm activity** (i.e. there is less deposited sediment in a stream or river than is expected under natural conditions).

Figure 3 from Prickett, 2018 highlights areas where the stream sedimentation observed/expected (O/E) and MCI observed/expected maps intersect. These areas have both a lower than expected MCI and higher than expected deposited fine sediment, using national datasets. Sites with this intersection are likely to be impacted by increased deposited sediment due to human activity and may have the greatest potential to improve measures of biodiversity with mitigation and changes in land management.

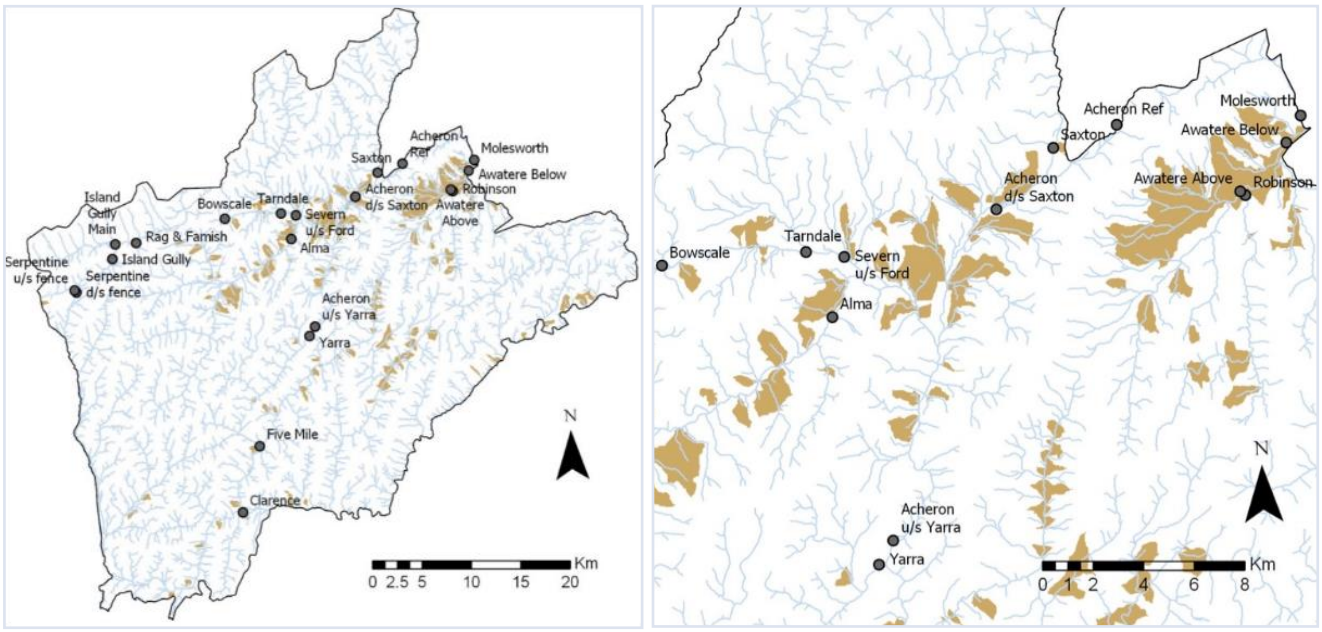

Figure 3 Map and detail of intersection of streambed sedimentation O/E (ratio ≤10) and MCI O/E (ratio ≤0.85) output using national datasets.

The areas of intersection of streambed sedimentation and MCI O/E identified in Figure 3 cover a large area (approximately 8,028ha). Based on current research, it is possible to narrow this area down to reaches of the river network that could be considered more vulnerable to impacts, more likely to respond to mitigation and more likely to have a flow on effect in improving the health of waterways on Molesworth Station and beyond.

It is also appropriate to use information gathered in the water quality survey of March 2018 and apply some basic knowledge of how people and livestock interact with waterways on Molesworth Station to identify appropriate areas to take action. The recommended actions are outlined in section 5.3 below.

5.2.3 *Faecal bacteria*

Faecal bacteria, if present in waterways, can present a significant risk to human and animal health. Sources on Molesworth include direct access from cattle in waterways, wild animals, including deer, waterfowl and other pests, and humans (not using facilities provided). Water quality monitoring has not shown cause for concern under current management. However, this situation needs to be maintained. A risk assessment for faecal bacteria is shown in Table 4.

Table 4 Risk assessment for faecal bacteria on Molesworth Station.

RISK FACTOR	DESCRIPTION	RISK RATING (H, M, L)	RISK MITIGATION
Cattle access to waterways	Cattle depositing faecal matter directly in waterways increases the risk.	**M**	Low stocking rate. Use of salt and shade to attract cattle away from waterways.
Stock type	Cattle have a higher volume of faeces to many other species, increasing the risk.	**H**	Maintaining low stocking rate reduces the impact of cattle on waterways.
Stocking rate	The greater the stocking rate, the greater the risk.	**L**	Maintain stocking rate at 0.3SU/ha.
Run-off from high-use areas	High-use areas such as yards can be a risk if run-off is not filtered before reaching waterways.	**L**	Yards sited on at least a terrace above waterways, with drainage away from waterways. Tracks and roads well maintained with run-off to waterways avoided. Plan to divert open drain in yards by Molesworth Stream.

5.3 Recommendations to manage, protect, enhance water quality

5.3.1 *Freshwater monitoring*

Water quality monitoring has occurred on Molesworth over the course of Pāmu's tenure. As a result of Prickett's work, a range of recommendations for ongoing monitoring have been suggested in Table 5 below.

Table 5 Recommendations for water quality monitoring on Molesworth Station.

RECOMMENDED ACTION	SUGGESTED TIMEFRAME
Produce and introduce cyanobacteria training materials for Pāmu and DOC staff. Develop protocols for Molesworth Station involving Pāmu and DOC staff to limit risk to the public and animals. Cyanobacteria should be monitored by both Pāmu and DOC staff through a system of shared recorded observations.	By end of 2020
Consistent with the management plan, work with DOC, to establish and maintain a three-yearly monitoring programme in order to track changes over time. Each round of monitoring should result in a substantive report monitoring should include E. coli, deposited sediment, conductivity, clarity, MCI, temperature, shade, periphyton, macrophytes, and substrate composition.	By end of 2020
In order to respond to localised concerns for waterways on the station in terms of ecosystem health, a conductivity meter can be purchased for the station as a first indicator in cases where nutrient contamination may be suspected.	By end of 2020
In order to respond to localised concerns of the suitability of waterways for recreation, human and stock drinking water, a guide to E. coli sampling and testing should be produced and made available to Pāmu and DOC staff.	By end of 2020
Advocate in management plan review for time-series monitoring of fish to be established to monitor fish species in key areas, or of key species to measure the impact of conservation, recreation and farm management practice and target further protection or enhancement work.	June 2021
Identify representative sites to carry-out the Freshwater Quick Assessments at least annually. Record results and monitor trends over-time. Respond as needed to declining scores or to scores not improving which are not showing 'excellent' water quality outcomes. Teach farm staff how to carry-out assessments.	Every summer (early and at median flow)

Figure 4 Stonefly (*Gripopterygidae zealandobius*) observed in Freshwater Quick Assessment in Awatere Stream on Molesworth in January 2019.

5.3.2 *Water quality*

Recommendations in Table 6 and Table 7 below include ongoing management practices, as well as new actions to protect water quality. Examples of these practices with photographs are shown in Appendix 18.4 with relevant images referenced in the table if applicable. In implementing the actions outlined in the Farm Environment Plan, where relevant, Pāmu will need to seek approval from DOC as per their obligations under the lease and management plan. In addition, some actions are being considered as part of the review of the management plan and therefore Pāmu will be advocating for these actions to be included.

Table 6 Recommended ongoing management practices to maintain water quality.

MANAGEMENT PRACTICE	EXPLANATION
No nitrogen or phosphorus fertiliser used on pasture.**	Reduces the risk of nutrient loss to waterways and supports a low-cost farming system.
Nitrogen and Phosphorus fertiliser use on crop is limited to crop requirements based on agronomic recommendations and soil test results.**	Ensures the crops are only what they need to grow, reducing the risk of nutrient loss to waterways and supports a low-cost farming system.
Direct drill standard practice. Minimum till only for light contouring when required.**	Supports soil structure, minimises the risk of wind-blow, and reduces the risk of carbon and nitrogen loss.
Maintain grazing residuals at 50%.**	Supports clover growth and the regeneration of native vegetation which is low to the ground, helps to maintain soil water holding capacity, builds soil organic matter and minimises risk of wind-blow from bare soil.
Lucerne all cut and carry for baleage.**	Reduces risk of high intensity of animals creating soil damage, supports soil structure.
Block grazing of ryecorn rather than strip-grazing.**	Reduces risk of high intensity of animals creating soil damage, supports soil structure.
Continued use of salt, ensuring salt site is located at least 30m away from waterway and any run-off from salt site not likely to reach waterway.* *(Reference: Figure 16 and Figure 17).*	Attracts cattle away from waterways.
Self-imposed stocking rate limit maintained*	Ensures impact from cattle to waterways remains low.
Sulphur and lime use remains below 1400m, and pasture management practices maintained.*	Discourages stock from venturing into high country, supporting native and woody vegetation recovery, and reduces risk of erosion on steeper slopes.
Maintain yard sites, including reticulated water supplies, and drainage to paddock rather than waterways. *(Reference: Figure 23 and Figure 24)*	Reduces risk of faecal bacteria entering waterways via run-off.

* Benefits to biodiversity as well as water quality.
** Benefits to soil health as well as water quality

Table 7 Recommended new actions to improve water quality on Molesworth Station.

ACTION	EXPLANATION	TIMEFRAME
Advocate in management plan review for willow management plan to remove willows in or close to stream and river.* *(Reference: Figure 20 and Figure 21)*	Willows are causing streambank erosion as the waterway scours out around the root systems. Not all willows should be removed as those further out from the waterways will be providing shade benefit and not causing impacts to the waterways.	Over next 3 years.
Encourage cattle away from waterway where possible in Northern Awatere through increased use of salt, provision of water reticulation throughout the block, and protection of seeps* Temporary fences (such as hot-wires with battery pack) could also be considered.	This area has been identified as a risk for reduced water quality due to sediment likely caused by farming practices. Removal of cattle from the waterway would be most beneficial in this part of the property as it is the most intensive. However, fencing is impractical at the scale required. Alternative methods to attract cattle away from waterways therefore need to be used.	As soon as possible.
Divert race at Molesworth Stream stock yards to avoid run-off from yards reaching stream. *(Reference: Figure 30)*	The race is open and runs through the yards from a small dam just above the yards. To avoid any runoff from yards entering the Molesworth Stream, this small race needs to be diverted over the neighbouring paddock.	By end of 2020.
Increase stock water reticulation and provision of shade.	Both troughed water, and shade help attract cattle away from waterways. Both also support positive animal welfare benefits.	Over next 5 years.

* Benefits to biodiversity as well as water quality

6. Wetlands

6.1 Situation

There are a number of wetland areas on Molesworth including wetlands associated with terraces and ephemeral wetlands. Freshwater Ecosystems of New Zealand (FENZ) hold a national database which includes wetlands, although it does not necessarily pick-up all of them. Map 9 shows the wetlands in the FENZ database for Molesworth. Wetland types include swamp, marsh, fen and seepage. Historic wetlands have also been identified.

There is limited data cataloguing the state of all wetlands present on Molesworth. Some wetlands have cattle excluded from grazing, while others do not. As wetlands are such an important and declining ecosystem nationally, further substantive monitoring would be valuable.

6.2 Recommendations to protect and enhance wetlands

Recommendations in Table 8 and Table 9 below include ongoing management practices, as well as new actions to protect wetlands. Examples of these practices with photographs are shown in Appendix 18.4 with relevant images referenced in the table if applicable. In implementing the actions outlined in the Farm Environment Plan, where relevant, Pāmu will need to seek approval from DOC as per their obligations under the lease and management plan. In addition, some actions are being considered as part of the review of the management plan and therefore Pāmu will be advocating for these actions to be included.

Table 8 Recommended ongoing management practices to protect and enhance wetlands on Molesworth Station.

MANAGEMENT PRACTICE	EXPLANATION
Maintain small mob sizes to reduce pressure on sensitive areas (e.g. wetlands) when mustering stock.*	If stock are moving through sensitive areas (which is minimised), smaller mobs do less damage.
Work with DOC to maintain fences on existing wetlands.*	Ensures cattle are not able to damage the wetland areas.

* Benefits to biodiversity as well as wetlands and water quality

Table 9 Recommended new actions to protect and enhance wetlands on Molesworth Station.

ACTION	EXPLANATION	TIMEFRAME
Advocate in management plan review for the state of all wetlands (including seeps, flushes, ephemeral tarns) to be identified and establish time-series monitoring. Key areas to focus are Lake McRae, and Sedgemere-Tarndale. Identify management actions from the monitoring.	Be able to measure the impact of conservation and farm management practices on wetlands.	June 2021
Work with DOC to fence seeps/soaks (45 identified). *(Reference: Figure 18 and Figure 19)*	These seeps/soaks are ephemeral wetlands which should be protected from cattle to enhance their value. Very few of these remain in New Zealand.	Over the next 5 years.

7. Biodiversity

7.1 Situation

As outlined in the resource assessment of indigenous biodiversity above, Molesworth boasts a significant number of species and sub-species of indigenous flora and fauna, both terrestrial and aquatic. Significant conservation effort has gone into understanding these species over several decades and this continues today. The primary focus of the conservation effort for Molesworth is to protect as many species as possible.

Historically, farming and biodiversity outcomes have clashed, with some farming practices such as burning and over-grazing resulting in significant decline of native vegetation habitat and probably detrimental outcomes for waterways. In the 1940's, a range of woody vegetation was planted on Molesworth for firewood, including pines. By the 1960's it was apparent that this was creating significant problems as a weed and so pines were removed from the planting regime. By the 1980's, the planting of large-scale woody vegetation on Molesworth ceased. Today, wilding pines pose one of the greatest threats to conservation, recreation and farming values on the property.

Current management is far more attuned to biodiversity outcomes. In particular, farm and conservation managers share a common enemy in many introduced weeds and pests such as wilding pines, broom, and possums. Continued combined resource and effort to manage these will result in benefits for all Molesworth users. A further significant change has been made over the past 20 years to grazing management with stocking rates reduced by 40%, the removal of nitrogen and phosphorus fertiliser application to the grazed area (excluding crop), and a focus on maintaining high grazing residuals allowing native vegetation to recover. While the grazed landscapes are still modified, there is recovery as demonstrated in vegetation assessments (discussed below). Figure 5 below shows an example of vegetation cover in a grazed area.

Figure 5 *Gentianella corymbifera* - Gentians flowering in the Severn Valley.

In 2018 Sean Husheer (Husheer, 2018) reviewed vegetation monitoring reports from 1952 and compared them to those taken between 1989 and 2008. These showed a very slow change in species composition, and native- and shrub-dominance related to over-sowing, landform, location and altitude. Since 1952, the proportion of native species has declined <1% per annum, in particular where over-sowing had occurred and on terraces and grazed areas. On slopes, there was an overall increase in the level of native woody species of an average of >2% per annum increase. The increase is evidence of the slow recovery of native shrub-lands after reduced grazing intensity following the vegetation degradation in the 1900's to 1950's. Altitude has the greatest influence on vegetation recovery once grazing pressure is removed and it may take centuries to fully recover.

Husheer (2018) concluded that grazing is important for plant conservation on Molesworth, and that there is an appropriate level of acceptable grazing. Too little could result in succession towards diverse native scrub and tall tussock grassland being slowed by the competitive dominance of exotic species. However, too much could also prevent this succession by trampling and killing native species. Husheer suggests that cattle numbers should be reduced over-time as native woody shrub vegetation recovers. Continued monitoring was suggested to inform management decisions.

A survey conducted in the Upper Wairau in 2005 concluded that the current level of grazing in that area is unlikely to increase the threats to any of the species surveyed but did identify that some of the species would benefit from a reduction or removal of grazing.

Native vegetation is not the only thing requiring protection. A large number of indigenous fauna call Molesworth home. Reduced stocking pressure has supported enhanced habitat, but there is still more to understand about population dynamics of our terrestrial and aquatic fauna on Molesworth to ensure management is enhancing biodiversity outcomes. An example of a recent piece of research is on the black-fronted terns.

A trapping study has been carried out on black-fronted terns over the past 4-years with treatment and non-treatment sites (Courtney, 2018). In the non-trapped control, nest failures occurred from flooding (40% of all failures), and the remainder from other animals – introduced (58% of animal induced failures) and native (42% of animal induced failures). A third of nest failures in the non-treated sites was from introduced animals, particularly feral cats, ferrets and hedgehogs. Native birds were also a significant contributor at 40% of all animal-induced failures. Cattle impact was 4-5% of animal induced failures. Nest failure was 5 times less from animals in the trapped areas compared to the non-treatment areas. Where cattle impact can be reduced to ideally zero, this should occur, temporary hot-wires around nest sites may assist with this if practical

While there is very good monitoring information across a broad range of species and environments on Molesworth, there is limited time-series information to be able to provide a comprehensive picture of the impact of management on the species present. To be able to provide sound management decisions across the wide range of values needing to be met on Molesworth, this information is critical. The recommendations below suggest a combined approach between Pāmu and DOC to establish regular monitoring as appropriate to support long-term decision making for Molesworth.

7.2 Risk Assessment - Biodiversity

Molesworth is a significant hotspot for indigenous biodiversity with numerous species found only in Southern Marlborough. A significant portion of the work DOC undertake on the property is for management of this biodiversity. Farming by its nature can be detrimental to biodiversity values. The scale of Molesworth means fencing areas off can be very challenging, so where biodiversity values are threatened, other methods also need to be considered. Table 10 provides a risk assessment of farm management practices that can impact on biodiversity outcomes.

Table 10 Risk assessment for biodiversity outcomes on Molesworth Station.

RISK FACTOR	DESCRIPTION	RISK RATING (H, M, L)	RISK MITIGATION
Stock access to native vegetation	Cattle have limited access to some areas of woody vegetation, and graze tussock grassland areas. Some monitoring has shown positive benefits and other monitoring has shown some impact.	**M**	Stocking rate maintained at current or less to ensure impact remains low. Access to woody vegetation is for shifting cattle only. Triennial monitoring of key sites. Continue grazing management practice of 50% residuals.
Stock access to waterways	Cattle have access to most of the waterways on Molesworth, although monitoring has shown low impact of this.	**M**	Plan to protect 45 seeps across the property. Stocking rate maintained at current or less to ensure impact remains low. Annual monitoring of waterways. Continue use of salt to attract stock away from waterways. Increased shade and water reticulation planned.
Plant pests	Molesworth biodiversity values are threatened by plant pests including broom, gorse, briar and wilding pines. With the latter being the most significant risk.	**H**	Continue investment in targeted weed management programmes in partnership with DOC.
Animal pests	Molesworth biodiversity values are threatened by animal pests including rabbits, hares, possums, goats, pigs, chamois, red deer, Canada geese, cats, mustelids and rats.	**H**	Continue investment in targeted animal pest management programmes with OSPRI and DOC.

Overall, farming on Molesworth does generate a medium to high risk to biodiversity values, and weeds and pests pose the greatest threat to conservation, recreation and farming values on the property. Under current management practices, this risk is significantly reduced due to low stocking rates, and grazing management favouring high residuals. Actions have been identified to further reduce this risk.

7.3 Recommendations to manage, protect, and enhance biodiversity outcomes

Most of the actions identified to improve water quality will also result in improved outcomes for biodiversity, particularly aquatic biodiversity. These are identified in the water quality recommended actions above.

Recommendations in Table 11 and Table 12 below include ongoing management practices, as well as new actions to protect and enhance biodiversity outcomes. Examples of these practices with photographs are shown in Appendix 18.4 with relevant images referenced in the table if applicable. In implementing the actions outlined in the Farm Environment Plan, where relevant, Pāmu will need to seek approval from DOC as per their obligations under the lease and management plan. In addition, some actions are being considered as part of the review of the management plan and therefore Pāmu will be advocating for these actions to be included.

Table 11 Recommended ongoing management practices to protect and enhance biodiversity on Molesworth Station.

MANAGEMENT PRACTICES	EXPLANATION
Continue access to native woody vegetation only when mustering stock between blocks, no long-term access. Where possible, avoid access. *(Reference: Figure 25)*	Cattle can damage the understory of native woody vegetation if given the opportunity to graze. By only using these areas to move stock through, this damage is minimised.
Work with DOC and the Ministry for Primary Industries on the coordinated wilding pine control programme. Annual spend is ~$50,000. *(Reference: Figure 27 and Figure 28)*	Wilding pines pose a significant threat to grazing areas, as well as areas under conservation management.
Maintain stocking rate at or below current levels to support native vegetation recovery.	Research on Molesworth suggests that a low stocking rate will support native vegetation recovery. This may need to be reduced over-time as conservation values are enhanced and depending on overall use of the landscape.
Work with DOC and others on continuing active, targeted pest management.	Pests will impact native flora and can also be vectors for disease.
Work with DOC to maintain culverts on high value native streams (e.g. Camp Stream).	Perched culverts are preventing introduced fish species predating on non-migratory native fish.

Table 12 Recommended new actions to protect and enhance biodiversity on Molesworth Station.

ACTION	EXPLANATION	TIMEFRAME
Advocate in management plan review to identify streams free of salmonids where protection would be beneficial.	Provides barriers to sports fish (predators of native fish) access.	June 2021
Stock-take of all exclusion fences to ensure functioning. Undertake maintenance as required. *(Reference: Figure 29)*	Some of the research suggests these have not been adequately maintained to protect biodiversity outcomes.	By end of 2020
Advocate in management plan review to ensure ongoing, time-series monitoring of native vegetation, terrestrial biodiversity, and aquatic biodiversity.	Monitoring is required to ensure conservation and farm management practices are achieving positive, measurable outcomes for biodiversity values.	June 2021
Advocate in management plan review for sweet briar removal from areas where no or low impact to native vegetation. Start with the Alma, then the Awatere, then the Guide. *(Reference: Figure 26)*		Over next 3 years.

8. Greenhouse Gas Emissions

8.1 Situation

Sources of greenhouse gas emissions from Molesworth include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). CO_2 emissions are generated from fuel and electricity use on the property and there are limited options to reduce these with current technology. Solar power may provide a reduction in electricity generated emissions. Agricultural gases of CH_4 and N_2O are also challenging to manage.

Since 1990, total agricultural emissions from Molesworth have reduced by 31% from approximately 153kg CO_2-e/ha/year to 106kg CO_2-e/ha/year. Methane makes up 65% of the emissions, with the remaining 31% coming from N_2O. CO_2 emissions from Molesworth are 4% of total and estimated at 4kg CO_2-e/ha/year.

Calculating the sinks on Molesworth is challenging, vegetation is incredibly slow-growing and there is limited data of the vegetation cover pre-1990 compared to post-1989. There has been reversion of native woody vegetation since the early 1990's which will be accumulating carbon and this will continue in areas where this regeneration is occurring.

Pāmu are working towards carbon neutrality for their whole business. As well as looking at farm management practices to reduce emissions (which are presently very limited), this includes plantation forestry planting in areas that are best suited to this type of land use (i.e. not Molesworth), to offset emissions from farms which are poorly suited to forestry.

At this stage, the first steps for Molesworth are to understand what their emissions are, and if there are any options to mitigate these through management. It will also be important to understand what, if any, technological solutions may be available in the short- to mid-term. An example which may work for Molesworth is genetics, although this work has largely focused on sheep to date.

8.2 Recommendations to understand and mitigate greenhouse gas emissions

Table 13 Recommended actions to understand and mitigate greenhouse gas emissions on Molesworth Station.

RECOMMENDED ACTION	EXPLANATION
Model greenhouse gas emissions and sinks on Molesworth annually.	Using Overseer (best tool available currently), modelling emissions helps to understand where they are at and inform any mitigation options as they arise.
Review options to mitigate emissions annually.	Options are evolving as the science continues and moves to commercialisation.

9. Climate Resilience

Climate is a driving element for Molesworth and every aspect of its use – from recreational users, through to the farm. Climate volatility has been the making and breaking of previous land managers of Molesworth as documented in the historical records. The predictions for Molesworth suggest it will be drier in the east, and wetter in the west with more extreme weather events – drought, snow, and storms. The current management has reported increased volatility over the past 20 years.

A key driver for reducing the stocking rate on Molesworth over the past 10 years was for climate resilience. That means, having a stocking rate, that even in the toughest year, can be sustained on the property. This also means, that in a good year, feed may be 'wasted'. Although additional value of this feed has been identified in terms of building soil organic matter, increasing soil water holding capacity, and banking feed for winter. Cows are well-suited to this sort of feeding regime.

9.1 Risk Assessment - Fire

Fire is a significant risk for Molesworth, particularly in summer. Public access further increases the risk, as do more extreme temperatures. The historic impact of fire is significant and well-known. Much of the property is still recovering from the damage from repetitive burning during early settlement. In addition, fire creates a significant risk for visitors, staff and animals. A risk assessment for fire is completed in Table 14 below.

Table 14 Risk assessment and mitigation for fire on Molesworth Station.

RISK FACTOR	DESCRIPTION	RISK RATING (H, M, L)	RISK MITIGATION
Fuel load	Long, dry grass provides a significant fuel load if ignited, particularly in summer.	M	Cattle grazing the valley floors, fans and rolling hills ensures the fuel-load is low which helps reduce the risk of fire.
People	With many visitors to the property, including campers, the risk of accidental fire is high.	H	All senior staff have Advanced Fire Response Training. Every Camp, every vehicle and every building has a fire extinguisher. The Station owns a Unimog vehicle which is has a pump and spray unit fitted especially for fire response. Machinery use is restricted when fire risk is high. A VHF radio system is used and shared by DOC to monitor and respond to any fire threat very quickly.

Overall, the risk of fire is high, particularly in a hot, dry, summer with a high number of visitors.

9.2 Hanmer

In 2007 and 2008 Pāmu leased two blocks of finishing land in Hanmer. This has enabled them to send finishing stock off-station and has supported the reduced stocking rate. This has enabled the Molesworth team to farm through challenging seasons without significant disruption. As well as the numerous other benefits of the lower stocking rates discussed in preceding sections. Figure 6 shows cattle grazing on one of the Hanmer properties.

Figure 6 Molesworth cattle grazing on the Hanmer properties.

9.3 Recommendations to maintaining a climate resilient Molesworth

Actions taken to-date have demonstrated success and should be maintained. Further, monitoring long-term climate predictions and monitoring climate information at Molesworth can inform subsequent management changes to ensure future climate resilience.

10. Soil Health and Management

10.1 Situation

Soils were visually assessed in the Awatere block including the lucerne and ryecorn blocks as these are the most intensively managed areas. Images from these are shown in Table 24. These were taken during a hot, dry period in January 2019. There was some evidence of compaction in all of the soils, although minor. There was some mottling present in the lucerne soil, which is a heavier soil anyway; ensuring that the soil is not too wet when machinery is on it is key to minimising this. The Awatere pasture and lucerne soils were of moderate score, while the score for soil under the ryecorn indicated good quality. None of the soils had any worms present due to the time of year not being highly suitable for conducting the assessment. Soil structure and porosity was generally very good, and current management should ensure this is maintained. Heavy cattle can increase the risk of pugging, but the low stocking rates on Molesworth ensure this is not an issue. Minimum tillage and direct drilling ensure that wind erosion risk is nil or minimal.

10.2 Recommendations to manage, protect and enhance soil health

A number of management practices undertaken to support water quality outcomes are also beneficial for soil health. These are identified in the water quality section.

Table 15 Recommended ongoing management practices to maintain soil health on Molesworth Station.

MANAGEMENT PRACTICES	EXPLANATION
Stock moved off crops when wet, vehicle movements managed to avoid soil compaction.	Soil structure can be impacted by heavy stock or machinery.
Grazing management ensures there is no need for over-sowing of seed.	The reduced stocking rate, large area, and management focused on high residuals and clover ensures there is adequate feed for the cattle on Molesworth without the need for more.

Table 16 Recommended new action to monitor soil health on Molesworth Station.

ACTION	EXPLANATION	TIMEFRAME
Undertake an annual visual soil assessment in each Land Management Unit (ideally), and at least in the Awatere block.	Visual soil assessment is a valuable tool to assess the long-term health of soils.	Annually in late winter or early Spring.

11. Animal Health and Welfare

Animal health and welfare is of utmost importance to the Molesworth team, particularly in managing animals over such a large area.

Cattle are managed to ensure they are well-fed at all times of the year. All staff are well-trained in animal husbandry to ensure when cattle are handled this is as stress-free as possible. There is active use of animal health plans, and good relationships with the local veterinarians to provide advice and support in implementing these. Stock are moved using horses, which are driven out to camps and to the base of valleys to ensure their health and wellbeing is also supported. Staff receive independent, specialist training to shoe their own horses and to break-in their own horses. Staff also receive expert, independent training on dog handling.

Genetics are selected to balance performance with environmental resilience, this, along with excellent feed management, helps to ensure cattle thrive on the property.

Some areas of the property would benefit from the provision of more shade and also reticulated stock water which would provide a dual benefit of keeping cattle out of waterways.

Cattle performance is carefully monitored throughout seasons, and between seasons to ensure management is appropriate for stock wellbeing. The main risk to cattle health is bovine tuberculosis. This is discussed in more detail below.

11.1 Disease management

Bovine tuberculosis (TB) is one of the greatest production threats to Molesworth. In previous National Pest Management Strategies, Marlborough/Canterbury high country was largely excluded under the official pest control programme. As a result, the TB Management Areas (TMAs) located within Molesworth Station (The Molesworth/Clarence Reserve and Clarence Catchment TMAs) have an extensive history of TB infection in both wildlife and livestock.

The aim of the TBfree programme (run by OSPRI) is to eradicate TB from New Zealand by 2055. TB has been found in all surveys undertaken on the property, most recently in ferrets in 2013 and pigs in 2015. Of the three livestock herds in the Molesworth TMA, one is infected at present which has been infected continuously for 30 years now, making it New Zealand's longest-standing infected herd.

Pāmu entered into 50/50 partnership arrangement with TBfree New Zealand (now OSPRI) between 2011-2016 to undertake wild animal control, and beginning winter 2017, Molesworth is the focus of a nine-year programme targeting possum control and wildlife surveillance. This plan involves the intensive control of possums and other vectors of bovine TB, with the goal of TB eradication. The timeframes set for TB freedom on Molesworth Station are 2023 for livestock and 2027 for possums.

OPSRI are taking a two-pronged approach to eradicating TB on Molesworth; a Pest Control Programme and a Disease Management Programme. For the Pest Control Programme, Molesworth Station will be split into large blocks. These blocks will be targeted in a rolling cycle with the Pest Control Programme to ensure recreational users continue to have as much access as possible. Possums will be targeted with a combination of ground-based control methods and aerial distribution of possum baits. The current control operations planned are for 27,900 ha of the Upper Awatere between 2018-2020, with consultation underway for aerial control proposed for 22,000 ha of the Bush Gully along with 50,000 ha of Tarndale.

The Disease Management Programme will begin with just blood testing of the replacement stock, before extending to other stock classes as the Pest Management Programme is implemented. Surveillance is planned from 2020 onwards to monitor and assess the TB prevalence in wildlife and measure the success of operations completed.

Source: OSPRI New Zealand (OSPRI New Zealand, 2017).

12. Waste Management

Waste is a small, but important element of the overall management of a farm such as Molesworth. A number of good practices are in place already and there is a philosophy of reduce, reuse and recycle within the Molesworth team.

Currently:

- Where possible, waste generated on the station is reused or recycled.
- Offal is buried away from waterways or groundwater and there are no offal holes/pits on the property.
- Household rubbish is buried in a confined, fenced-off site away from waterways or groundwater in-line with Marlborough District Council rules. The site is fenced and covered.
- Household food waste is used for pig food.

This year, household recycling will start. This has been limited by proximity to recycling facilities in the past, but the team have identified it as important so will be ensuring it happens. Alternatives are also being sought to the use of plastic baleage wrap. This is presently recycled.

13. Heritage

People have played a pivotal role in Molesworth's status. Māori used Molesworth to access the northern parts of what is now known as Canterbury, and also the West Coast. Tools, paua shells and the remains of eel baskets, along with other articles have been found on the route to the West Coast. European explorers followed, looking for routes to move sheep from Marlborough through to Canterbury. Since farming began in the mid-1850's on Molesworth, some 10 owners have been involved (prior to the Crown). Molesworth as it stands today is the amalgamation of five runs – Rainbow Run, Tarndale Run, St Helens Run, Dillon Run, and Molesworth Run. Remnants of the horse and dray tracks remain, as do some of the pack-tracks which were used before horses (Figure 7).

Figure 7 Historic, remnant Pack Track hand-cut in the head of the Awatere heading over Barefell Saddle.

Throughout the multiple owners and changes associated with the different runs which were eventually amalgamated to form what we now know as Molesworth the homesteads and camps have been at the heart. Camps were and remain a home-away-from-home for the shepherds and station hands who can spend months at a time out at camp. In the earlier years of station life, the camps were tents. Fortunately, buildings now form the camps with good roads to cart gear, dogs, horses and provisions when needed. A VHF radio system is also a huge asset for all camps, buildings, DOC huts, staff and contractors alike who can connect with each other and the farm manager at any time.

The buildings themselves have significant heritage value. These buildings have a high level of authenticity and integrity. They provide insight into 19th century back country accommodation in the (largely

unaltered) environment in which they were built, and are the work of one builder, Ned James. The buildings at Acheron and Tarndale are nationally significant for their heritage value. They are both excellent examples of their type, are built from local materials of earth, beech and (originally) tussock thatching. Their design is also distinctive. The Acheron Accommodation House is one of the South Island's earliest accommodation houses (Bradley, 2018). The cottage in the Acheron was sold to DOC for $1, and Pāmu maintain the cob and heritage values of Tarndale.

Figure 8 Tarndale homestead preserved in its original state. An addition to the Tarndale buildings, built from cob, serves as a camp for farm staff for significant times of the year.

When Bill Chisholm took over as manager in 1938, he began the transformation of the landscape from degraded to recovering. Science and conservation became integral to the farming history at this point. Soil conservation work and weed and pest management research began with the DSIR and is of national importance now. Lucy Moore's work on monitoring vegetation change from 1944 to 1977 was also pioneering (Bradley, 2018).

Since Crown ownership, Molesworth has been managed by just three farming families – the Chisholm's, the Reid's, and now the Ward's, all of whom have taken great pride in their roles as manager and have made a significant mark on the place. Numerous farm staff and contractors have been employed at Molesworth over the years, many of whom continue to work and visit long into their retirement. At a recent reunion of previous staff, money raised at the event was agreed to be invested in continuing the restoration work at Tarndale. This is another demonstration of the strong, ongoing connection those involved with Molesworth have with the place.

DOC have designated Molesworth a 'Historic Icon' site (one of 20 currently). Molesworth was selected to highlight the highs and lows of high country farming, its important role in New Zealand's history and economy and the characters it helps shape (Bradley, 2018).

14. Relationship Between Farm, People, Environment

Molesworth is a farm within a Recreational Reserve which makes it unique. As has been mentioned, there are a range of values associated with Molesworth which are trying to be met by all users - in a nutshell, recreation, culture, conservation and farming. At times, these values clash, but with tension comes opportunity. Molesworth is a unique opportunity to showcase how these values can all be met through an asset which is owned by the people of New Zealand.

It is common in New Zealand farming to meet farm managers who will tell you they treat the farm they manage as though it was their own, a highly admirable trait. However, Jim Ward doesn't subscribe to this, because he says, "Molesworth is owned by all New Zealanders". He treats it as such and hopes that every New Zealander will take the opportunity to "visit their farm".

Molesworth is a high-performing farm for its type which generates an income that supports significant investment into maintaining access and weed and pest control. DOC conduct a significant amount of conservation management on Molesworth protecting conservation and historic values and supporting recreational use as the administrators of the property. Both DOC and Pāmu have acknowledged a need to engage at a greater level with relevant iwi to protect and enhance cultural values associated with Molesworth, in particular, Mahinga Kai.

Pāmu and the Molesworth team have identified the need to continue increasing recreational access to the property. As has previously been discussed, current restrictions are for the safety of people and animals. Outside of these, there are opportunities. The nature of recreational use matters – options for a mountain biker or walker will be greater than for vehicles or hunters for example.

One option Pāmu have considered is a mountain bike trail that comes off the Acheron Road and follows the Severn on true river left (Figure 9), crosses a purpose-built cycle bridge where the old Tarndale Run Boundary used to be then follows the foothills out to the tarns at Tarndale and connects with the Wairau-Hanmer Springs Road.

Another option is to work with iwi to reinstate the trails used by Māori, sharing more of the cultural heritage and significance of Molesworth pre-farming.

Pāmu acknowledge that there are few opportunities for New Zealanders and overseas visitors to visit a working high country farm. Consideration should be given to how to enhance this experience and share the work Pāmu are undertaking to enhance the values of Molesworth.

Some options include an agri-tourism venture on the property and enhanced interpretation information that shares the history of the farm, as well as how it is managed currently. Another idea is the use of virtual reality technology which could provide visitors with access to areas which are restricted or to experience farm activity such as mustering virtually. Examples in terms of buildings could include a tour of Tarndale, or the newly renovated homestead.

The relationship between farming and the environment is under significant scrutiny in New Zealand presently, as it should be. This is something that Pāmu are acutely aware of and have been working hard to ensure they are at the forefront of addressing, while acknowledging there is still a way to go. To best support positive environmental outcomes on Molesworth, the team need robust, scientific data. With the harsh environment of Molesworth, time-series data is particularly valuable to both measure the effectiveness of interventions and understand the implications of current management. This may require additional investment from Pāmu and a closer working relationship with DOC to achieve.

Figure 9 The Severn River where a suggested mountain bike trail could be established on the true river left to this point, crossing a bridge, then heading towards the tarns at Tarndale before connecting back with the road.

Based on existing research, and over 30 years of leasing the property, Pāmu firmly believe that farming has a future on Molesworth, and that this can be done in such a way that enhances conservation and environmental outcomes, supports recreational use, respects cultural and historic values, and demonstrates truly integrated land use management which farming is a part of. They also know that the way Molesworth is farmed today will continue to change, evolve and develop and hope they can be leaders in high country farming management.

15. Summary

Molesworth has a long history of people who are deeply connected to the land and the environment it supports. As New Zealand's largest farm, it necessitates scrutiny for how it is managed and how it is achieving the values people identify with it. Where these values clash or don't align, solutions, rather than compromise have been found.

There is a significant body of research associated with Molesworth which goes back nearly 80 years and continues today. In fact, few farming properties in New Zealand would have access to as much information about nearly every facet of the landscape. Yet, there is still more to be discovered, tested and learned.

With a rich history, significant scale, and people who care deeply about this special place, Molesworth has an important role to play in New Zealand's conservation, recreation and farming future. With appropriate and careful management, recognition of all of the values associated with the property, and a shared approach, Molesworth can retain its 'iconic' status for farming, conservation, recreation, heritage and culture.

As Jim says, "all New Zealanders should visit this place and experience it for themselves, after all, it belongs to them".

16. Acknowledgements

The author would like to acknowledge a number of people who have provided significant contributions to this body of work.

First and foremost, to Jim and Tracey Ward who opened up their home and shared insights well beyond the brief of this project. They are genuine stewards of Molesworth and have a care and depth of understanding of the place that appears to exceed their 18 years on the property so far. They represent both the old and the new high country farmer. They recognise the value of change while respecting those who have farmed the land before them and why they did what they did. They understand that expectations of New Zealanders and our overseas markets today are different, rapidly evolving and require a different approach to farming. They apply innovation with practicality to make it happen. I have learned far more from them than I suspect they have from me and they have got Molesworth under my skin like so many before me.

Marnie Prickett for her significant work and support on the water quality section of this report. Her research took a subject of phenomenal scale and considered how to use multiple data sources to achieve genuine outcomes for water quality rather than just identify problems or potential problems. The basis of the water quality recommendations is from her work.

To the team at DOC who have hunted out historic reports and answered a lot of questions in relation to their work, I am very grateful.

Finally, to the team at Pāmu for your support in completing this document, particularly to Bronwyn for your brilliant GIS skills, and to Alison and Graeme for encouragement, problem-solving and rich discussions, and the opportunity to complete this body of work. Thank you.

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18. Appendices

18.1 Appendix 1 – Summary Results from Prickett Survey 2018

Table 17 Site location, date of sample, reach length, improved and non-improved pasture, grazing season and River Environment Classification (REC) (note: u/s is upstream, d/s is downstream)

Site Name	Date	Catchment	Reach length (m)	Easting (Up)	Northing (Up)	Easting (Down)	Northing (Down)	Improved pasture?	Summer/ Winter grazing?	REC class
Robinson	16-03-18	Awatere	150	1619976	5337844	1619987	5337985	Y	Winter	G3
Awatere Below	16-03-18	Awatere	150	1621606	5339874	1621684	5339998	Y	Winter	G3
Awatere Above	16-03-18	Awatere	150	1619784	5338017	1619790	5338141	Y	Winter	G3
Molesworth	16-03-18	Awatere	86	1622266	5341117	1622295	5341045	Y	Winter	G3
Acheron u/s Yarra	4-03-18	Waiau Toa	150	1605654	5324892	1605531	5324875	N	Winter	H5
Yarra	4-03-18	Waiau Toa	150	1604851	5323899	1604933	5323944	N	Winter	G3
Five Mile	5-03-18	Waiau Toa	80	5199432	5313078	1599464	5313018	Y	Winter	G3
Tarndale	6-03-18	Waiau Toa	70	1602491	5336384	1602537	5336422	Y	Winter	H6
Severn u/s Ford	10-03-18	Waiau Toa	150	1603921	5336247	1604039	5336167	Y	Winter	H5
Acheron d/s Saxton	10-03-18	Waiau Toa	150	1610251	5337862	1610124	5337810	N	Winter	H5
Saxton	10-03-18	Waiau Toa	150	1612499	5340291	1612469	5340155	N	Winter	H5
Clarence	11-03-18	Waiau Toa	150	1597419	5306536	1597485	5306411	Y	Summer	G3
Serpentine d/s fence	13-03-18	Waiau Toa	115	1581536	5329362	1581527	5329266	N	Summer	H1
Serpentine u/s fence	13-03-18	Waiau Toa	64	1581295	5329512	1581349	5329480	Y	Summer	H1
Acheron Ref	17-03-18	Waiau Toa	150	1615086	534108	1615013	5340969	N	Winter	H6
Alma	17-03-18	Waiau Toa	150	-	-	1603478	5333802	Y	Summer	H1
Bowscale Lake Outlet	18-03-18	Waiau Toa	20	1596809	5336112	1596822	5336113	N	Summer	H6
Rag & Famish	13-03-18	Wairau	50	1587759	5334022	1621231	5340956	N	Summer	H1
Island Gully	14-03-18	Wairau	60	1585227	5332416	1585641	5333962	N	Summer	H1

Table 18 Water quality guidelines for New Zealand freshwaters

VARIABLE	UNIT	GUIDELINE	SOURCE
E. coli – primary contact	E.coli/100mL	>260 (single sample) - acceptable >550 (single sample) - alert	(Ministry for the Environment, 2003)
Faecal coliform – stock drinking water		100 (median of at least five samples collected within a 30 day period)	ANZECC
Clarity	Metres (m)	Upland rivers "trigger" value >0.8 Recreational contact guidelines >1.6	(Davies-Colley, 2000) (ANZECC, 2000)
Deposited sediment (bankside visual estimate)	% coverage	<20 – to protect in-stream biodiversity value <20 – to protect in-stream Salmonid spawning habitat value <25 – to protect in-stream amenity value	(Clapcott et al., 2011)
Macroinvertebrate Community Indices	MCI	>119 – Excellent 100-1119 – Good 80-99 – Fair <80 – Poor	(Stark & Maxted, 2007)

Table 19 Interpretation of MCI, QMCI and SQMCI (Adapted from (Stark & Maxted, 2007))

Quality Class	Description	MCI
Excellent	Clean water	>119
Good	Doubtful quality or possible mild pollution	100 – 119
Fair	Probable moderate pollution	80 – 99
Poor	Probable severe pollution	<80

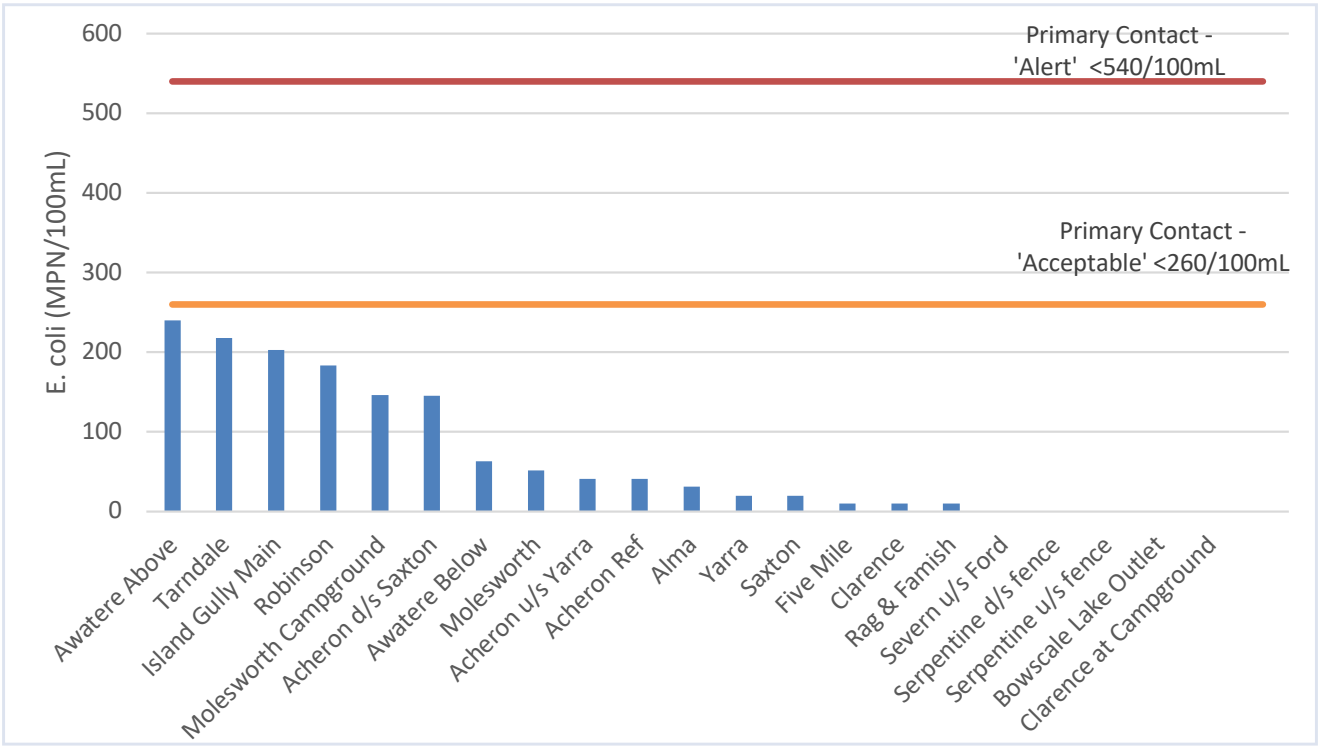


Figure 10 E. coli 'spot test' results: March 2018. Absent bars indicate a result of <10 MPN/100mL.

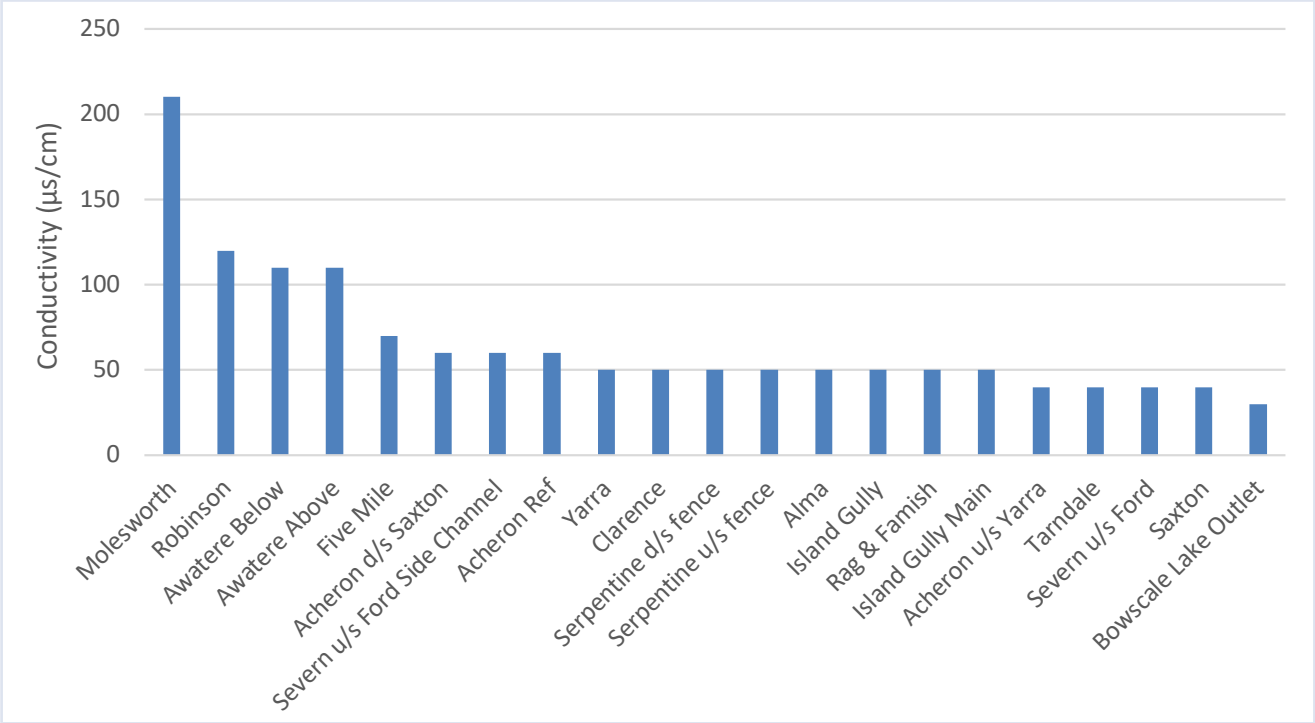


Figure 11 Conductivity 'spot test' results: March 2018.

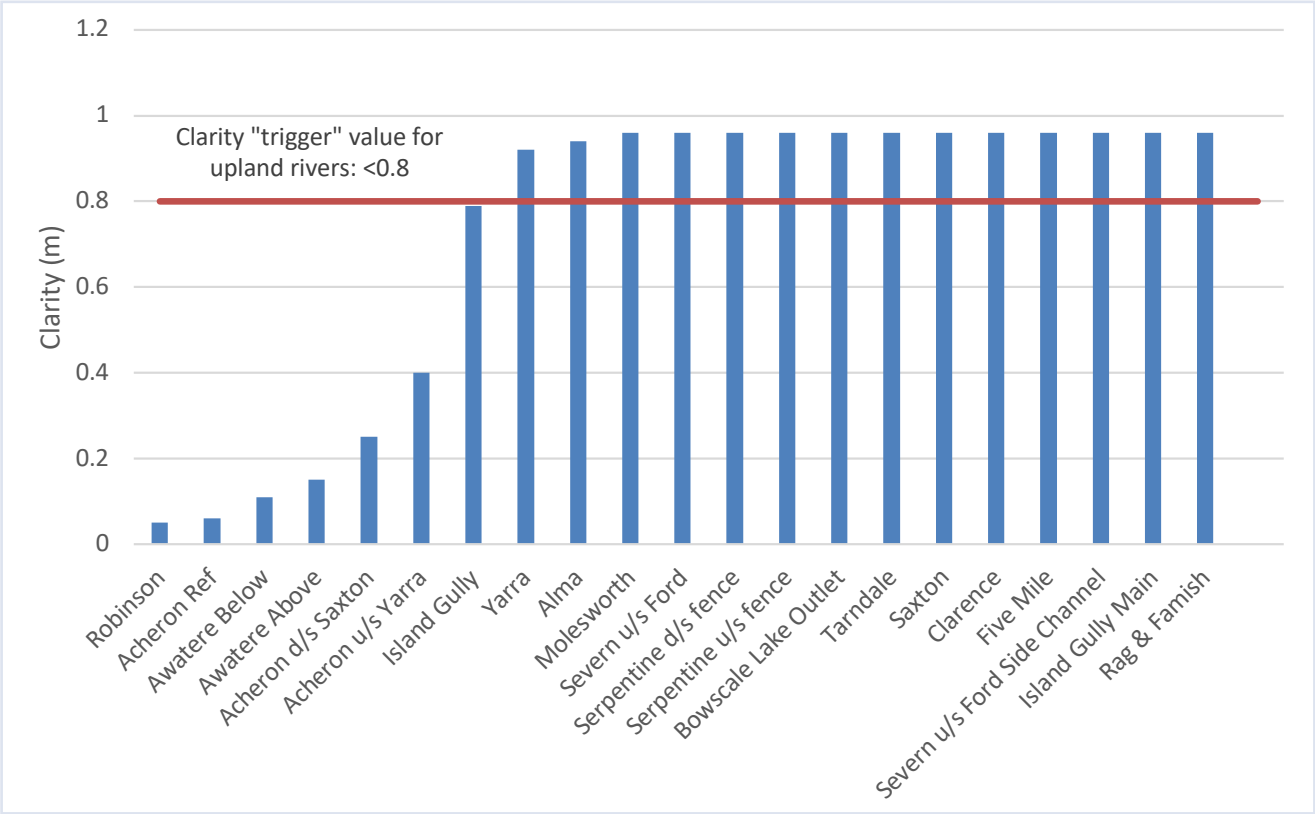


Figure 12 Clarity 'spot test' results: taken using clarity tube methods, where 97cm is the maximum clarity that can be measured. Sites with 97cm are likely to have had greater clarity than this method could account for.

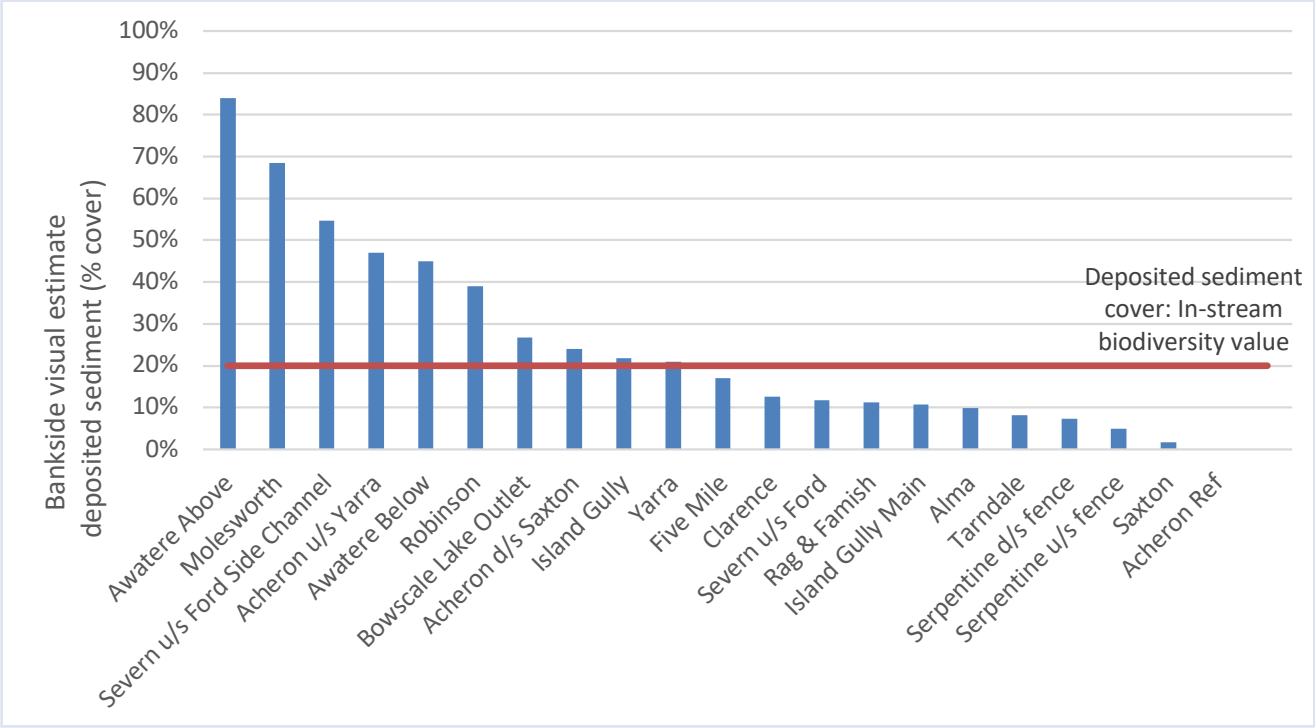


Figure 13 Bankside visual estimate (% cover) deposited sediment: Depth of river and poor clarity made meant visual estimate was not able to be recorded at Acheron Ref site.

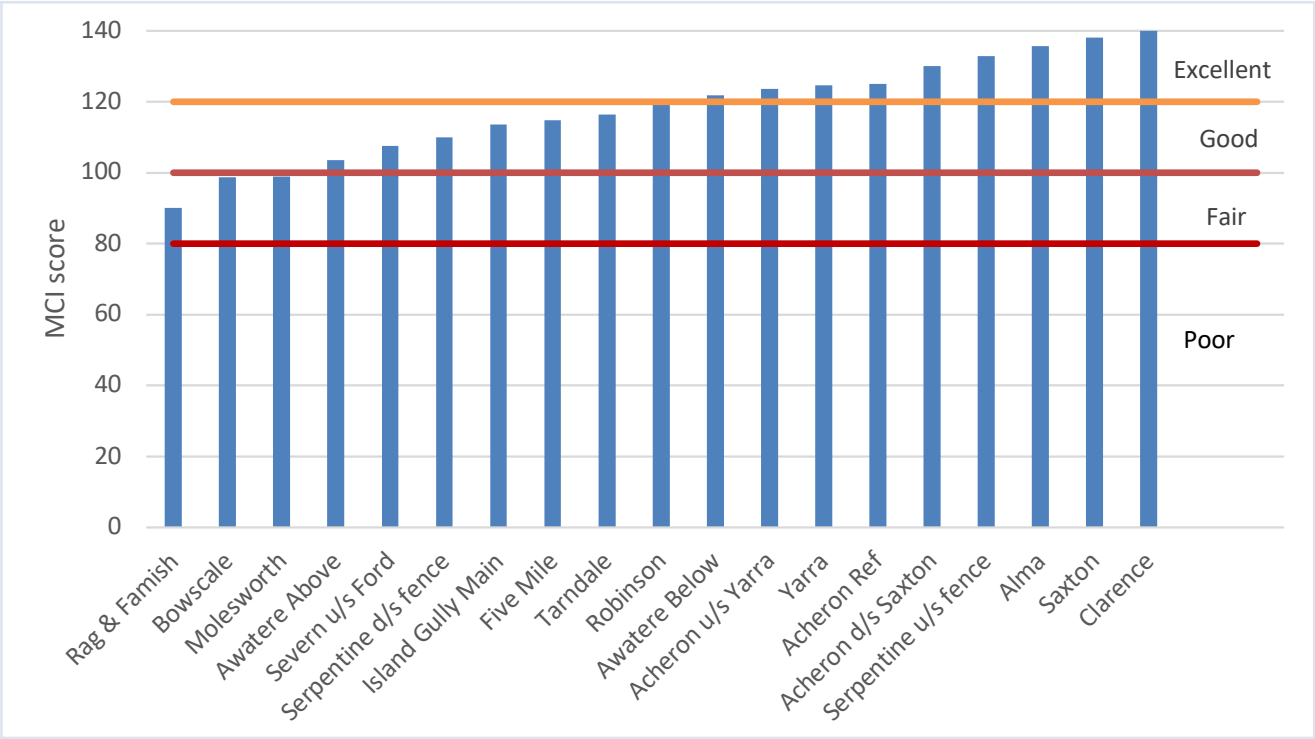
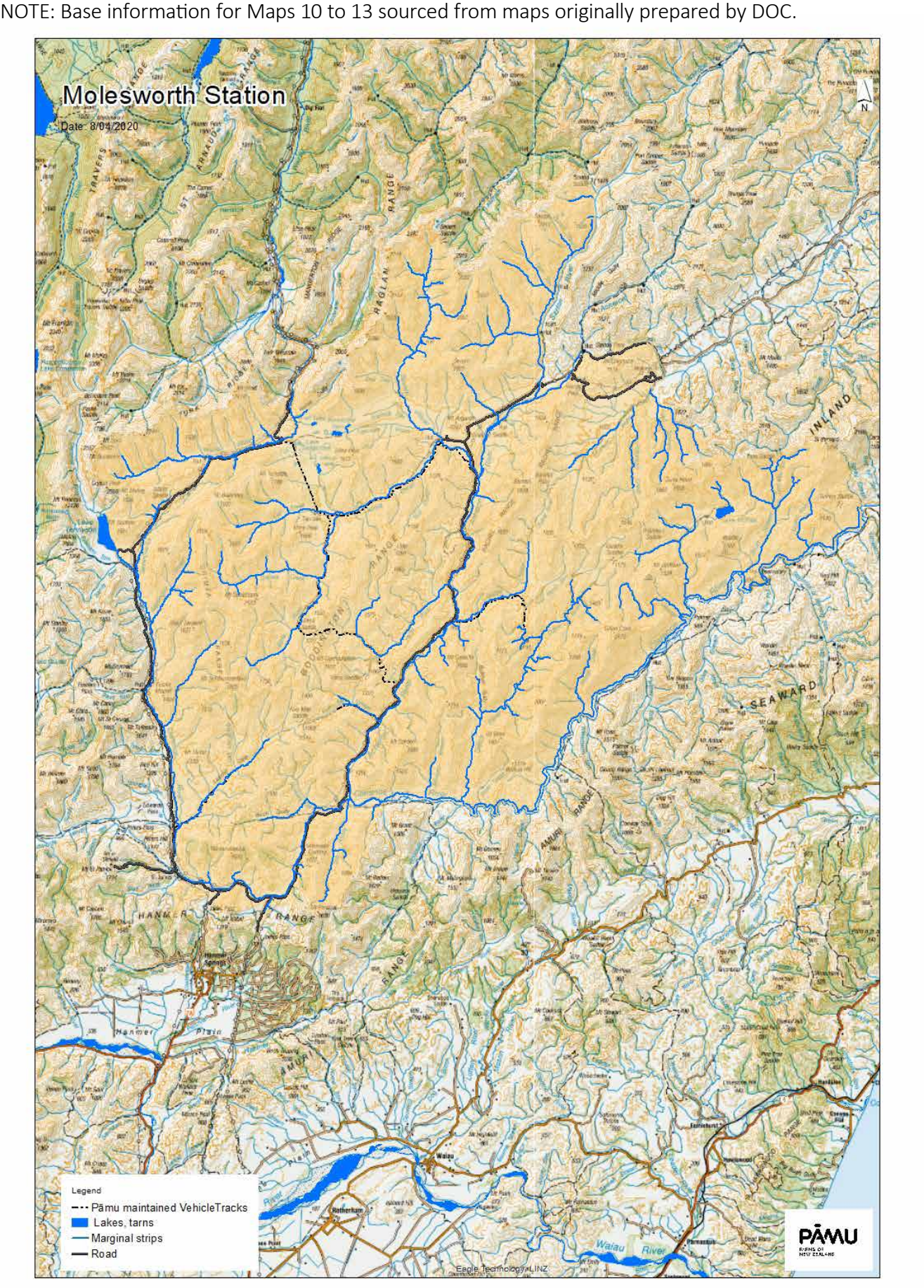


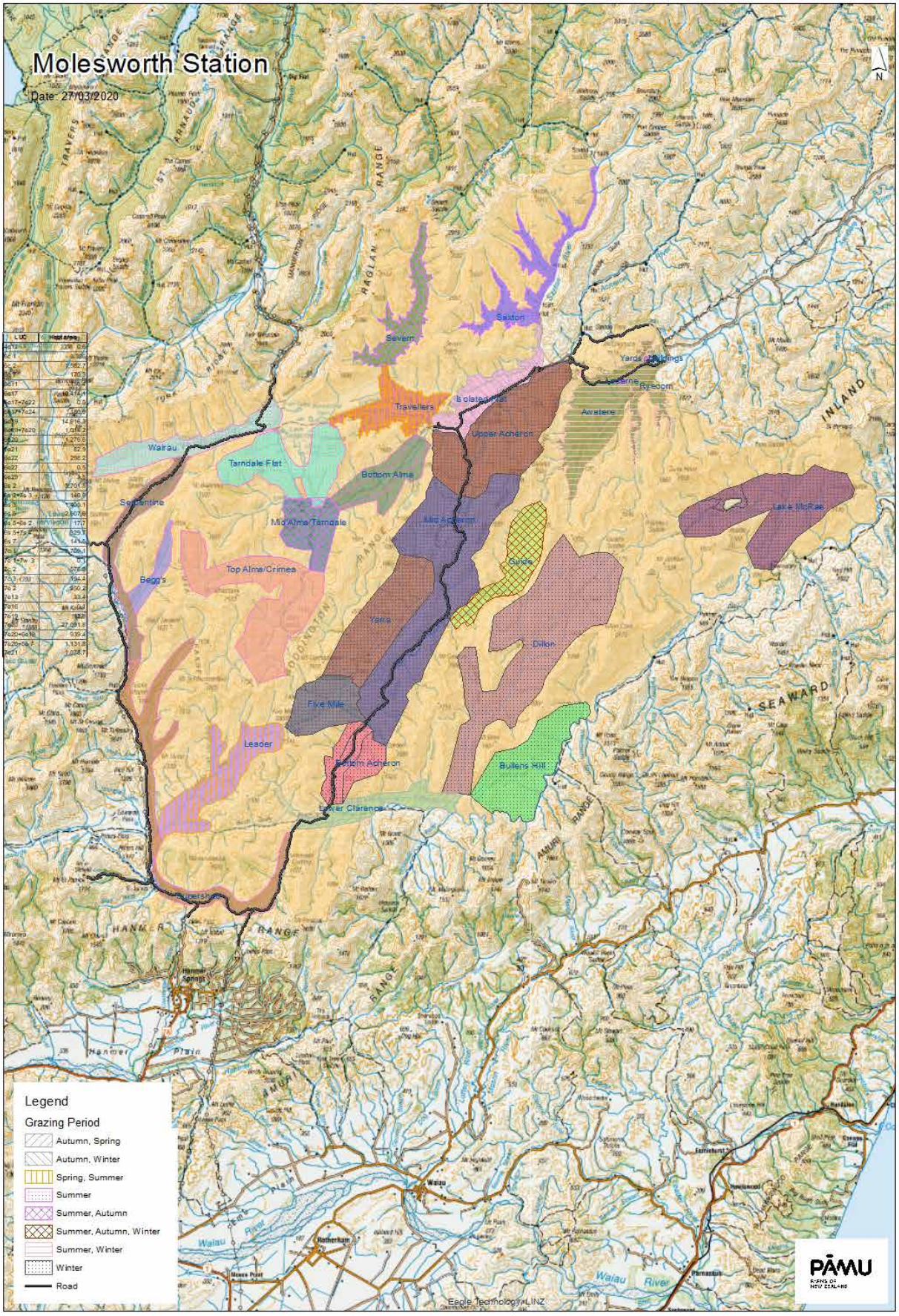
Figure 14 Macroinvertebrate Community Index (MCI) scores: March, 2018

18.2 Appendix 2: Maps

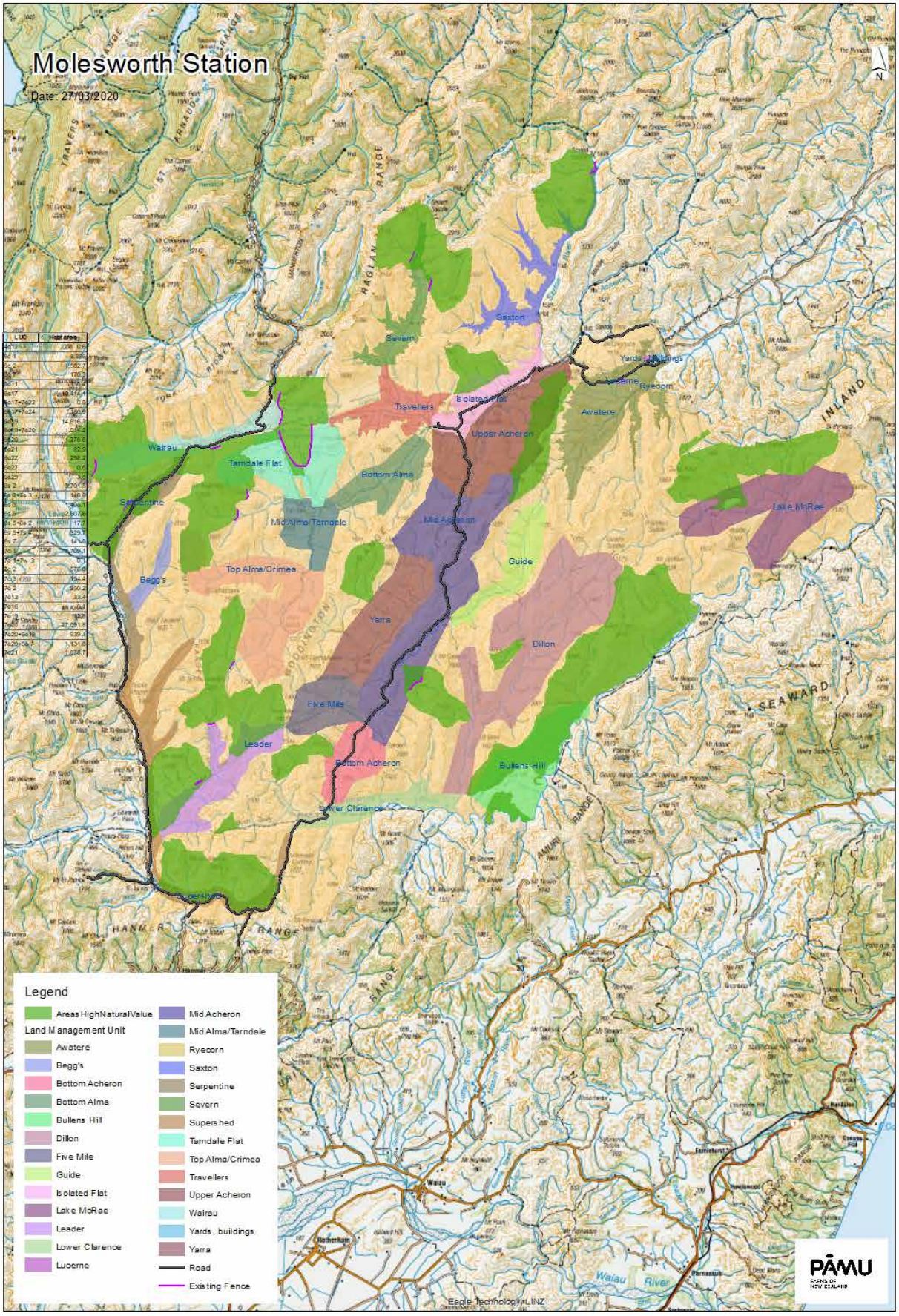
NOTE: Base information for Maps 10 to 13 sourced from maps originally prepared by DOC.



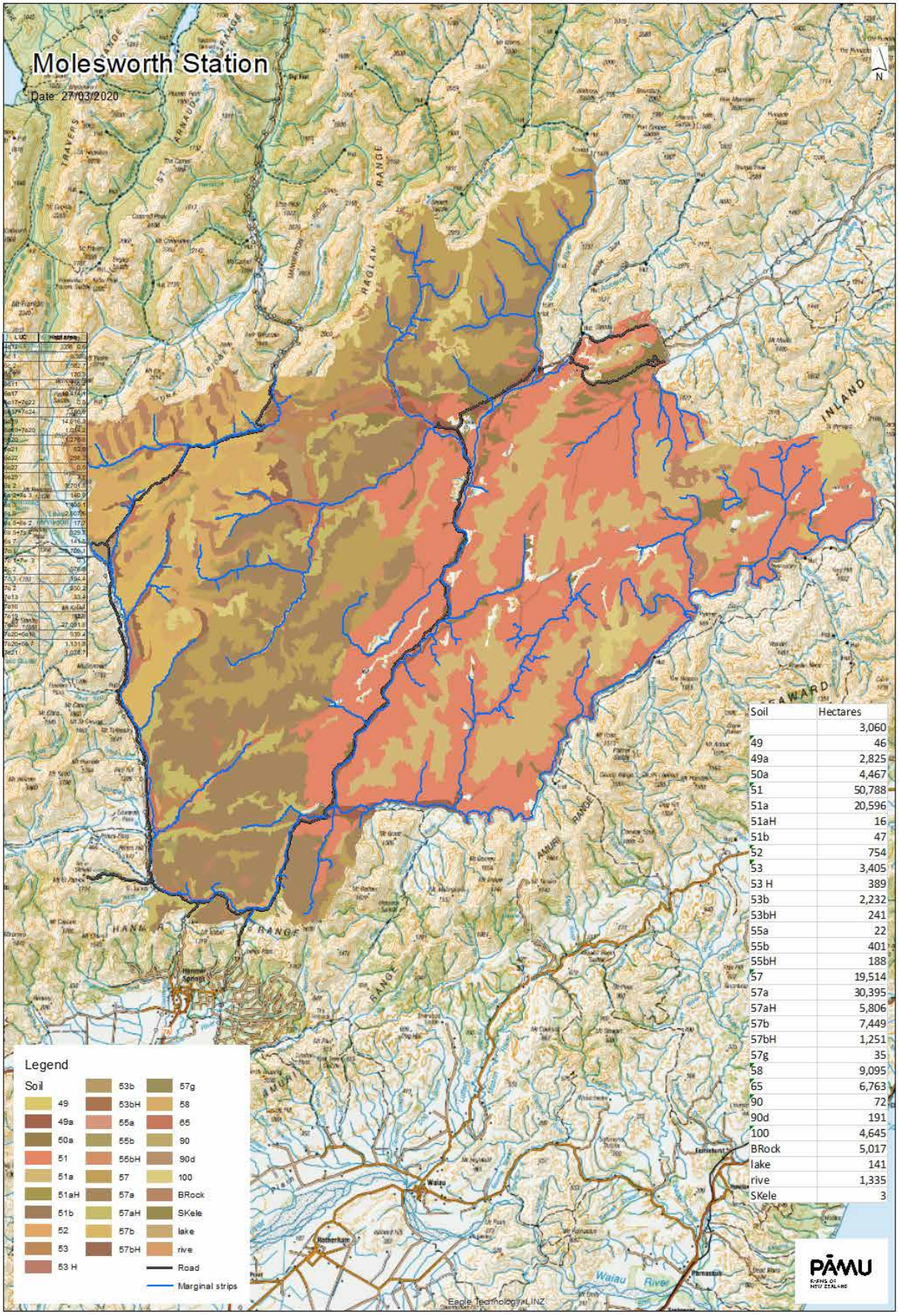
Map 1 Major waterways, roads and tracks on Molesworth Station.



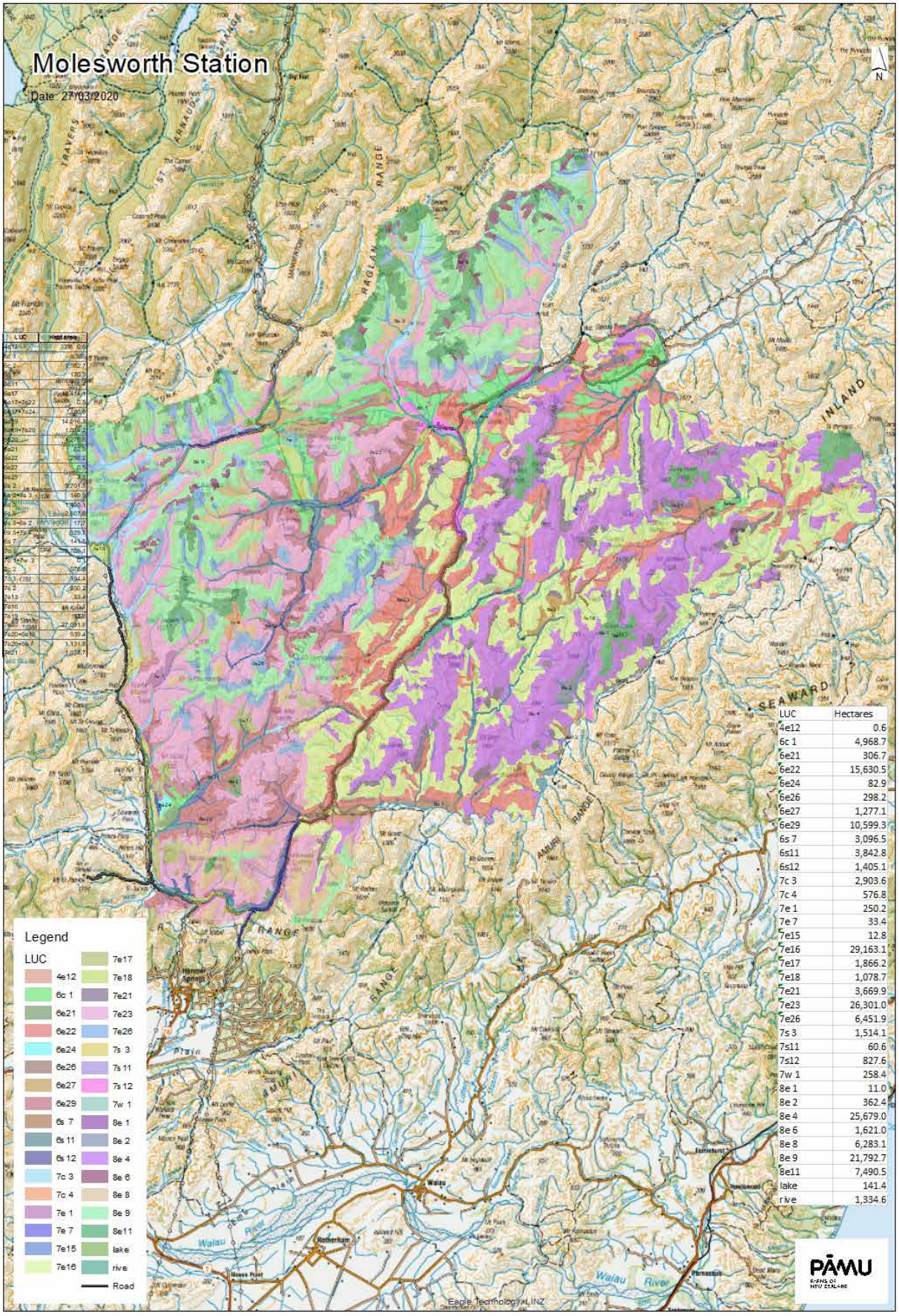
Map 2 Land Management Units and grazing timing for Molesworth Station.



Map 3 Areas of High Natural Value in relation to Land Management Units on Molesworth Station.

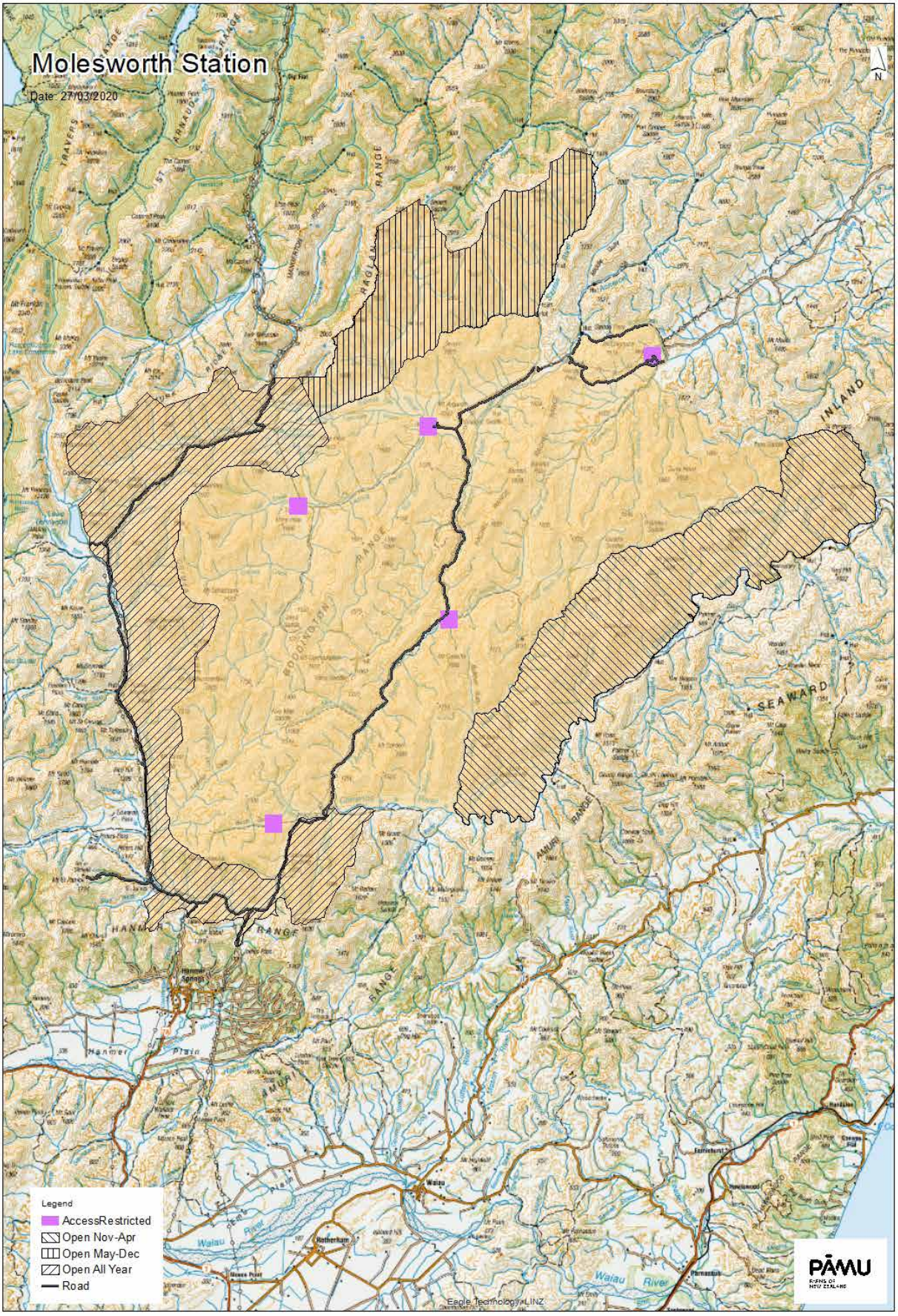


Map 4 Fundamental soil types for Molesworth Station (Sutherland, 1988)

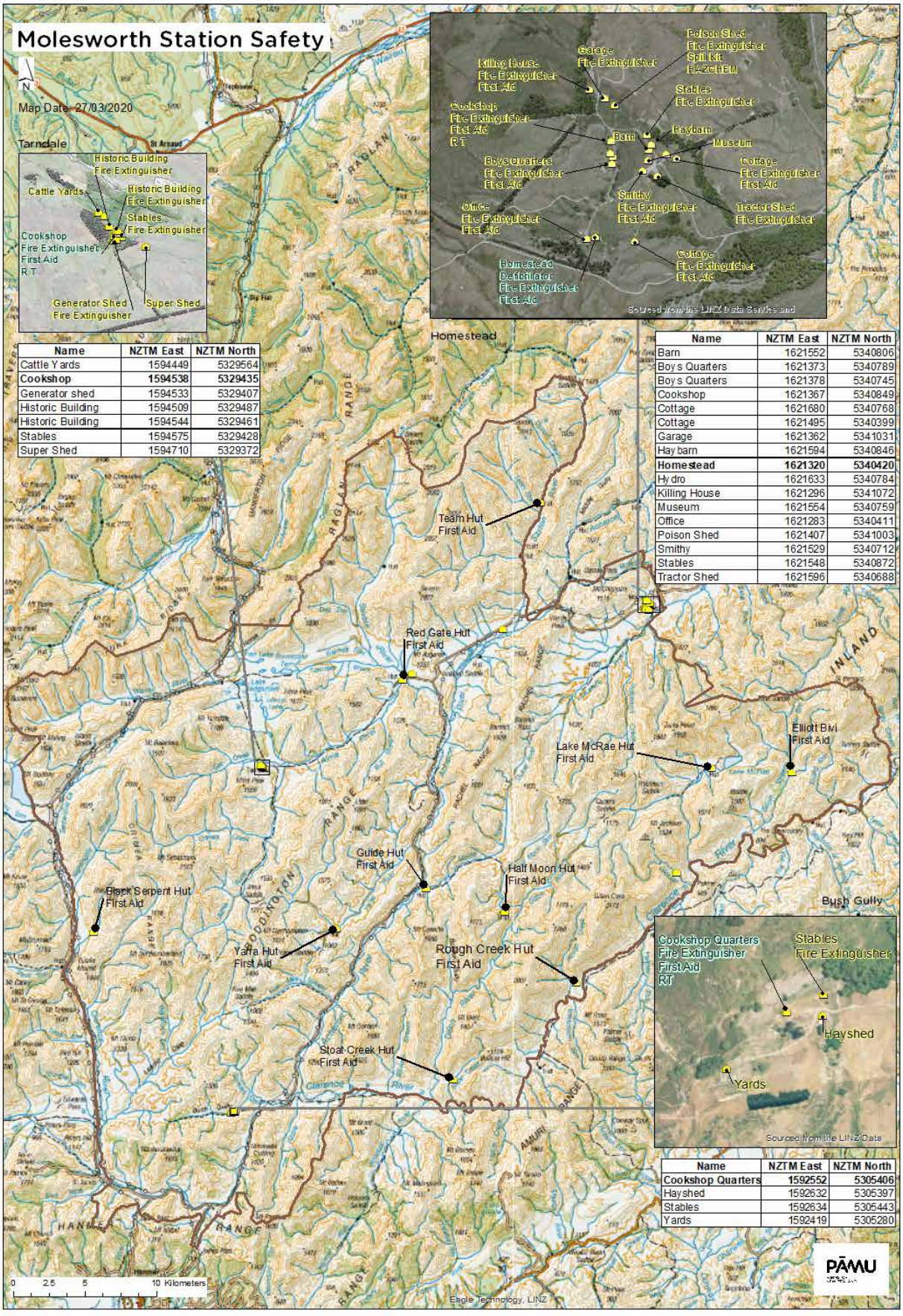


LUC	Hectares
4e12	0.6
6c 1	4,968.7
6e21	306.7
6e22	15,630.5
6e24	82.9
6e26	298.2
6e27	1,277.1
6e29	10,599.3
6s 7	3,096.5
6s11	3,842.8
6s12	1,405.1
7c 3	2,903.6
7c 4	576.8
7e 1	250.2
7e 7	33.4
7e15	12.8
7e16	29,163.1
7e17	1,866.2
7e18	1,078.7
7e21	3,669.9
7e23	26,301.0
7e26	6,451.9
7s 3	1,514.1
7s11	60.6
7s12	827.6
7w 1	258.4
8e 1	11.0
8e 2	362.4
8e 4	25,679.0
8e 6	1,621.0
8e 8	6,283.1
8e 9	21,792.7
8e11	7,490.5
lake	141.4
rive	1,334.6

Map 5 Land Use Capability Units for Molesworth Station (National Land Resource Inventory Database)



Map 6 Public access and timing for Molesworth Station.

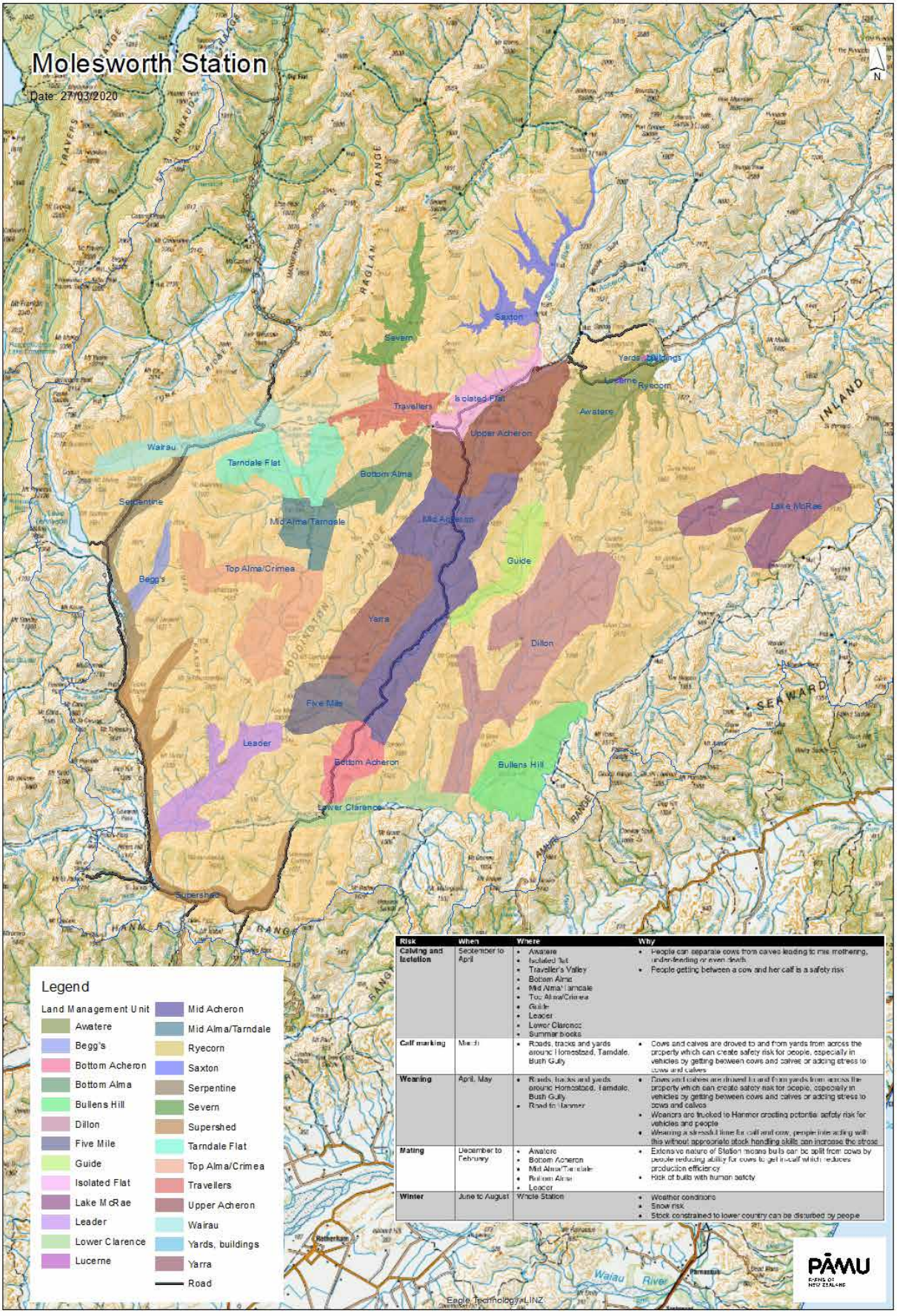


Name	NZTM East	NZTM North
Cattle Yards	1594449	5329564
Cookshop	**1594538**	**5329435**
Generator shed	1594533	5329407
Historic Building	1594509	5329487
Historic Building	1594544	5329461
Stables	1594575	5329428
Super Shed	1594710	5329372

Name	NZTM East	NZTM North
Barn	1621552	5340806
Boys Quarters	1621373	5340789
Boys Quarters	1621378	5340745
Cookshop	1621367	5340849
Cottage	1621680	5340768
Cottage	1621495	5340399
Garage	1621362	5341031
Hay barn	1621594	5340846
Homestead	**1621320**	**5340420**
Hydro	1621633	5340784
Killing House	1621296	5341072
Museum	1621554	5340759
Office	1621283	5340411
Poison Shed	1621407	5341003
Smithy	1621529	5340712
Stables	1621548	5340872
Tractor Shed	1621596	5340688

Name	NZTM East	NZTM North
Cookshop Quarters	**1592552**	**5305406**
Hayshed	1592632	5305397
Stables	1592634	5305443
Yards	1592419	5305280

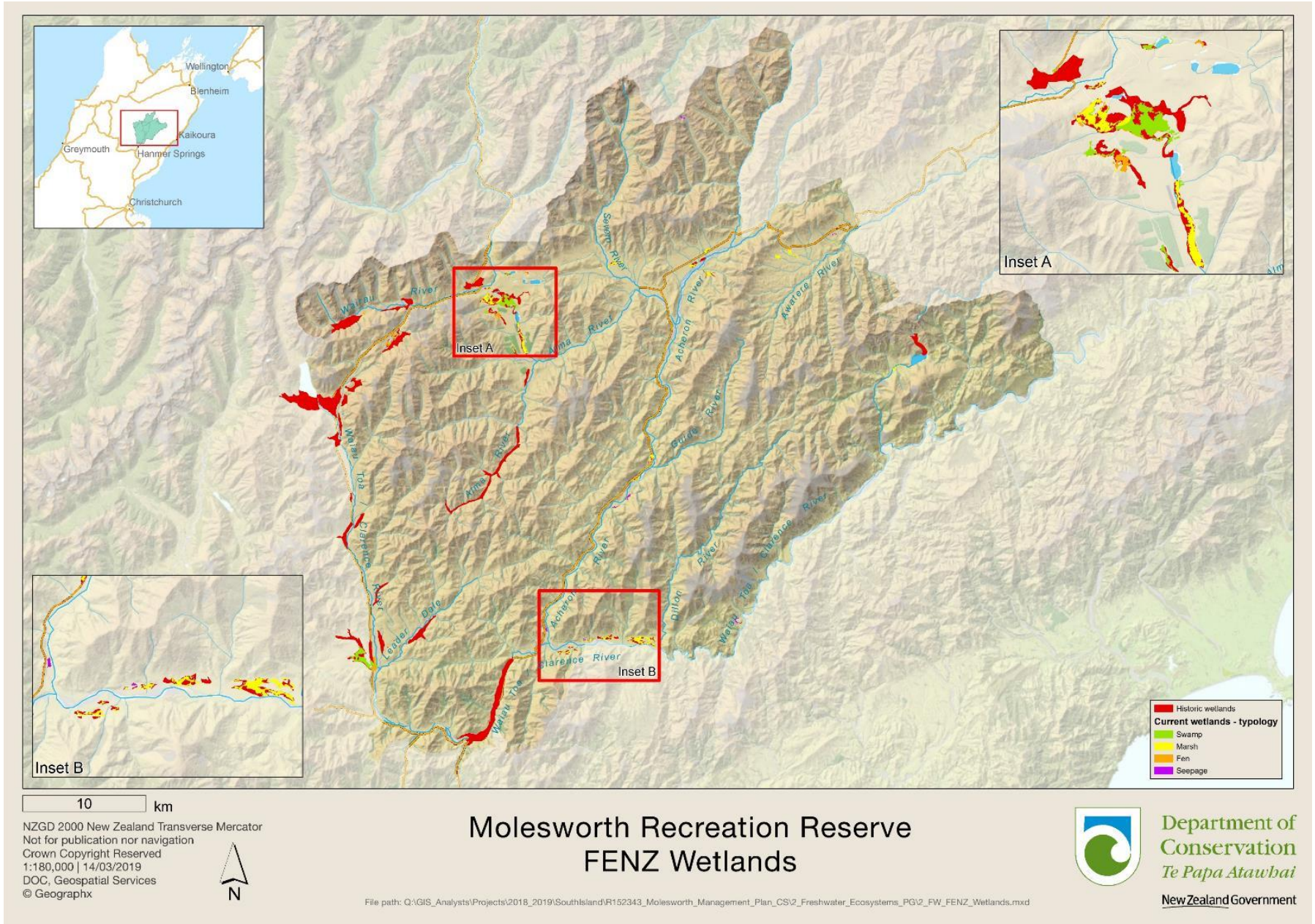
Map 7 Places of historic significance and First Aid Stations for Molesworth Station.



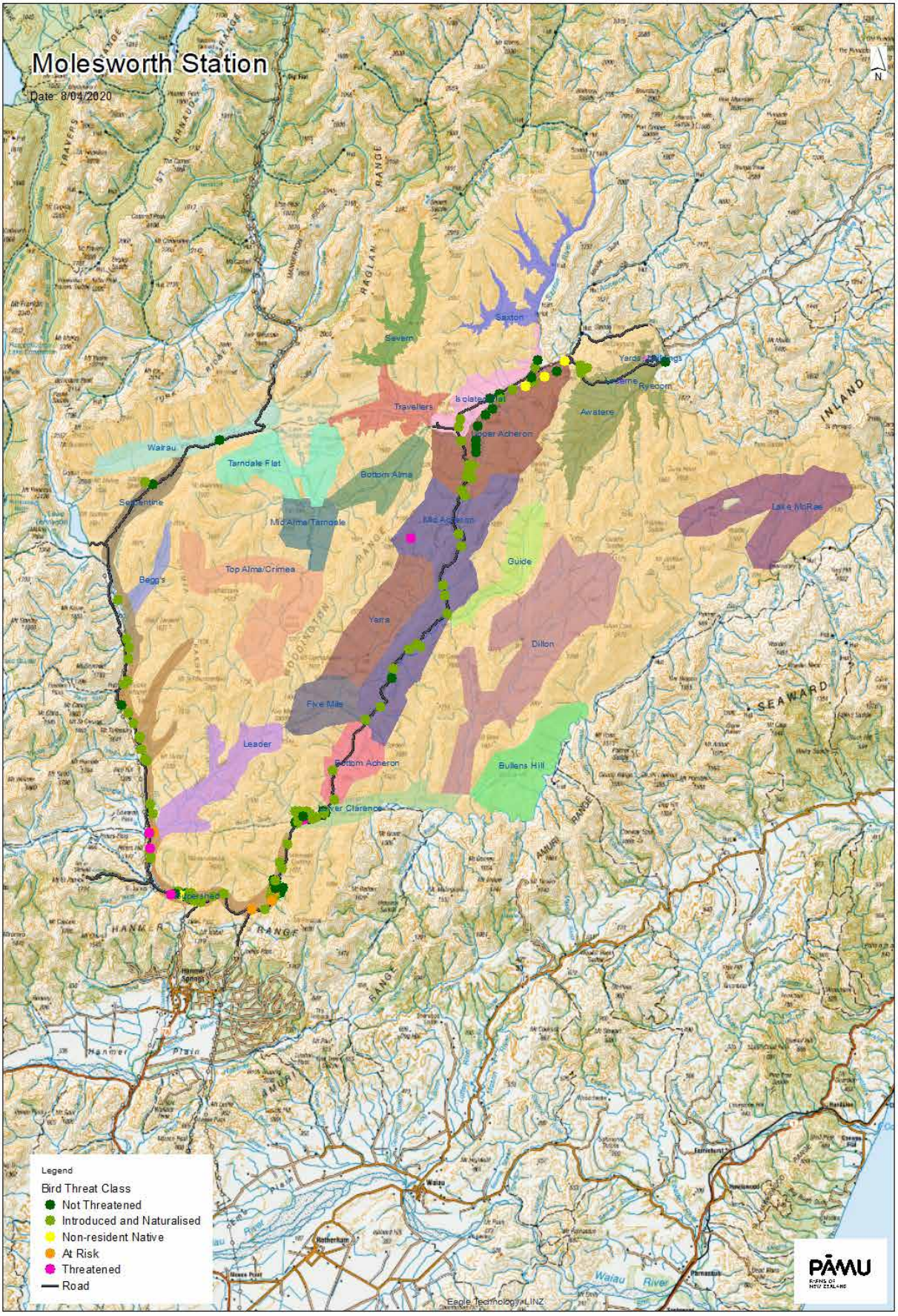
Risk	When	Where	Why
Calving and lactation	September to April	• Awatere • Isolated Tat • Traveller's Valley • Bottom Alma • Mid Alma/ Tarndale • Top Alma/Crimea • Guide • Leader • Lower Clarence • Summer blocks	• People can separate cows from calves leading to mis mothering, under-feeding or even death • People getting between a cow and her calf is a safety risk
Calf marking	March	• Roads, tracks and yards around Homestead, Tarndale, Bush Gully	• Cows and calves are droved to and from yards from across the property which can create safety risk for people, especially in vehicles by getting between cows and calves or adding stress to cows and calves
Weaning	April, May	• Roads, tracks and yards around Homestead, Tarndale, Bush Gully • Road to Hanmer	• Cows and calves are droved to and from yards from across the property which can create safety risk for people, especially in vehicles by getting between cows and calves or adding stress to cows and calves • Weaners are trucked to Hanmer creating potential safety risk for vehicles and people • Weaning is stressful time for calf and cow, people interacting with this without appropriate stock handling skills can increase the stress
Mating	December to February	• Awatere • Bottom Acheron • Mid Alma/Tarndale • Bottom Alma • Leader	• Extensive nature of Station means bulls can be split from cows by people reducing ability for cows to get in-calf which reduces production efficiency • Risk of bulls with human safety
Winter	June to August	Whole Station	• Weather conditions • Snow risk • Stock constrained to lower country can be disturbed by people

Map 8 High Risk Operational Areas in relation to interaction with Molesworth users

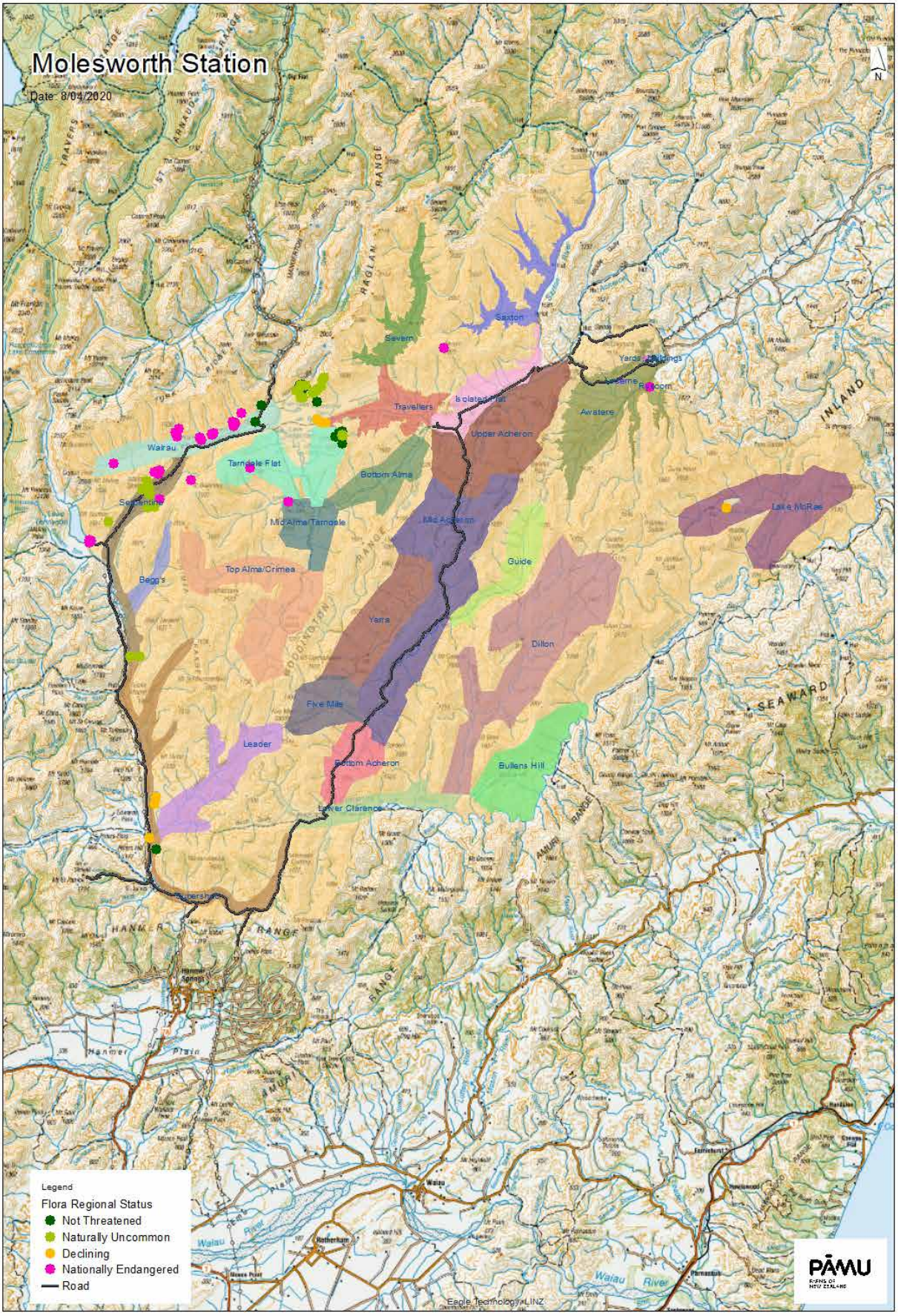
Note: table on map is presented in Table 25



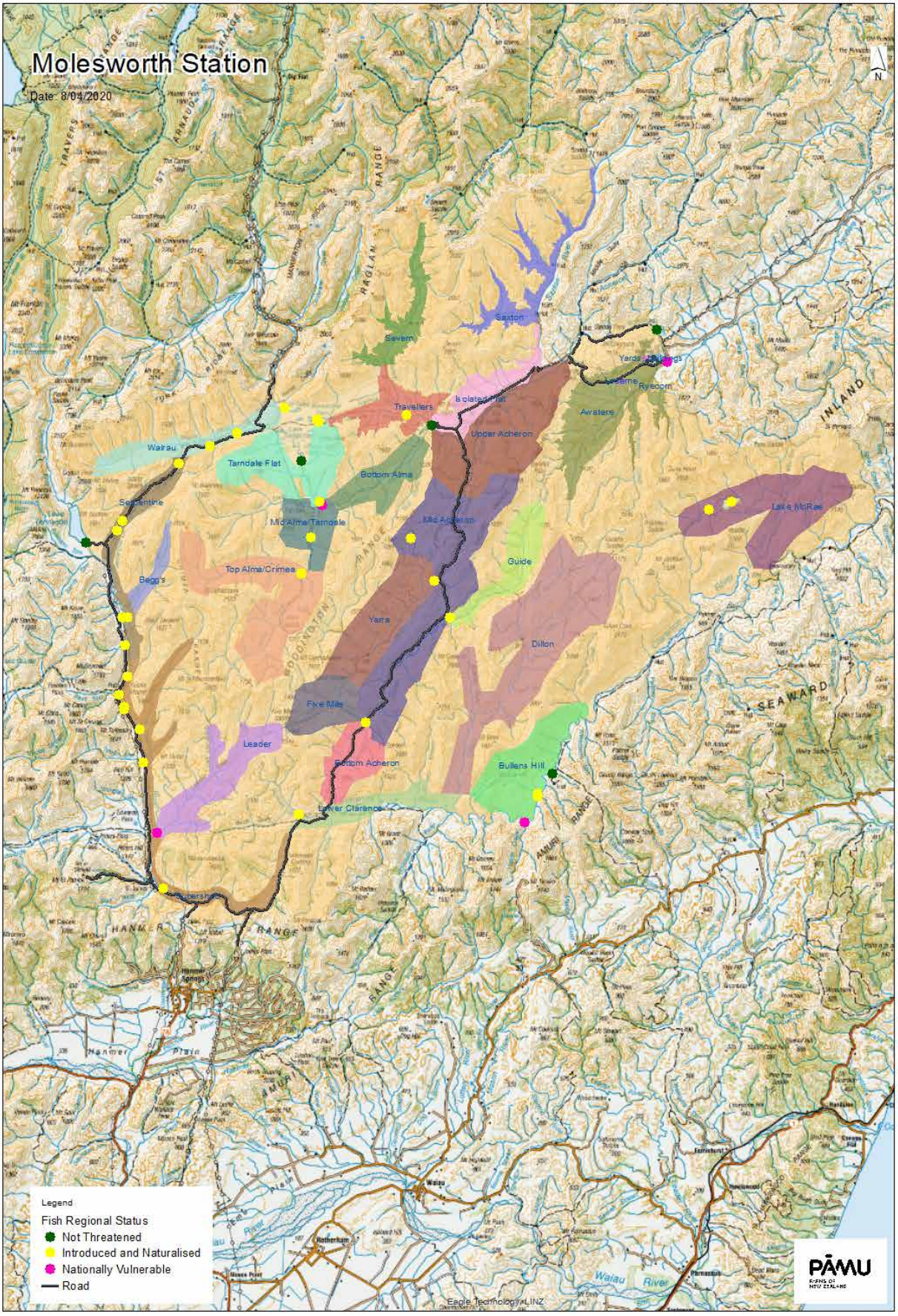
Map 9 Freshwater Ecosystems New Zealand wetlands database for Molesworth.



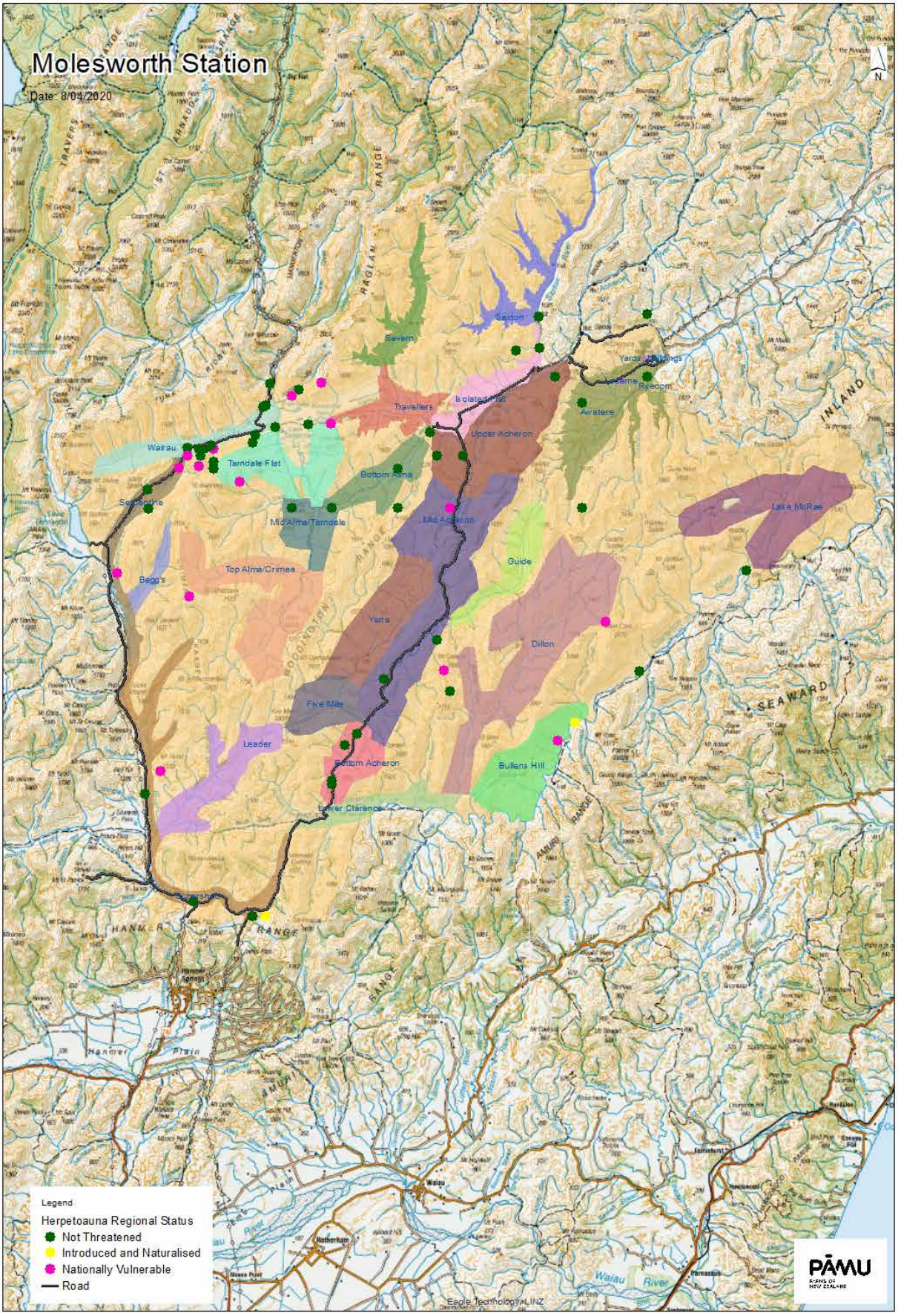
Map 10 National threat class of birds surveyed on Molesworth.



Map 11 National threat class of flora surveyed on Molesworth.



Map 12 National threat class of freshwater fish surveyed on Molesworth.



Map 13 National threat class of herpetofauna (reptiles and frogs) surveyed on Molesworth.

18.3 Appendix 3: Tables

Table 20 Relationship of soil sets mapped on Molesworth Station to rainfall, landforms, and elevation (Sutherland, 1988).

		Landform			
		Terraces	Fans and moraines	Hill and mountain slopes	
			Low elevation <1,370m	High elevation >1,370m	
Rainfall	Low (<800mm)	Acheron 49a	Molesworth 50a	Muller 51	Benmore 51a
	Medium (800-1200mm)	Craigieburn 52	Cass 53	Tekoa 57a	Kaikoura 57
	High (>1200mm)	Katrine 53b		Bealey 57b	Spenser 58

Table 21 Predominant (>1,000ha) Land Use Capability (LUC) units, area and description (Lynn, 1996)

LUC UNIT	AREA (ha)	DESCRIPTION
6c1	4,968.7	Undulating to rolling stable terraces, fans and uplands below 11 00 m asl, in low rainfall inland montane areas with a favourable sheltered aspect and silt loam to stony sandy loam textured medium fertility soils.
6e22	15,630.5	Undulating to rolling terraces and fans with shallow (15-30 cm) loess mantled soils susceptible to wind erosion. Low to moderate rainfall inland areas.
6e27	1,277.1	Rolling to strongly rolling terraces, fans and moraines with loess mantled silt loam to sandy loam textured soils susceptible to wind erosion in moderate rainfall inland areas.
6e29	10,599.3	Strongly rolling to steep lower hill slopes developed on strongly indurated sedimentary rocks with low fertility upland and high country yellow brown earth soils in moderate rainfall inland areas.
6s7	3,096.5	Flat to undulating terraces and fans with very shallow (<15 cm) and stony silt loam to sandy loam textured soils, in low rainfall inland areas.
6s11	3,842.8	Flat to undulating floodplains, low terraces and fans with very shallow (<15 cm) and stony silt loam to sandy loam textured recent soils in low to moderate rainfall inland areas.
6s12	1,405.1	Undulating to rolling terraces and fans with very shallow (<15 cm) and stony silt loam textured soils, in moderate rainfall inland areas.
7c3	2,903.6	Undulating to rolling stable terraces, fans and moraine above 1000 m asl in cool, low rainfall inland areas.
7e16	29,163.1	Moderately steep to steep mountain slopes, below 1340 m developed on strongly indurated sedimentary rocks with upland and high country yellow brown earth soils susceptible to moderate to severe sheet, scree, debris avalanche and/or gully erosion, in low rainfall inland areas with a marked summer moisture deficit.

LUC UNIT	AREA (ha)	DESCRIPTION
7e17	1,866.2	Strongly rolling to moderately steep, lower slopes developed on strongly indurated sedimentary rocks with low fertility upland and high country yellow brown earth soils susceptible to moderate to severe sheet and scree erosion, in moderate to high rainfall high country areas.
7e18	1,078.7	Moderately steep to steep hill country developed on strongly indurated sedimentary and schistose rocks in high rainfall areas, with low to very low fertility soils susceptible to severe sheet and soil slip erosion.
7e21	3,669.9	Rolling to strongly rolling morainic slopes with loessial silt loam to sandy loam textured soils susceptible to moderate to severe wind erosion in moderate rainfall, high country areas.
7e23	26,301	Moderately steep to steep midslopes developed on strongly indurated sedimentary rocks with upland and high country yellow brown earth soils susceptible to moderate to severe sheet, debris avalanche and/ or scree erosion between 900 and 1600 m, in low to moderate rainfall, inland mountain areas.
7e26	6,451.9	Moderately steep to very steep hill country developed on moderately to strongly indurated sedimentary rocks with yellow grey to yellow brown intergrade soils susceptible to moderate to severe sheet and/ or gully erosion, with minor scree, in low to moderate rainfall inland areas with a moderate summer dry season.
7s3	1,514.1	Flat to undulating floodplains, low terraces and fans with very shallow and stony silt loam to sandy loam textured recent soils in low to high rainfall inland areas.
8e4	25,679	Steep to very steep, severely eroded tussock slopes developed on strongly indurated sedimentary rocks with upland and high country yellow brown earth soils, in low to moderate rainfall inland areas, up· to 1400 m.
8e6	1,621	Rolling to moderately steep mountain and ridge summits on strongly indurated sedimentary rocks, in moderate (to high) rainfall areas within the tussock zone with a severe erosion hazard.
8e8	6,283.1	Steep to very steep, severely eroded tussock slopes developed on strongly indurated sedimentary rocks with upland and high country yellow brown earth soils, in low to moderate rainfall inland areas, above 1300 m.
8e9	21,792.7	Steep to very steep mountain slopes and summits developed on strongly indurated sedimentary and schistose rocks above the timber line, in high rainfall areas, susceptible to extreme erosion.
8e11	7,490.5	Steep to very steep alpine slopes and summits developed on strongly indurated sedimentary rocks in moderate to high rainfall areas, comprising bare rock and scree above the altitudinal limit of semi-continuous vegetation.

Table 22 Molesworth Station Land Management Units (Grazing Area)

LAND MANAGEMENT UNIT (LMU)	AREA GRAZED	DESCRIPTION	MANAGEMENT	STOCK NUMBERS
Awatere Easier Country	2,700ha	• Flat to gentle contour • Improved pastures[1] • Scattered native • Close proximity to homestead and main yards	• Salt used to attract cattle away from waterways • Lime and sulphur applied once every 3-years • Clover is the focus so stock density managed to ensure clover enhanced and grazing residuals maintained to conserve soil moisture levels and minimise any risk of soil erosion	• 750 R2[2] heifers (Summer) • 800 R38 heifers (Summer, Autumn) • 1,000 R18 heifers (Winter, Spring)
Awatere Moderate Country	900ha	• Moderate contour • Increased native vegetation	• No nutrients or minerals applied • Very low grazing density • Native vegetation observed as indicator of appropriate grazing density	
Lucerne (long-term crop)	58ha (0.075%)	• Better soils • Flat contour • Sown in lucerne • Aim for at least 10-years for each crop	• Direct drilled to protect soils, light cultivation used for contouring if needed and only when conditions allow. • All cut-and-carry, made into baleage to minimise wastage, baleage wrap recycled. • Fertiliser: 21.6kg Phosphorus per hectare applied in Spring and 6.8kg Phosphorus per hectare applied in Summer	• No stock fed on lucerne
Ryecorn (short-term crop)	50ha (0.065%)	• Better soils • Gentle contour • Sown in ryecorn	• Block-fed (rather than strip-grazed) to protect soils • Direct drilled to protect soils • Cattle moved off in wet weather to protect soils • Fertiliser: 21.2kg Nitrogen per hectare and 29.6 Phosphorus per hectare applied in Spring	• 50-100 heifers (Winter)
Buildings/holding paddocks	600ha	• Buildings, yards and holding paddocks around homestead and camps at Tarndale and Bush Gully.	• Buildings kept clean and tidy • Pest control maintained in all buildings • Holding paddocks maintained for stock-proof • Not over-grazed • Stock water reticulation in yards and holding paddocks	• Varies – stock in these areas for short periods of time around particular tasks (e.g. calf-marking, weaning).
Isolated Flat Easier Country	1,000ha	• Flat to gentle contour • Improved pastures • Scattered native	• Salt used to attract cattle away from waterways • Lime and sulphur applied once every 3-years • Clover is the focus so stock density managed to ensure clover enhanced and grazing residuals maintained to conserve soil moisture levels and minimise any risk of soil erosion	• 300 cows with calves (Autumn) • 400 cows (Autumn, Winter
Isolated Flat Moderate Country	1,000ha	• Moderate contour • Increased native vegetation	• No nutrients or minerals applied • Very low grazing density • Native vegetation observed as indicator of appropriate grazing density	
Traveller's Easier Country	1,000ha	• Flat to gentle contour • Improved pastures • Scattered native	• Salt used to attract cattle away from waterways • Lime and sulphur applied once every 3-years • Clover is the focus so stock density managed to ensure clover enhanced and grazing residuals maintained to conserve soil moisture levels and minimise any risk of soil erosion	• 300 cows (Spring, Summer
Traveller's Moderate Country	1,000ha	• Moderate contour • Increased native vegetation	• No nutrients or minerals applied • Very low grazing density • Native vegetation observed as indicator of appropriate grazing density	
Bottom Alma Easier Country	1,000ha	• Flat to gentle contour • Improved pastures • Scattered native	• Salt used to attract cattle away from waterways • Lime and sulphur applied once every 3-years • Clover is the focus so stock density managed to ensure clover enhanced and grazing residuals maintained to conserve soil moisture levels and minimise any risk of soil erosion	• 1,200 cows (Spring) • 250 cows (Summer)
Bottom Alma Moderate Country	1,000ha	• Moderate contour • Increased native vegetation	• No nutrients or minerals applied • Very low grazing density • Native vegetation observed as indicator of appropriate grazing density	
Mid Alma/Tarndale Easier Country	800ha	• Flat to gentle contour • Improved pastures • Scattered native	• Salt used to attract cattle away from waterways • Lime and sulphur applied once every 3-years • Clover is the focus so stock density managed to ensure clover enhanced and grazing residuals maintained to conserve soil moisture levels and minimise any risk of soil erosion	• 300 cows (late-Spring, Summer
Mid Alma/Tarndale Moderate Country	500ha	• Moderate contour • Increased native vegetation	• No nutrients or minerals applied • Very low grazing density • Native vegetation observed as indicator of appropriate grazing density	
Top Alma/Crimea Moderate Country	5,000ha	• Moderate contour • Increased native vegetation	• No nutrients or minerals applied • Very low grazing density • Native vegetation observed as indicator of appropriate grazing density	• 350 cows (Summer)

Note: Areas grazed are approximate and will vary between seasons

1 Improved pastures on Molesworth were created historically by burning, then aerially over-sowing with productive grass seeds such as fescues, and applying aerial phosphorus fertiliser to improve the base fertility. There has been no over-sowing or topdressing of phosphorus fertiliser on Molesworth for 18 years, and no intention of reinstating this practice.

2 R1, R2 and R3 heifers are Rising 1-year old, Rising 2-year old, and Rising 3-year old.

LAND MANAGEMENT UNIT (LMU)	AREA GRAZED	DESCRIPTION	MANAGEMENT	STOCK NUMBERS
Guide Easier Country	1,000ha	• Flat to gentle contour • Improved pastures • Scattered native	• Salt used to attract cattle away from waterways • Clover is the focus so stock density managed to ensure clover enhanced and grazing residuals maintained to conserve soil moisture levels and minimise any risk of soil erosion	• 500 R1 heifers (Summer) • 300 cows (Winter, early-Spring)
Bottom Acheron Easier Country	800ha	• Flat to gentle contour • Improved pastures • Scattered native	• Salt used to attract cattle away from waterways • Lime and sulphur applied once every 3-years • Clover is the focus so stock density managed to ensure clover enhanced and grazing residuals maintained to conserve soil moisture levels and minimise any risk of soil erosion	• R2 heifers (Winter, early-Spring)
Bottom Acheron Moderate Country	1,000ha	• Moderate contour • Increased native vegetation	• No nutrients or minerals applied • Very low grazing density • Native vegetation observed as indicator of appropriate grazing density	
Lower Clarence Easier Country	1,000ha	• Flat to gentle contour • Improved pastures • Scattered native • Natural fertility	• Salt used to attract cattle away from waterways • Lime and sulphur applied once every 3-years • Clover is the focus so stock density managed to ensure clover enhanced and grazing residuals maintained to conserve soil moisture levels and minimise any risk of soil erosion	• 800 cows and calves (Autumn) • 800 cows (September)
Lower Clarence Moderate Country	500ha	• Moderate contour • Increased native vegetation	• No nutrients or minerals applied • Very low grazing density • Native vegetation observed as indicator of appropriate grazing density	
Leader Easier Country	1,000ha	• Flat to gentle contour • Improved pastures • Scattered native • Natural fertility	• Salt used to attract cattle away from waterways • Lime and sulphur applied once every 3-years • Clover is the focus so stock density managed to ensure clover enhanced and grazing residuals maintained to conserve soil moisture levels and minimise any risk of soil erosion	• 800 cows and calves (Autumn) • 1,000 R2 heifers (Winter)
Leader Moderate Country	2,000ha	• Moderate contour • Increased native vegetation	• No nutrients or minerals applied • Very low grazing density • Native vegetation observed as indicator of appropriate grazing density	
Winter Blocks	39,000ha	• Natural fertility • Flat to gentle contour • Warmer and less snow-prone	• Low stocking rate • Regular checks throughout winter period • Where supplement fed, avoid feeding in the same place and wheel marks tracking in same place • Salt used to attract cattle away from waterways	• 800 cows (Winter) • 800 cows and calves (Autumn) (Upper Acheron) • 1,000 R2 heifers (Winter) • 1,000 R2 heifers (Winter, Spring) (5-mile, Mid Acheron)
Summer Blocks	18,500ha	• Moderate contour • Natural fertility • Scattered native	• Salt used to attract cattle away from waterways • Lime and sulphur applied once every 3-years • Clover is the focus so stock density managed to ensure clover enhanced and grazing residuals maintained to conserve soil moisture levels and minimise any risk of soil erosion	• 1100 cows (Summer)

Note: Areas grazed are approximate and will vary between seasons

Table 23 Land Management Units (LMU) and description with representative photographs

LMU

Awatere Easy

2,700ha

(See Soil table below for soils photos)

- Flat to gentle contour
- Improved pastures
- Scattered native
- Close proximity to homestead and main yards

LMU

Awatere Moderate

900ha

(See Soil table below for soils photos)

- Moderate contour
- Increased native vegetation

LMU

Lucerne

58ha

(See Soil table below for soils photos)

- Better soils
- Flat contour
- Sown in lucerne
- Aim for at least 10-years for each crop

LMU

Ryecorn

50ha

(See Soil table below for soils photos)

- Better soils
- Gentle contour
- Sown in ryecorn

LMU

Bottom Acheron Moderate

1,000ha

- Moderate contour
- Increased native vegetation

LMU

Lower Clarence Easier

1,000ha

- Flat to gentle contour
- Improved pastures
- Scattered native
- Natural fertility

LMU

Guide

1,000ha

- Flat to gentle contour
- Improved pastures
- Scattered native

LMU

Isolated Flat Easier Country

- Flat to gentle contour
- Improved pasture
- Scattered native

LMU

Leader Moderate

2,000ha

- Moderate contour
- Increased native vegetation

LMU

Leader Easier

1,000ha

- Flat to gentle contour
- Improved pastures
- Scattered native
- Natural fertility

LMU

Clarence Moderate

500ha

- Moderate contour
- Increased native vegetation

LMU

Acheron Easier

1,000ha

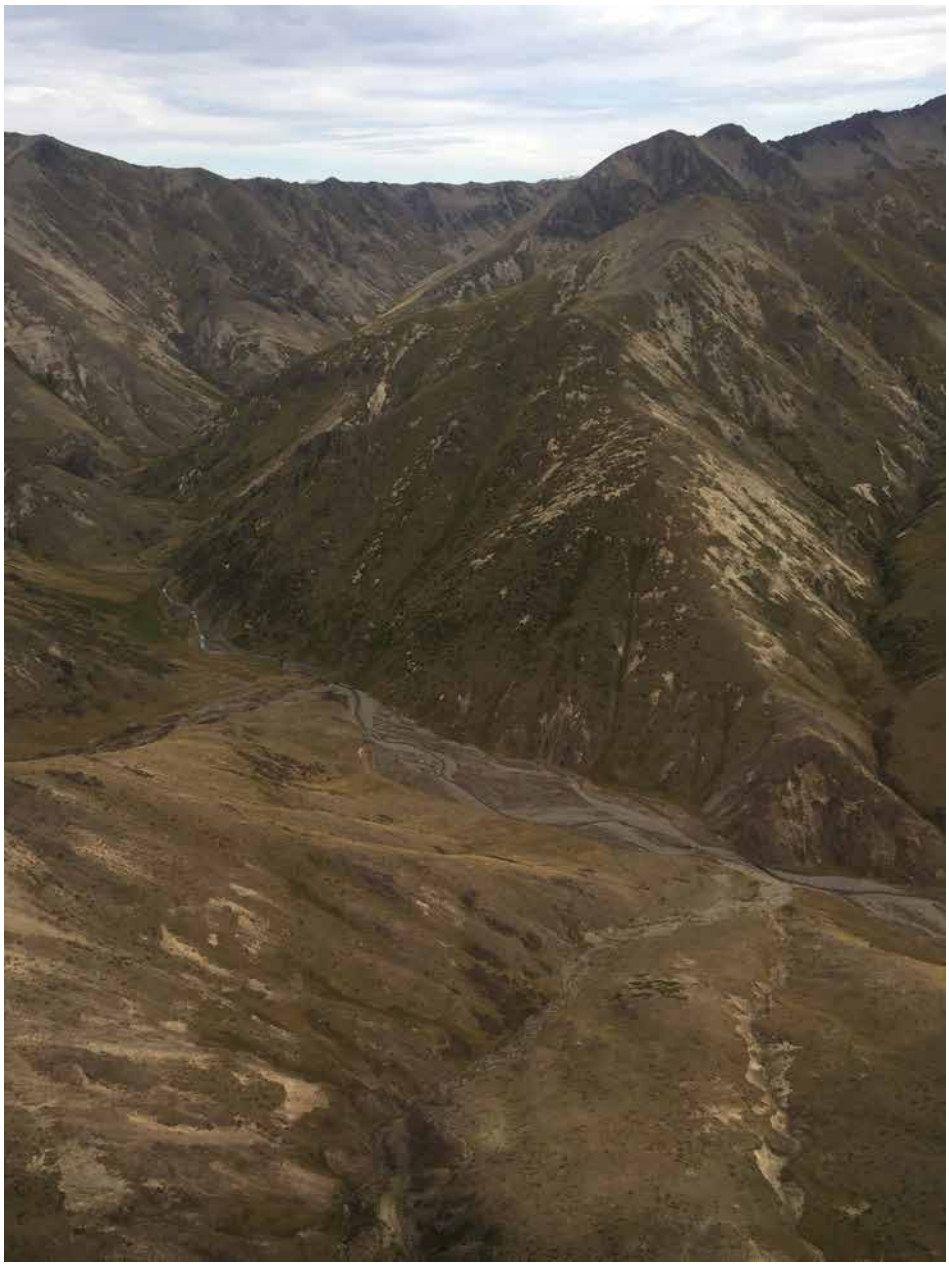
- Flat to gentle contour
- Improved pastures
- Scattered native

LMU

Crimea

5,000ha

- Moderate contour
- Increased native vegetation



Summer Country- 18,500ha

- Moderate contour
- Natural fertility
- Scattered native

Serpentine

Severn

Wairau

Saxton

Winter Country- 39,000ha

- Natural fertility
- Flat to gentle contour
- Warmer and less snow-prone

Dillon

Lake McRae

Table 24 Photographs of soils for the Awatere easier country, including the ryecorn and lucerne blocks, the most intensively managed on the property.

Awatere pasture

Lucerne

Ryecorn

Table 25 High Risk Operational Areas in relation to interaction with Molesworth users

RISK	WHEN	WHERE	WHY
Calving and lactation	September to April	• Awatere • Isolated flat • Traveller's Valley • Bottom Alma • Mid Alma/Tarndale • Top Alma/Crimea • Guide • Leader • Lower Clarence • Summer blocks	• People can separate cows from calves leading to mis-mothering, under-feeding or even death • People getting between a cow and her calf is a safety risk
Calf marking	March	• Roads, tracks and yards around Homestead, Tarndale, Bush Gully	• Cows and calves are droved to and from yards from across the property which can create safety risk for people, especially in vehicles by getting between cows and calves or adding stress to cows and calves
Weaning	April, May	• Roads, tracks and yards around Homestead, Tarndale, Bush Gully • Road to Hanmer	• Cows and calves are droved to and from yards from across the property which can create safety risk for people, especially in vehicles by getting between cows and calves or adding stress to cows and calves • Weaners are trucked to Hanmer creating potential safety risk for vehicles and people • Weaning a stressful time for calf and cow, people interacting with this without appropriate stock handling skills can increase the stress
Mating	December to February	• Awatere • Bottom Acheron • Mid Alma/Tarndale • Bottom Alma • Leader	• Extensive nature of Station means bulls can be split from cows by people reducing ability for cows to get in-calf which reduces production efficiency • Risk of bulls with human safety
Winter	June to August	• Whole Station	• Weather conditions • Snow risk • Stock constrained to lower country can be disturbed by people

18.4 Appendix 4: Maps and photographs of recommended actions

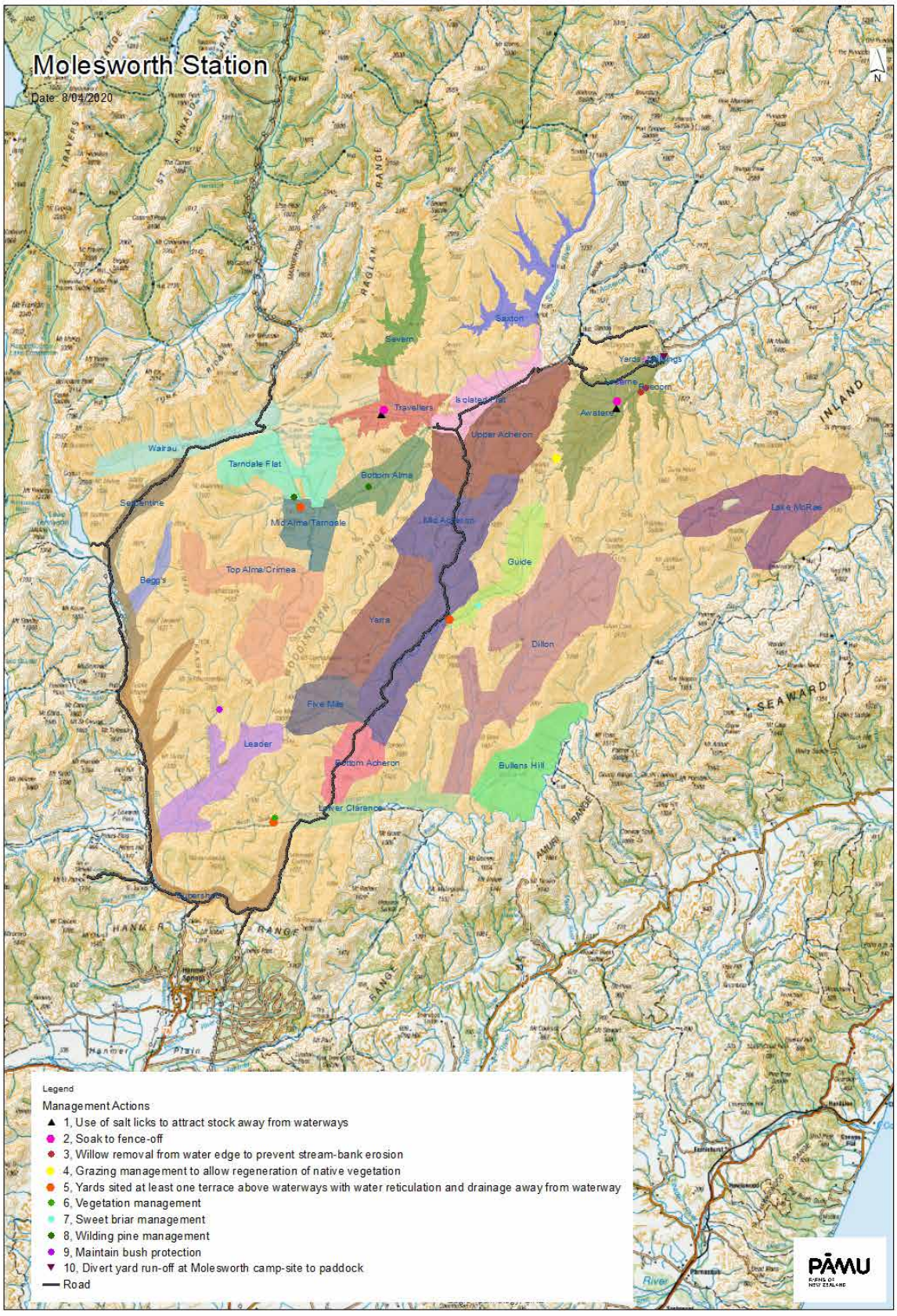


Figure 15 Locations for new management actions
Note: some actions relate to multiple sites, not all sites are shown on the map (e.g. soaks).

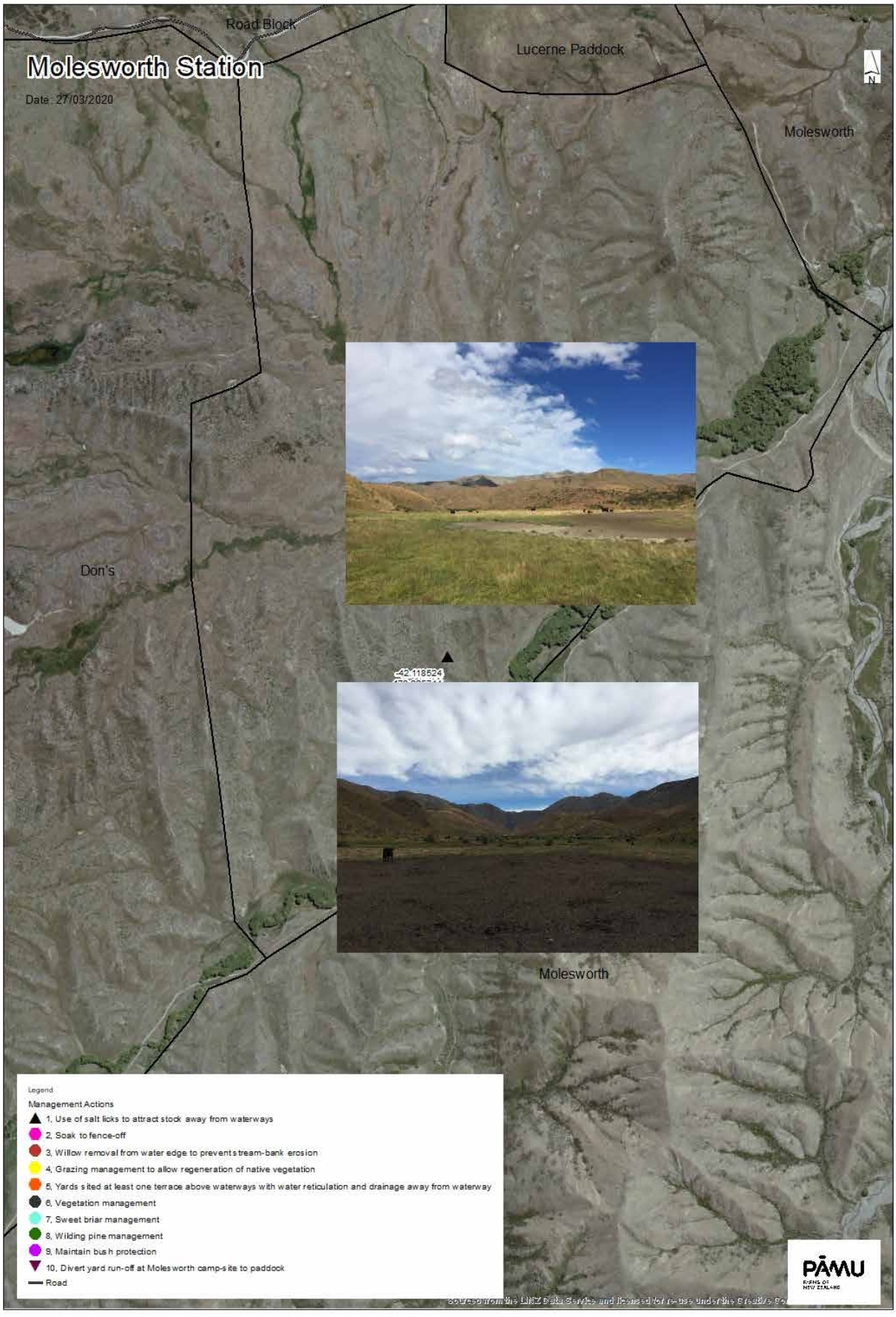


Figure 16 Example of use of salt licks to attract stock away from waterways on Molesworth Station.

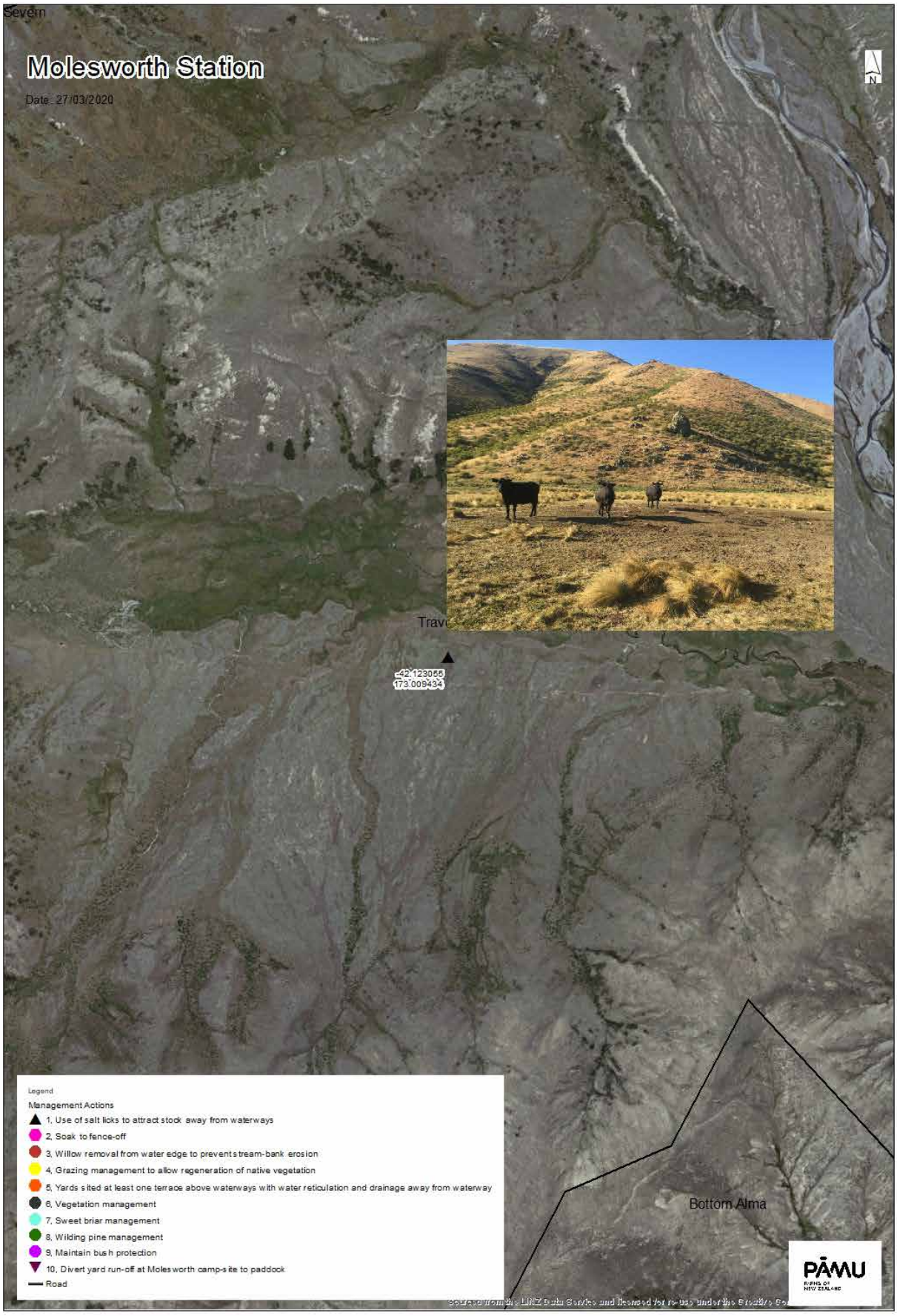


Figure 17 Example 2 of salt licks to attract stock away from waterways on Molesworth Station.

Figure 18 Example of soak/seep to fence-off and protect from cattle grazing on Molesworth Station.

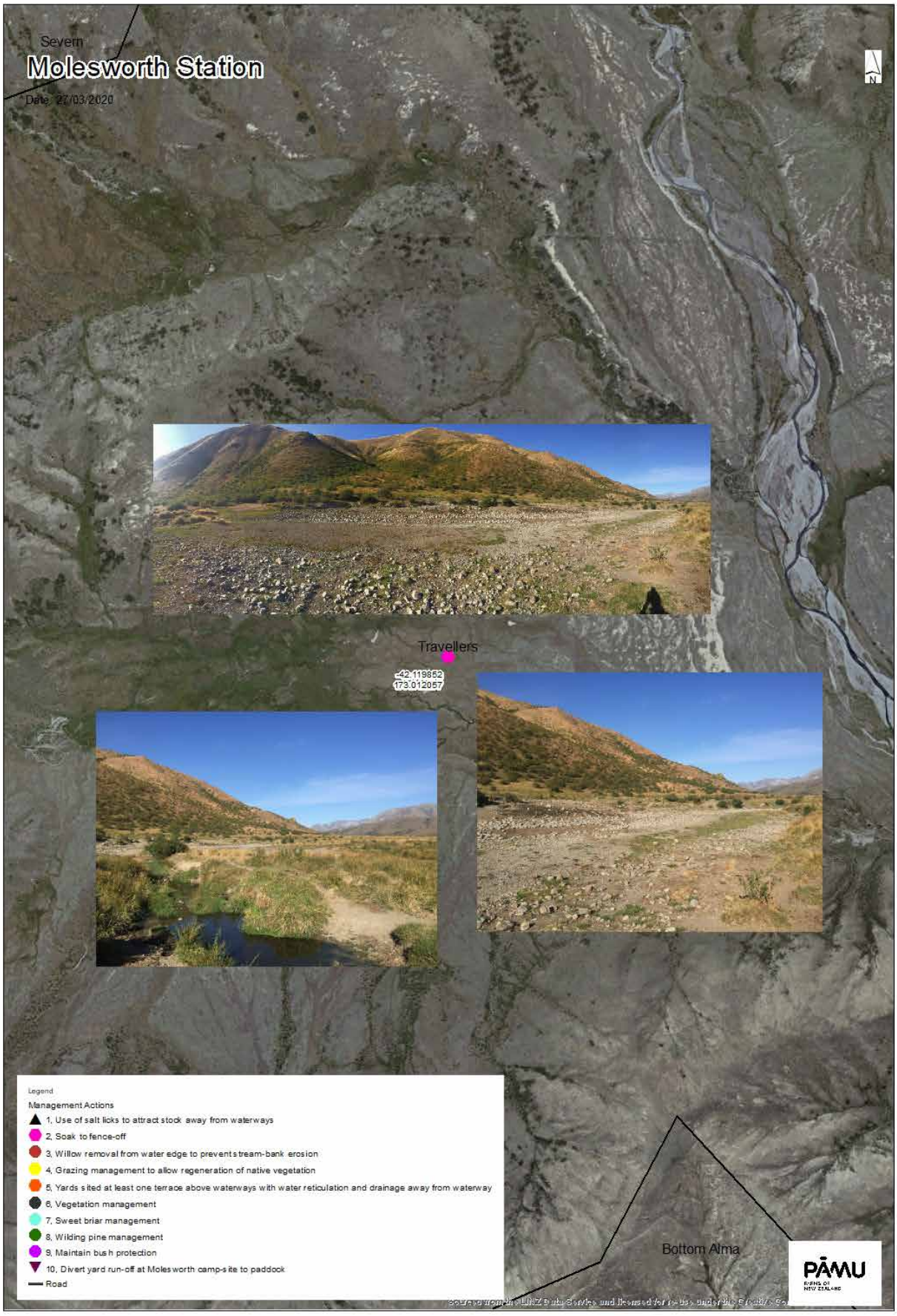


Figure 19 Example 2 of soak/seep to fence off and exclude cattle on Molesworth Station.

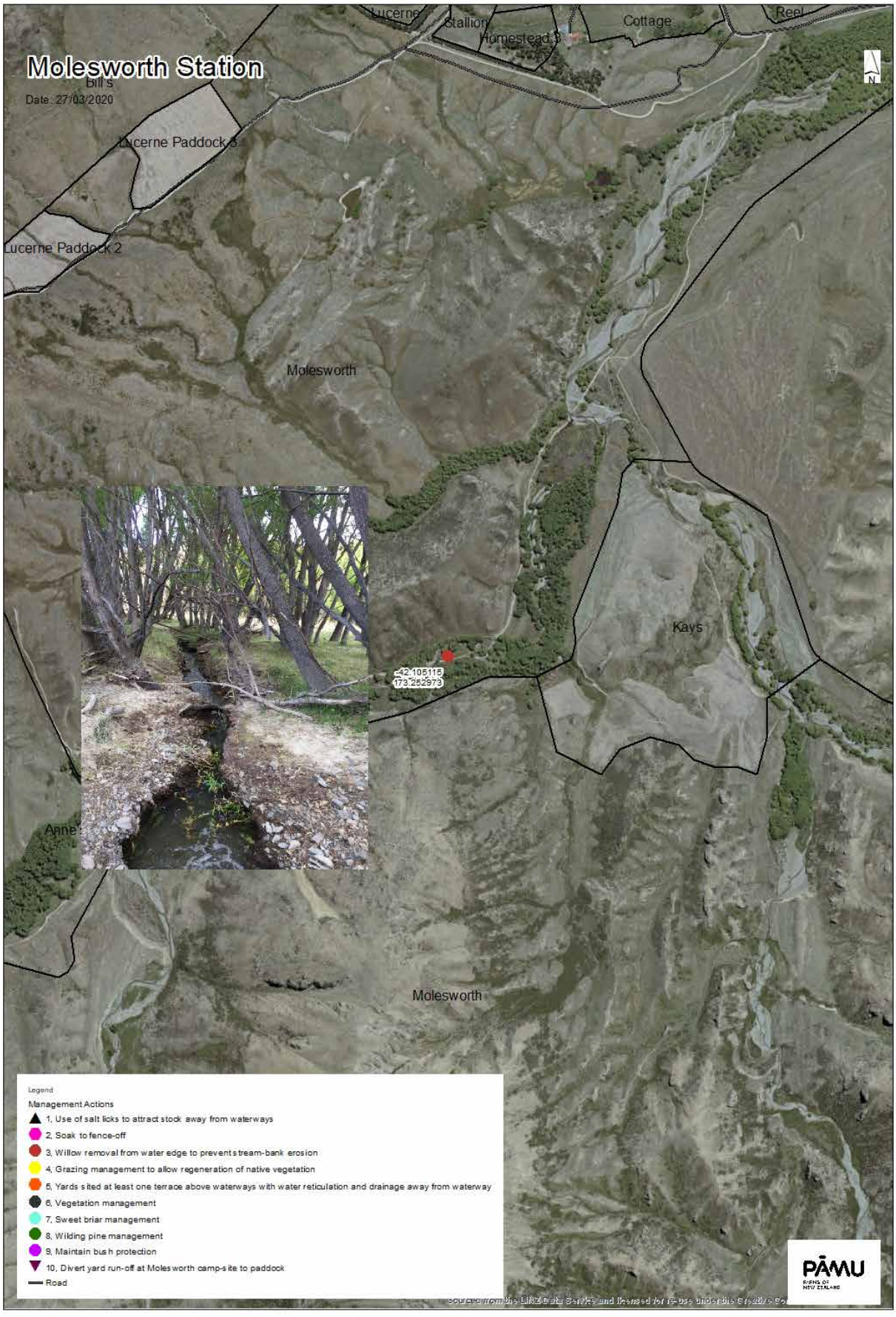


Figure 20 Example of streambank erosion caused by willows that would benefit from removal on Molesworth Station.

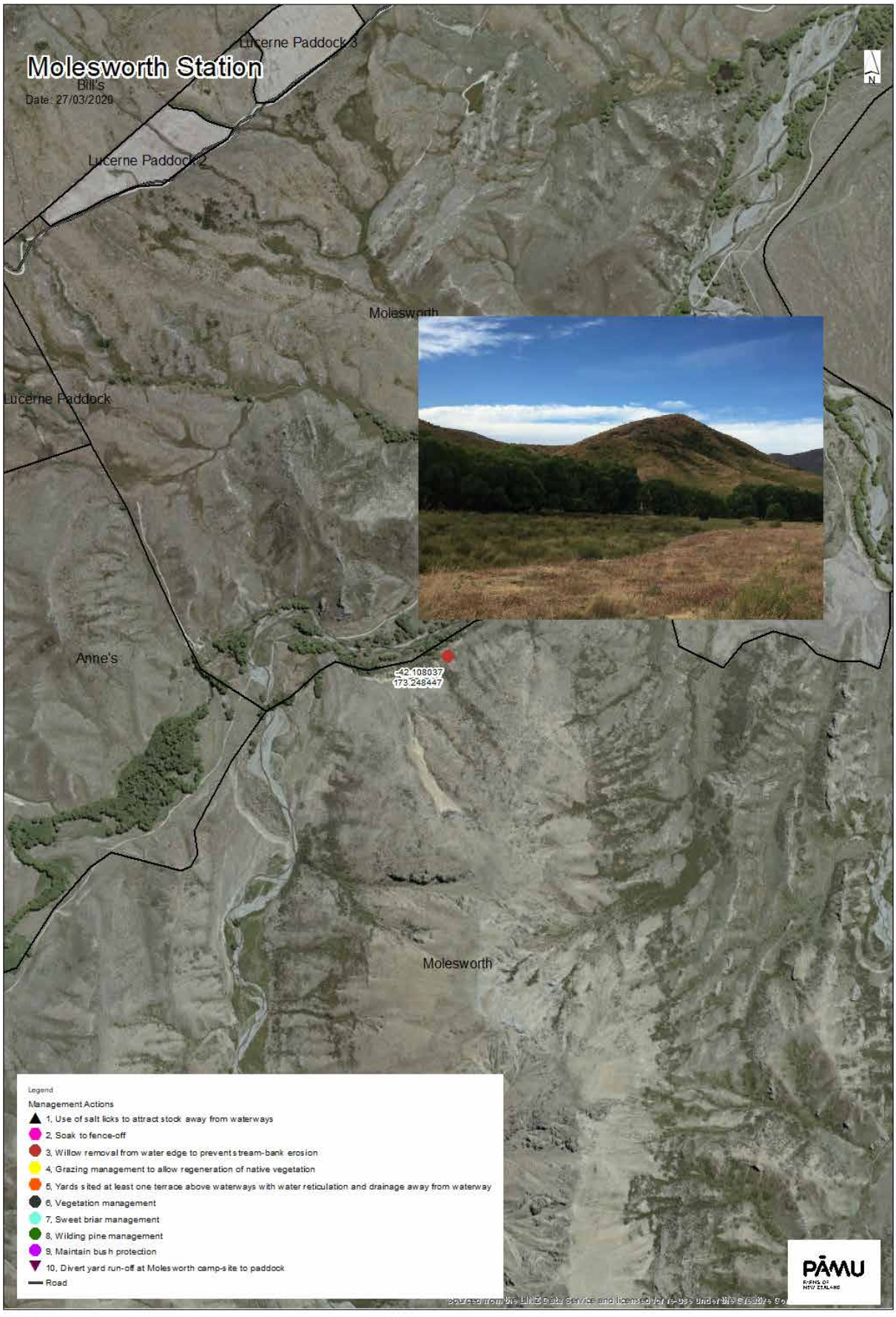


Figure 21 Willows that would benefit from removal to prevent streambank erosion on Molesworth Station.

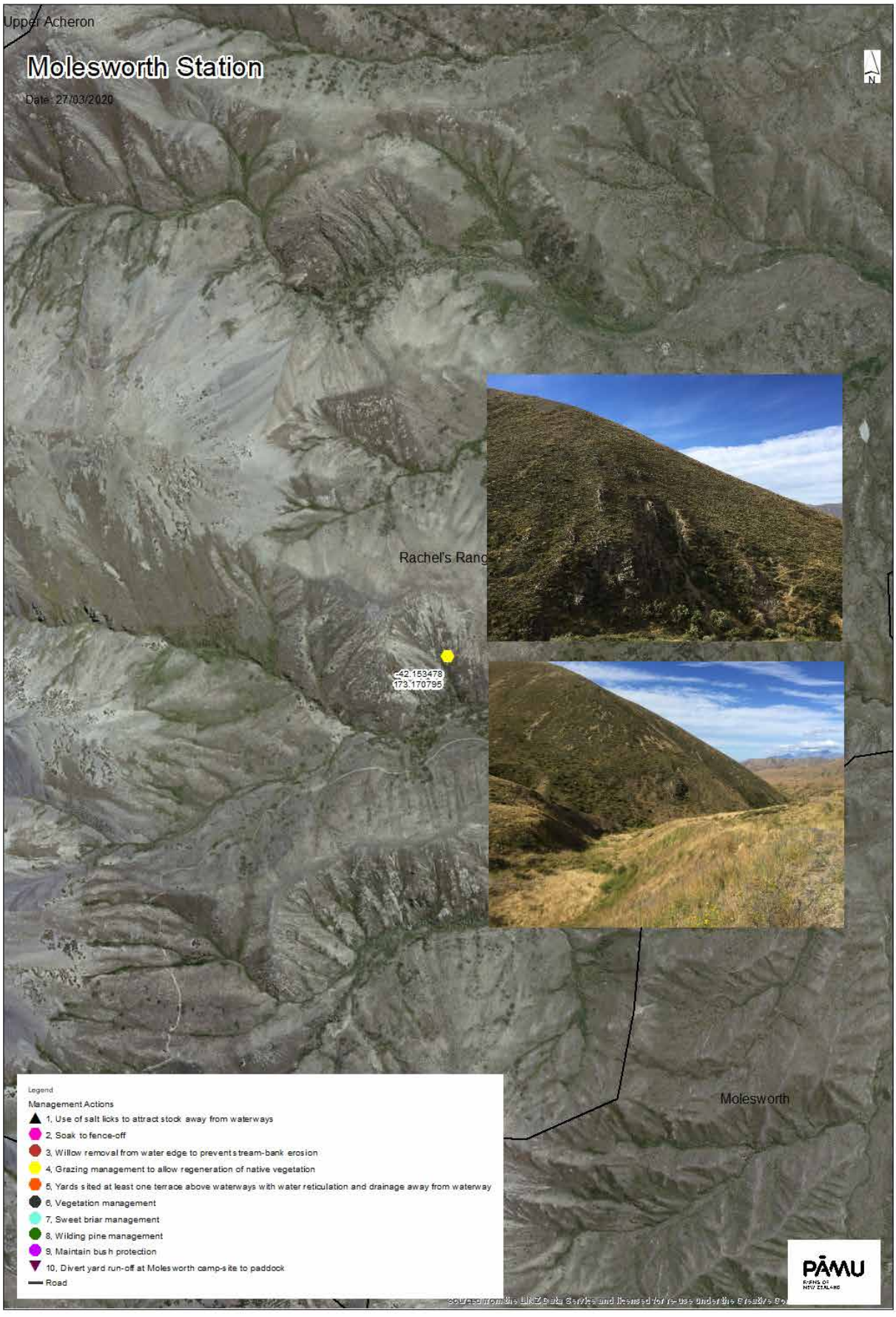


Figure 22 Example of vegetation recovery by ensuring cattle are attracted to alternative areas on Molesworth Station.

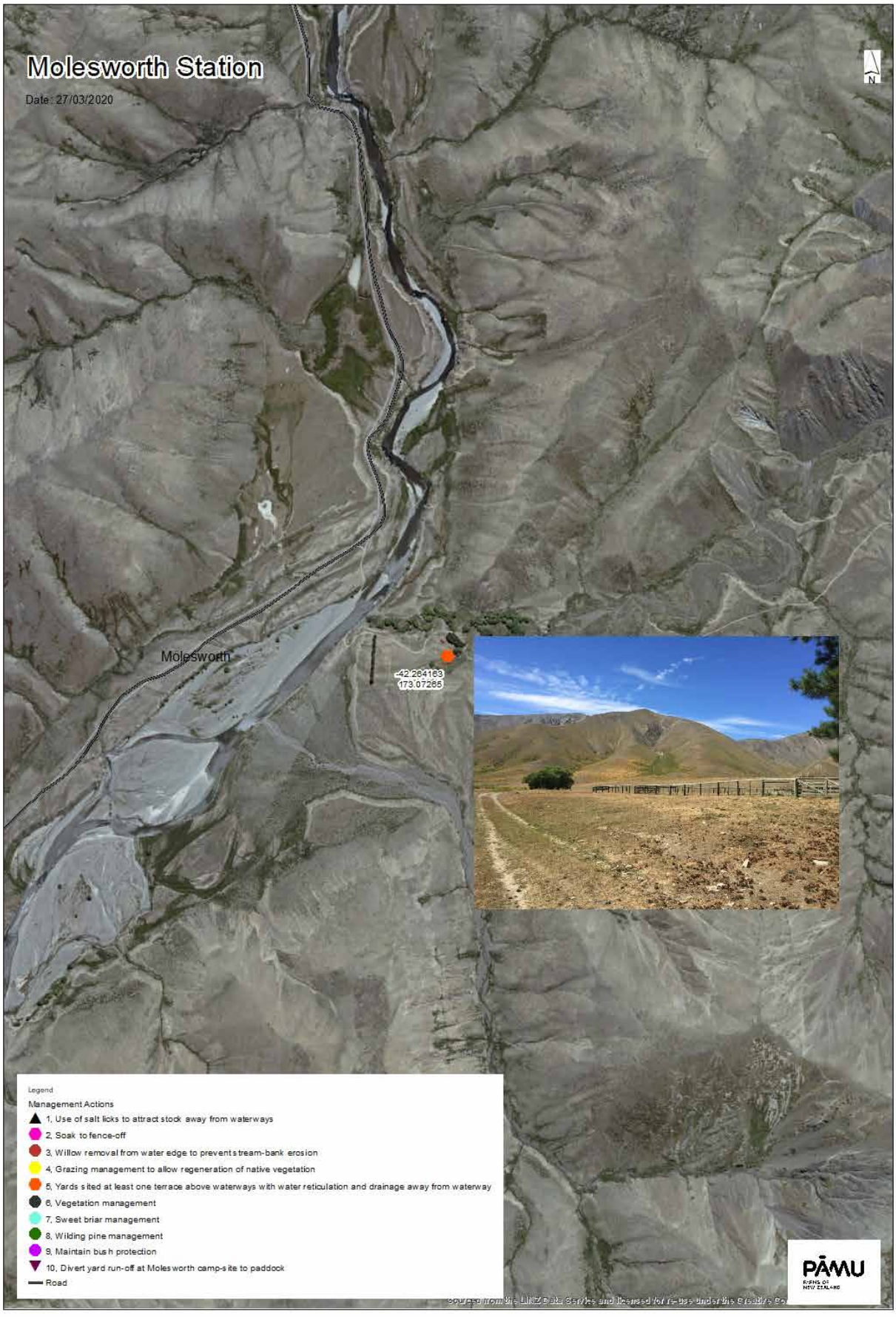


Figure 23 Example of yard siting away waterways on Molesworth Station.

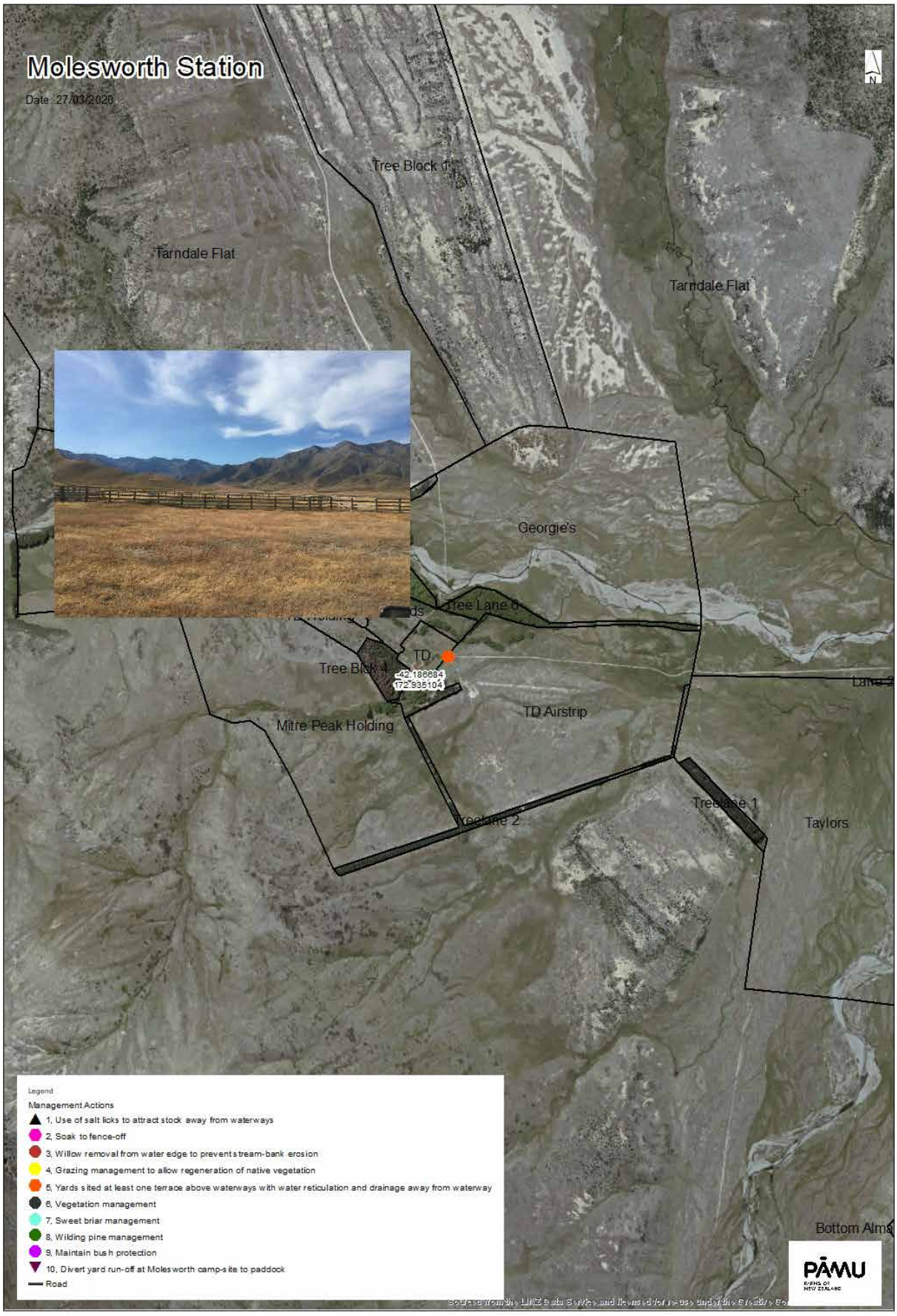


Figure 24 Example 2 of yard siting away from waterways on Molesworth Station.

Figure 25 Recovery of woody vegetation (Totara), stock access is limited to cattle moving through during mustering on Molesworth Station.

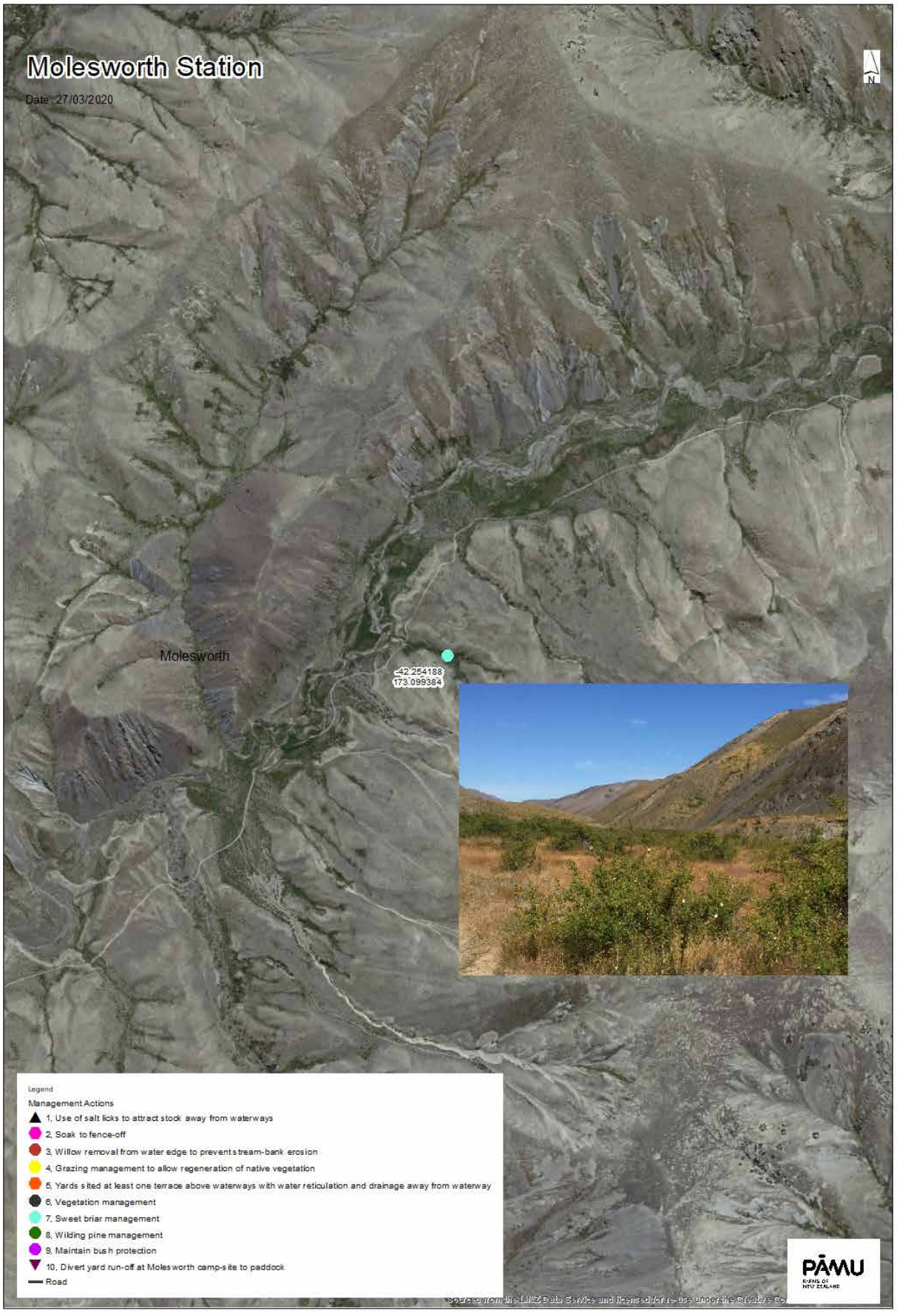


Figure 26 Sweet briar encroaching on pasture which needs to be removed on Molesworth Station.

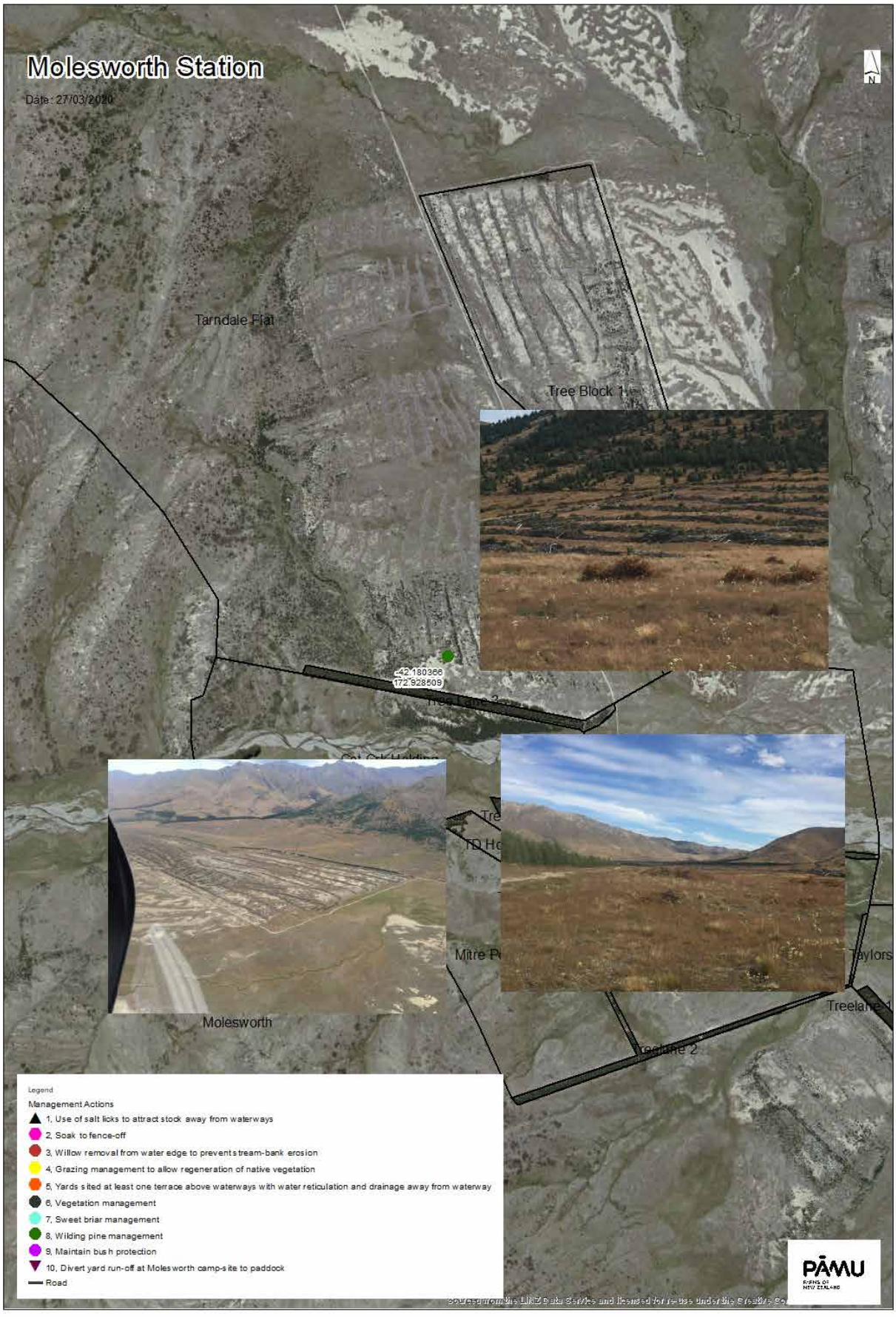


Figure 27 Wilding pine management - example of root raking at Tarndale on Molesworth Station.

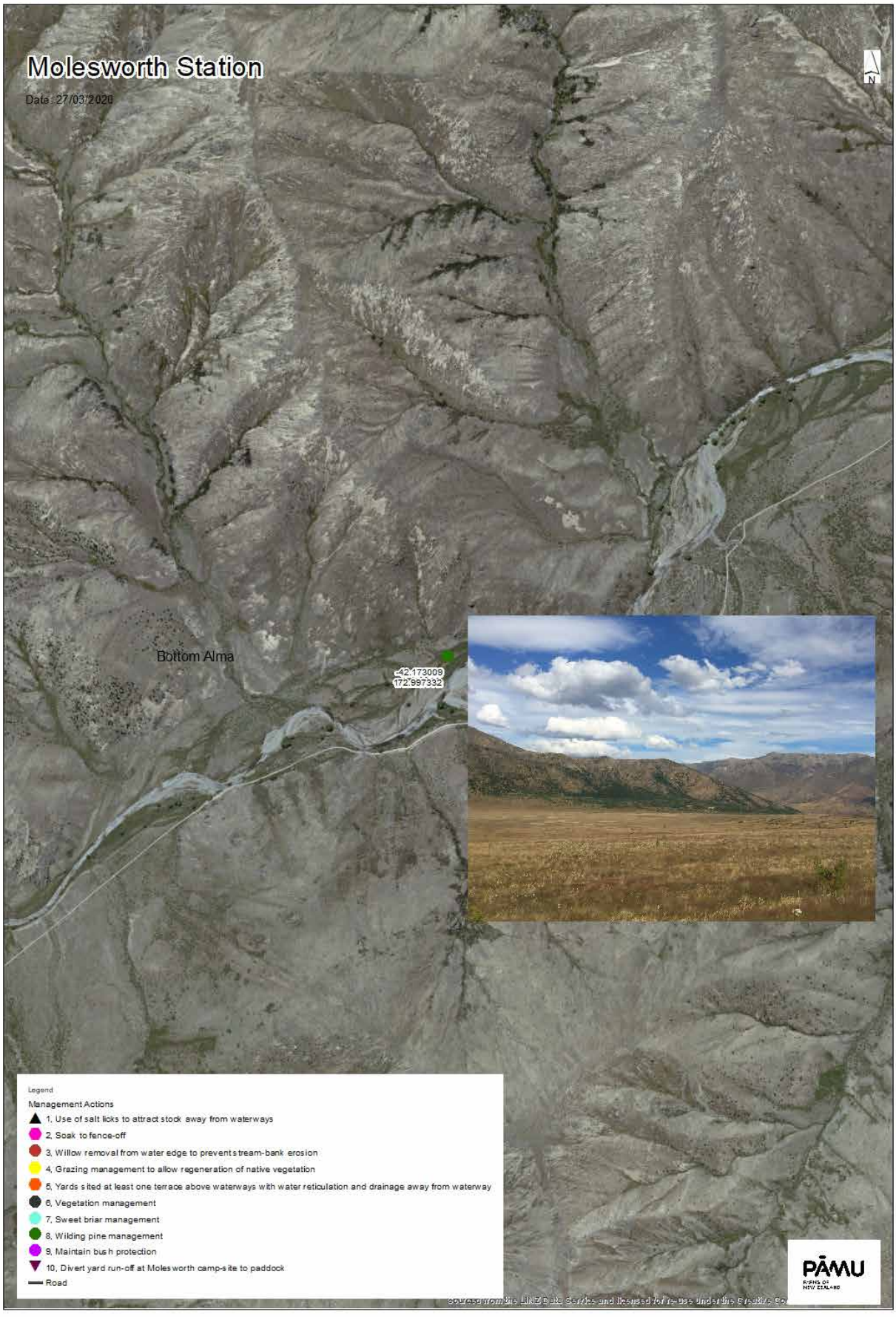


Figure 28 Wilding pines which require removal from Molesworth Station.

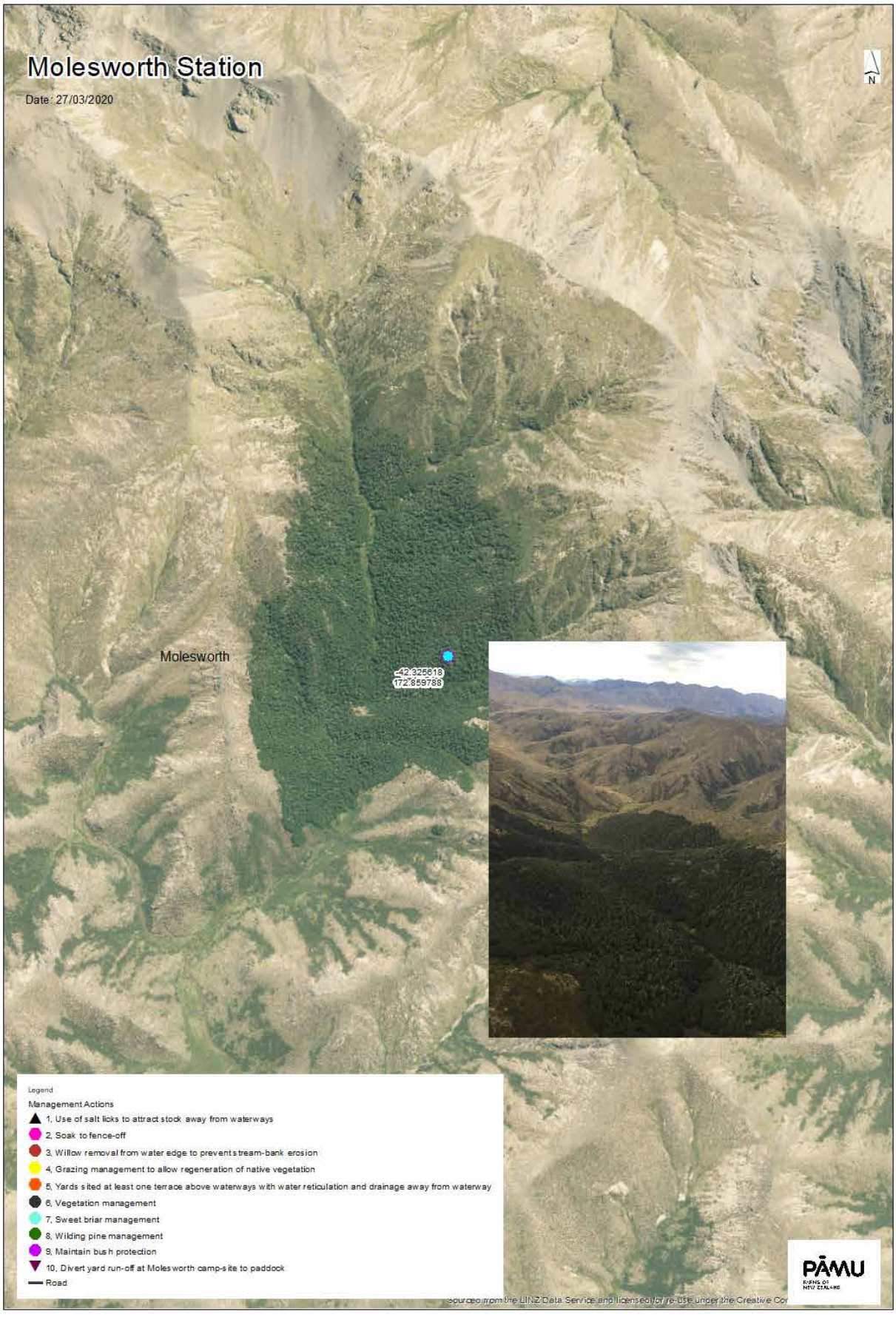


Figure 29 Example of Area of High Natural Value (AHNV) protected from cattle grazing.

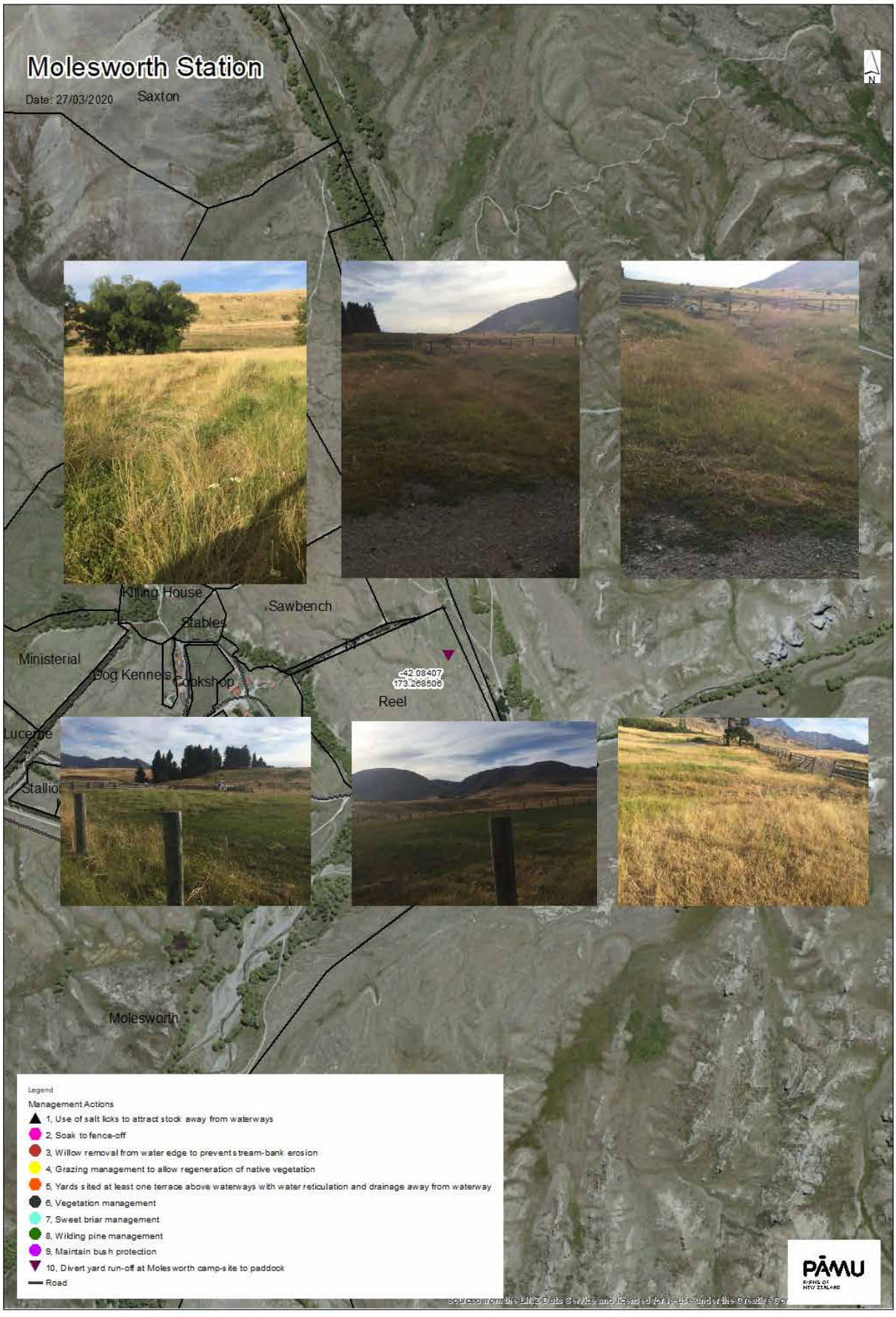


Figure 30 Drain to divert from yards at Molesworth Stream.

18.5 Appendix 5: Species known to occur on Molesworth Station

Source: Molesworth Management Plan 2013 (Department of Conservation, 2013)

Key
* = introduced species
# = no actual records from Molesworth but within the natural range of the species so likely to occur
aff. = has affinities to
agg. = an aggregate of species
sp. = species
ss. = in the strict sense
subsp. = subspecies
var. = variety
‘ ’ = tag name
× = hybrid between two species
↔ = an intergrade between species

18.5.1 *Plant species*

18.5.1.1 *Conifers*

Halocarpus bidwillii (bog pine)
Halocarpus biformis (pink pine)
Larix decidua (larch)*
Larix kaempferi (Japanese larch)*
Phyllocladus alpinus (toatoa, mountain toatoa, celery pine)
Pinus contorta (lodgepole pine)*
Pinus nigra (Corsican pine)*
Pinus ponderosa (Ponderosa pine)*
Pinus radiata (radiata pine)*
Pinus silvestris (Scots pine)*
Podocarpus cunninghamii (tōtara kōtukutuku, thin-barked tōtara)
Podocarpus cunninghamii × *P. nivalis*
Podocarpus nivalis (snow tōtara)

18.5.1.2 *Trees and shrubs*

Acrothamnus colensoi
Androstoma empetrifolia
Aristotelia fruticosa (mountain wineberry)
Brachyglottis bidwillii var. *viridis*
Brachyglottis cassinioides
Brachyglottis greyi var. ‘laxifolia’
Brachyglottis monroi
Carmichaelia australis var. *ovata* (tarangahape, native broom)
Carmichaelia corrugata
Carmichaelia juncea
Carmichaelia kirkii (climbing broom)
Carmichaelia monroi (mat broom)

Carmichaelia nana
Coprosma acerosa var. *brunnea* (tarakupenga)
Coprosma atropurpurea
Coprosma cheesemanii
Coprosma depressa
Coprosma dumosa
Coprosma fowerakeri
Coprosma intertexta
Coprosma linariifolia (yellowwood)
Coprosma microcarpa
Coprosma niphophila
Coprosma perpusilla subsp. *perpusilla*
Coprosma petriei
Coprosma propinqua (mingimingi)
Coprosma pseudociliata
Coprosma pseudocuneata
Coprosma rhamnoides
Coprosma rigida
Coprosma serrulata
Coriaria angustissima (tutu heuheu)
Coriaria arborea (tutu)
Coriaria plumosa (tutu heuheu, feathery tutu)
Coriaria plumosa × *C. sarmentosa*
Coriaria sarmentosa (shrub tutu)
Corokia cotoneaster (korokio)
Cytisus scoparius (broom)*
Discaria toumatou (tūmatakuru, matagouri)
Dracophyllum filifolium (inaka)
Dracophyllum filifolium ×
D. rosmarinifolium
Dracophyllum pronum (prostrate inaka)
Dracophyllum pronum × *D. rosmarinifolium*
Dracophyllum rosmarinifolium (mountain inaka)
Exocarpos bidwillii (mountain sandalwood)
Gaultheria antipoda (tāwiniwini)
Gaultheria crassa
Gaultheria crassa ×
G. macrostigma
Gaultheria crassa × *G. depressa* var. *novaezelandiae*
Gaultheria depressa var. *depressa* (koropuka, snowberry)
Gaultheria macrostigma
Gaultheria macrostigma × *G. depressa* var. *novae-zelandiae*
Gaultheria depressa var. *novae-zelandiae* (koropuka, snowberry)
Gaultheria nubicola
Griselinia littoralis (kāpuka, broadleaf)
Hebe anomala
Hebe canterburiensis
Hebe crenulata
Hebe cryptomorpha
Hebe decumbens
Hebe epacridea
Hebe glaucophylla
Hebe hectorii subsp. *coarctata* (a whipcord)
Hebe lycopodioides
Hebe macrantha var. *brachyphylla*
Hebe macrocalyx var. *humilis*

Hebe odora
Hebe pauciramosa
Hebe pimeleoides subsp. *pimeleoides*
Hebe pinguifolia
Hebe rakaiensis
Hebe ramosissima
Hebe rupicola
Hebe salicifolia (koromiko)
Hebe salicornioides
Hebe stenophylla var. *stenophylla*
Hebe subalpina
Hebe traversii
Hebe venustula
Hebe vernicosa
Helichrysum lanceolatum (niniao)
Helichrysum coralloides (coral daisy)
Helichrysum coralloides × *H. intermedium*
Helichrysum coralloides × *H. parvifolium*
Helichrysum depressum (sticks)
Helichrysum depressum × *H. parvifolium*
Helichrysum intermedium
Helichrysum parvifolium
Heliohebe acuta
Heliohebe pentasepala
Heliohebe raoulii subsp. *raoulii*
Hoheria lyallii (houhi, mountain ribbonwood)
Kunzea ericoides (kānuka)
Leonohebe cheesemanii
Leonohebe ciliolata
Leonobebe cupressoides
Leonohebe tumida
Leptecophylla juniperina (prickly mingimingi)
Leptospermum scoparium (mānuka, kahikātoa)
Leucopogon fraseri (pātōtara)
Leucopogon nanum
Melicytus aff. *alpinus* (fine, narrow lvs)
Melicytus aff. *crassifolius* var. 'erect'
Melicytus alpinus ss. (porcupine shrub)
Myrsine divaricata (weeping māpou)
Myrsine nummularia (creeping māpou)
Nothofagus menziesii (tawhai, silver beech)
Nothofagus solandri var. *cliffortioides* (wawhairauriki, mountain beech)
Olearia arborescens
Olearia avicenniifolia (akeake)
Olearia cymbifolia
Olearia cymbifolia × *O. paniculata*
Olearia nummulariifolia
Olearia odorata
Olearia paniculata (akiraho)
Ozothamnus 'albida'
Ozothamnus leptophyllus (tauhinu)
Ozothamnus leptophyllus × *O. vauvilliersii*
Ozothamnus vauvilliersii (mountain tauhinu)
Pachystegia 'B' (a Marlborough rock daisy)
Pentachondra pumila
Peraxilla tetrapetala (pikirangi, red mountain mistletoe)

Pimelea concinna
Pimelea oreophila subsp. *hetera*
Pimelea sericeovillosa
Pimelea traversii subsp. *traversii*
Pittosporum anomalum
Pittosporum divaricatum
Pittosporum patulum
Pittosporum tenuifolium (rautāwhiri, kōhūhū)
Pseudopanax 'ternatus' (orihou, mountain three finger)
Ribes uva-crispa (gooseberry) *
Rosa rubiginosa (briar, mihinare)*
Salix fragilis (crack willow)*
Sambucus nigra (elder)*
Sophora prostrata (prostrate kōwhai)
Sorbus aucuparia (rowan)*
Traversia baccharoides
Tupeia antarctica (pirita, a mistletoe)
Ulex europaeus (gorse)*
Ulmus thomasii (cork elm)
Lianes and trailing plants
Clematis afoliata (leafless clematis)
Clematis forsteri (pataua)
Clematis marata
Clematis paniculata (puawānanga, bush clematis)
Clematis petrei
Clematis quadribracteolata
Convolvulus fractosaxosa
Muehlenbeckia axillaris (creeping pōhuehue)
Muehlenbeckia axillaris × *M. ephedroides*
Muehlenbeckia complexa agg. (pōhuehue)
Muehlenbeckia ephedroides
Parsonsia capsularis (aka kiore, native jasmine)
Rubus schmidelioides var. *subpauperatus* (bush lawyer, tataramoa)
Clubmosses and quillworts
Huperzia australiana (fir clubmoss)
Huperzia varia (iwituna, hanging clubmoss)
Isoetes kirkii (quillwort)
Lycopodium fastigiatum (mountain clubmoss)
Lycopodium scariosum (creeping clubmoss)

18.5.1.3 *Ferns*

Asplenium flabellifolium agg. (necklace fern)
Asplenium flaccidum (makawe, hanging spleenword)
Asplenium richardii (matuakaponga)
Asplenium trichomanes agg. (maidenhair spleenwort)
Azolla filiculoides
Blechnum chambersii (rereti)
Blechnum minus (swamp kiokio)
Blechnum montanum (mountain kiokio)
Blechnum penna-marina (little hard fern)
Botrychium australe (pānako, parsley fern)
Cheilanthes sieberi (rock fern)
Cystopteris tasmanica (bladder fern)
Dryopteris filix-mas (male fern)*
Grammitis billardierei

Grammitis patagonica
Grammitis poeppigiana
Histiopteris incisa (water fern)
Hymenophyllum multifidum (a filmy fern)
Hymenophyllum villosum (a filmy fern)
Hypolepis millefolium (thousand-leaved fern)
Ophioglossum coriaceum agg. (adder's tongue)
Pellaea calidirupium (hot rock fern)
Pilularia novae-hollandiae (pillwort)
Polystichum cystostegia (mountain shield fern)
Polystichum vestitum (pūniu, prickly shield fern)
Pteridium esculentum (rārahu, bracken)

18.5.1.4 *Orchids*

Aporostylis bifolia
Caladenia lyallii
Gastrodia cunninghamii (hūperei, potato orchid)
Hymenochilus tanypodus
Hymenochilus tristis (a greenhood orchid)
Microtis unifolia (onion orchid)
Nematoceras rivulare (a spider orchid)
Nematoceras trilobum (a spider orchid)
Prasophyllum colensoi
Pterostylis australis (a greenhood orchid)
Thelymitra formosa (a sun orchid)
Thelymitra longifolia (maikuku, a sun orchid)

18.5.1.5 *Grasses*

Agrostis aff. *dyeri* (spreading panicle)
Agrostis capillaris (browntop)*
Agrostis muelleriana
Agrostis muscosa
Agrostis pallescens
Agrostis stolonifera (creeping bent)*
Aira caryophyllea (silvery hairgrass)*
Alopecurus geniculatus (kneed foxtail)*
Anthosachne aff. *solandri* 'channel' (tūtaekurī,a wheatgrass)
Anthosachne solandri (tūtaekurī, blue wheatgrass)
Anthoxanthum odoratum (sweet vernal)*
Arrhenatherum elatius (tall oat grass)*
Avena fatua (wild oat)*
Bromus diandrus (ripgut brome)*
Bromus hordeaceus (soft brome)*
*Bromus tectorum**
Chionochloa australis (wīkura, carpet grass)
Chionochloa australis × *C. macra*
Chionochloa australis × *C. pallens*
Chionochloa flavescens subsp. *brevis* (haumata,broadleaved snow tussock)
Chionochloa flavescens × *C. macra*
Chionochloa flavescens × *C. rubra*
Chionochloa macra (slim snow tussock)
Chionochloa macra × *C. pallens*
Chionochloa oreophila (snow bank grass)

Chionochloa pallens subsp. *pilosa* (midribbed snow tussock)
Chionochloa rubra subsp. *rubra* (red tussock)
Connorochloa tenuis
Cynosurus cristatus (crested dogstail)*
Dactylis glomerata (cocksfoot)*
Deschampsia novae-zelandiae
Deyeuxia aucklandica
Deyeuxia avenoides
Deyeuxia lacustris
Dichelachne crinita (pātītī, plume grass)
Festuca aff. *rubra*
Festuca matthewsii (alpine fescue)
Festuca novae-zelandiae (hard tussock)
Festuca rubra (Chewings fescue)*
Glyceria declinata (floating sweet grass)*
Hierochloe equiseta
Hierochloe novae-zelandiae
Hierochloe redolens
Holcus lanatus (Yorkshire fog)*
Koeleria cheesemanii
Koeleria novozelandica (broad lf, tufted)
Koeleria riguorum (slender lf, creeping)
Lachnagrostis lyallii
Lachnagrostis sp.
Lachnagrostis striata
Lolium perenne (perennial ryegrass)*
Microlaena avenacea (bush rice grass)
Phleum pratense (timothy)*
*Poa annua**
Poa breviglumis
Poa buchananii
Poa cita (wī, silver tussock)
Poa cockayneana (avalanche grass)
Poa colensoi (blue tussock)
Poa dipsacea
Poa imbecilla
Poa kirkii
Poa lindsayi
Poa novae-zelandiae
*Poa palustris**
*Poa pratensis**
Poa subvestita (meadow grass)
*Poa trivialis**
Rytidosperma australe
Rytidosperma buchananii agg.
Rytidosperma clavatum
Rytidosperma gracile (danthonia)
Rytidosperma merum
Rytidosperma nigricans
Rytidosperma pumilum
Rytidosperma setifolium (bristle tussock)
Rytidosperma thomsonii agg.
Schedonorus arundinacea (tall fescue)*
Stenostachys enysii (was *Elymus enysii*)
Stenostachys gracilis
Trisetum lepidum

Trisetum spicatum
Trisetum tenellum
Trisetum youngii
Vulpia bromoides (vulpia hairgrass)*

18.5.1.6 *Sedges*

Carex acicularis
Carex aff. *testacea* (red lvs, utricle not scabrid)
Carex berggrenii
Carex breviculmis
Carex buchananii
Carex carsei
Carex colensoi
Carex comans (maurea)
Carex coriacea (cutty grass, toetoe rautahi)
Carex diandra (makura)
*Carex divisa**
Carex echinata var. 'australis' (star sedge)
Carex enysii
Carex flagellifera (mānia)
Carex flaviformis (yellow sedge)
Carex gaudichaudiana
Carex kaloides
Carex muelleri
*Carex muricata**
Carex ovalis (oval sedge)*
Carex petriei
Carex pyrenaica var. *cephalotes*
Carex resectans
Carex secta (pūkio)
Carex sinclairii
Carex tenuiculmis
Carex wakatipu ss.
Carpha alpina (plume sedge)
Eleocharis acuta (spike rush)
Eleocharis gracilis
Eleocharis pusilla
Isolepis aucklandica
Isolepis basilaris
Isolepis caligenis
Isolepis habra agg.
Isolepis subtilissima
Oreobolus pectinatus (comb sedge)
Oreobolus strictus
Schoenus pauciflorus (red sedge)
Uncinia clavata (matau, a hookgrass)
Uncinia divaricata (matau, a hookgrass)
Uncinia fuscovaginata (matau, a hookgrass)
Uncinia nervosa (matau, a hookgrass))
Uncinia purpurata (matau, a hookgrass)
Uncinia rubra (matau, a hookgrass)

18.5.1.7 *Rushes and allied plants*

Centrolepis ciliata
Empodisma minus agg. (wire rush)
Juncus antarcticus
Juncus articulatus (jointed rush)*
Juncus bufonius (toad rush)*
Juncus bulbosus (bulbous rush)*
*Juncus conglomeratus**
Juncus edgariae
Juncus effusus (soft rush)*
Juncus novae-zelandiae (dwarf rush)
Juncus pusillus
Juncus squarrosus (heath rush)*
Juncus tenuis (track rush)*
Luzula celata
Luzula aff. *rufa* (rhizomatous)
Luzula 'albicomans'
Luzula colensoi
Luzula crinita
Luzula leptophylla
Luzula 'limosa'
Luzula migrata
Luzula picta (woodrush)
Luzula pumila
Luzula rufa
Luzula subclavata
Luzula traversii
Luzula 'Wairau'
Marsippospermum gracile (alpine rush)

18.5.1.8 *Other monocot herbs*

Astelia nervosa (kakaha)
Astelia petriei
Bulbinella hookeri (Māori onion)
Elodea canadensis (oxygen weed)*
Lemna minor agg. (duckweed)
Phormium cookianum (whaarikí, mountain flax)
Potamogeton cheesemanii (mānihi, red pondweed)
Potamogeton ochreatus
Potamogeton suboblongus
Triglochin palustris
Typha orientalis (raupō)

18.5.1.9 *Composite herbs*

Abrotanella caespitosa
Achillea millefolium (yarrow)*
Anaphalioides bellidioides (everlasting daisy)
Argyrotegium mackayi (a cudweed)
Argyrotegium nitidulum (a cudweed)
Brachyglottis bellidioides
Brachyglottis haastii
Brachyglottis lagopus

Brachyscome radicata (ronui)
Brachyscome sinclairii
Celmisia allanii (a mountain daisy)
Celmisia alpina (a mountain daisy)
Celmisia bellidioides (a mountain daisy)
Celmisia cockayneana (a mountain daisy)
Celmisia discolor
Celmisia du-rietzii
Celmisia gracilenta (pekapeka, a mountain daisy)
Celmisia haastii (a mountain daisy)
Celmisia incana (a mountain daisy)
Celmisia laricifolia (a mountain daisy)
Celmisia lateralis (a mountain daisy)
Celmisia monroi (tikumu, a mountain daisy)
Celmisia monroi × *C. spectabilis*
Celmisia monroi × *C. traversii*
Celmisia 'rhizomatous' (a mountain daisy)
Celmisia semicordata (tikitimu)
Celmisia sessiliflora (a mountain daisy)
Celmisia sessiliflora × *C. traversii*
Celmisia sinclairii (a mountain daisy)
Celmisia spectabilis (tikumu, cotton daisy)
Celmisia spectabilis × *C. traversii*
Celmisia traversii (a mountain daisy)
Celmisia viscosa (a mountain daisy)
Cirsium arvense (Californian thistle)*
Cirsium vulgare (Scotch thistle)*
Craspedia 'elongata' (puatea, a woollyhead)
Craspedia incana (white woollyhead)
Craspedia lanata (grey woollyhead)
Craspedia 'Leatham'
Craspedia 'long hairs' (puatea, a woollyhead)
Craspedia 'short hairs' (puatea, a woollyhead)
Craspedia 'tarn' (puatea, a woollyhead)
Craspedia uniflora
Craspedia 'white margin' (puatea, a woollyhead)
Craspedia × 'tarn margin' (puatea, a woollyhead)
Crepis capillaris (hawksbeard)*
Dolichoglottis lyallii (yellow snow marguerite)
Dolichoglottis scorzoneroides (white snow marguerite)
Euchiton audax (a cudweed)
Euchiton lateralis (a cudweed)
Euchiton limosus (a cudweed)
Euchiton polylepis (a cudweed)
Euchiton sphaericus (a cudweed)
Euchiton traversii (a cudweed)
Ewartiothamnus sinclairii
Haastia 'minor'
Haastia pulvinaris (giant vegetable sheep)
Haastia recurva var. *recurva*
Haasta recurva var. *wallii*
Haastia sinclairii
Helichrysum filicaule
*Hieracium aurantiacum**
Hieracium caespitosum (field hawkweed)*
*Hieracium lepidulum**

*Hieracium murorum**
Hieracium pilosella (hawkweed, mouse-ear hawkweed)*
*Hieracium pollichiae**
*Hieracium praealtum**
Hypochoeris radicata (catsear)*
Lagenifera barkeri
Lagenifera cuneata
Lagenifera strangulata
Leptinella dendyi
Leptinella dendyi × *L. pyrethrifolia*
Leptinella dioica subsp. *dioica*
Leptinella filiformis
Leptinella pectinata subsp. *pectinata*
Leptinella pusilla
Leptinella pyrethrifolia agg.
Leptinella serrulata
Leptinella squalida subsp. *mediana*
Leucanthemum vulgare (oxeye daisy)*
Leucogenes grandiceps (South Island edelweiss)
Leucogenes grandiceps × *Raoulia bryoides*
Leucogenes neglecta (Marlborough edelweiss)
Microseris scapigera
Mycelis muralis (wall lettuce)*
Pseudognaphalium ephemerum
Pseudognaphalium luteoalbum agg. (pukatea)
Rachelia glaria (scree daisy)
Raoulia apicinigra
Raoulia australis agg. (scabweed)
Raoulia bryoides (vegetable sheep)
Raoulia cinerea
Raoulia eximia (vegetable sheep)
Raoulia glabra (a mat daisy)
Raoulia grandiflora (a mat daisy)
Raoulia hookeri (a mat daisy)
Raoulia monroi
Raoulia parkii (a mat daisy)
Raoulia sp. 'M' (a mat daisy)
Raoulia subsericea (a mat daisy)
Raoulia subulata (a cushion daisy)
Raoulia tenuicaulis (tutahuna)
Senecio glaucophyllus subsp. toa
Senecio jacobaea (ragwort)*
Senecio quadridentatus (pāhohoraka)
Senecio wairauensis
Sonchus asper (pūhā, prickly sow thistle)*
Sonchus oleraceus (rauriki, sow thistle)*
Taraxacum magellanicum (tohetaka, native dandelion)
Taraxacum officinale (tawao, dandelion)*
Vittadinia australis agg. (fuzzweed)

18.5.1.10 *Dicot herbs other than composites*

Acaena anserinifolia (piripiri, bidibid)
Acaena anserinifolia × *A. inermis*
Acaena caesiiglauca (piripiri, bidibid)

Acaena dumicola (piripiri, bidibid)
Acaena fissistipula (piripiri, bidibid)
Acaena glabra (piripiri, bidibid)
Acaena inermis (piripiri, bidibid)
Acaena juvenca (piripiri, bidibid)
Acaena profundeincisa (piripiri, bidibid)
Acaena saccaticupula (piripiri, bidibid)
Aciphylla aurea (golden speargrass)
Aciphylla colensoi (a speargrass)
Aciphylla glaucescens (giant speargrass)
Aciphylla monroi (dwarf speargrass)
Aciphylla 'St. Patrick' (a speargrass)
Aciphylla subflabellata (a speargrass)
Anagallis arvensis (scarlet pimpernel)*
Anisotome aromatica agg. (kopoti)
Anisotome filifolia
Anisotome flexuosa var. *flexuosa*
Anisotome haastii var. *haastii*
Anisotome pilifera
Anisotome 'prostrata'
Aphanes arvensis (parsley piert)*
Arenaria serpyllifolia (sandwort)*
Callitriche petriei subsp. *petriei*
Callitriche stagnalis (starwort)*
Cardamine bilobata (panapana, a bittercress)
Cardamine corymbosa (panapana, a bittercress)
Cardamine 'narrow petal' (panapana, a bittercress)
Cardamine 'scree race' (panapana, a bittercress)
Cardamine 'tarn'
Centaurium erythraea (centaury)*
Cerastium fontanum subsp. *vulgare* (mouse-ear chickweed)*
Cerastium glomeratum (annual mouse-ear chickweed)*
Chaerophyllum colensoi agg.
Chaerophyllum colensoi var. *delicatulum*
Chaerophyllum ramosum
Chaerophyllum novae-zelandiae agg.
Chenopodium detestans
*Chenopodium pumilio**
Chenopodium pusillum
Chionohebe pulvinaris
Colobanthus acicularis
Colobanthus apetalus
Colobanthus brevisepalus
Colobanthus buchananii
Colobanthus strictus
Conium maculatum (hemlock)*
Coronilla varia (crown vetch)*
Crassula multicaulis
Crassula sieberiana
Crassula sinclairii
Daucus glochidiatus (pīnaki, native carrot)
Dianthus armeria (Deptford pink)*
Dichondra repens agg. (Mercury Bay weed)
Digitalis purpurea (foxglove)*
Drosera arcturi (wahu, sundew)

Echium vulgare (viper's bugloss (false blue borage))*
Einadia allanii (poipapa)
Elatine gratioloides
Epilobium alsinoides (a willowherb)
Epilobium angustum (a willowherb)
Epilobium atriplicifolium (a willowherb)
Epilobium brevipes (a willowherb)
Epilobium brunnescens (a willowherb)
Epilobium chionanthum (a willowherb)
Epilobium chlorifolium (a willowherb)
Epilobium ciliatum (a willowherb)*
Epilobium cinereum (a willowherb)
Epilobium cockayneanum (a willowherb)
Epilobium crassum (a willowherb)
Epilobium elegans (a willowherb)
Epilobium forbesii (a willowherb)
Epilobium glabellum (a willowherb)
Epilobium hectorii (a willowherb)
Epilobium hirtigerum (a willowherb)
Epilobium insulare (a willowherb)
Epilobium komarovianum (a willowherb)
Epilobium krulleanum (a willowherb)
Epilobium macropus (a willowherb)
Epilobium melanocaulon (a willowherb)
Epilobium microphyllum (papakōura,a willowherb)
Epilobium 'minutiflorum' (a willowherb)
Epilobium nerteroides (a willowherb)
Epilobium nummulariifolium (a willowherb)
Epilobium obscurum (a willowherb)*
Epilobium pernitens (a willowherb)
Epilobium petraeum (a willowherb)
Epilobium pictum (a willowherb)
Epilobium porphyrium (a willowherb)
Epilobium pubens (a willowherb)
Epilobium pycnostachyum (scree willowherb)
Epilobium rostratum (a willowherb)
Epilobium tasmanicum (a willowherb)
Epilobium tenuipes (a willowherb)
Erodium cicutarium (cranesbill)*
Erophila verna (whitlow grass)*
Euphrasia laingii (an eyebright)
Euphrasia monroi (an eyebright)
Euphrasia revoluta (an eyebright)
Euphrasia townsonii (an eyebright)
Euphrasia zelandica (an eyebright)
Forstera purpurata
Forstera tenella
Galium aparine (cleavers)*
Galium perpusillum
Galium propinquum (māwe)
Galium 'lacustrine'
Gentianella bellidifolia
Gentianella corymbifera
Gentianella grisebachii
Gentianella montana
Gentianella patula

Gentianella magnifica
Geranium brevicaule
Geranium microphyllum 'mainland'
Geranium molle (dove's foot, crane's bill)*
Geum cockaynei (alpine avens)
Gingidia decipiens
Gingidia montana (naupiro, mountain aniseed)
Gingidia trifoliolata
Glossostigma diandrum
Glossostigma elatinoides
Gonocarpus aggregatus
Gonocarpus micranthus (piripiri)
Gonocarpus montanus
Gunnera densiflora
Gunnera monoica
Haloragis erecta (toatoa)
Hydrocotyle heteromeria (a pennywort)
Hydrocotyle microphylla (a pennywort)
Hydrocotyle 'montana' (a pennywort)
Hydrocotyle moschata (a pennywort)
Hydrocotyle aff. *sulcata* (a pennywort)
Hypericum perforatum (St. John's wort)*
Hypericum pusillum
Kelleria croizatii
Kelleria dieffenbachii
Kelleria laxa
Kelleria villosa
Leptostigma setulosum
Lignocarpa carnosula
Lignocarpa diversifolia
Lilaeopsis ruthiana
Limosella lineata agg.
Linum catharticum (purging flax)*
Linum monogynum (rauhuia)
Lobelia angulata agg.
Lobelia ionantha
Lobelia macrodon
Lobelia roughii (scree lobelia)
Lotus pedunculatus (lotus)*
Mazus radicans
Medicago sativa (lucerne)*
Mentha cunninghamii (hīoi, native mint)
Mimulus guttatus (monkey musk)*
Mimulus moschatus (musk)*
Montia calycina
Montia fontana subsp. *fontana* (blinks)
Montigena novae-zelandiae (scree pea)
Myosotis arvensis (field forget-me-not)*
Myosotis australis 'white' (a forget-me-not)
Myosotis australis 'yellow (a forget-me-not)
Myosotis brevis (a forget-me-not)
Myosotis discolor (grassland forget-me-not)*
Myosotis drucei (a forget-me-not)
Myosotis laingii (a forget-me-not)
Myosotis laxa subsp. *caespitosa* (water forgetme-not)*
*Myosotis scorpioides**

Myosotis traversii (scree forget-me-not)
Myosurus minimus subsp. *novae-zelandiae*
Myriophyllum pedunculatum subsp. *novaezelandiae*
Myriophyllum propinquum (a milfoil)
Myriophyllum triphyllum (a milfoil)
Myriophyllum votschii (a milfoil)
Navarretia squarrosa (Californian stinkweed)*
Nertera balfouriana
Nertera depressa
Notothlaspi rosulatum (penwiper)
Orobanche minor (broomrape)*
Ourisia caespitosa var. *caespitosa*
Ourisia glandulosa
Ourisia macrophylla subsp. *lactea*
Ourisia sessilifolia subsp. *sessilifolia*
Ourisia sessilifolia × *O. simpsonii*
Ourisia simpsonii
Oxalis exilis
Oxalis magellanica (Tūtaekāhu)
Oxalis 'scree' (scree oxalis)
Pachycladon cheesemanii
Pachycladon enysii
Pachycladon fastigiatum
Pachycladon stellatum
Parahebe cheesemanii
Parahebe decora
Parahebe decora × *P. lyallii*
Parahebe linifolia
Parahebe lyallii
Phyllachne clavigera
*Plantago australis**
Plantago lanceolata (narrow-leaved plantain)*
Plantago lanigera
Plantago novae-zelandiae
Plantago obconica
Plantago raoulii (kopakopa)
Plantago triandra
Plantago unibracteata
*Polygonum aviculare**
Potentilla anserinoides (kōwhai kura,silverweed)
Prunella vulgaris (selfheal)*
Psychrophila novae-zelandiae
Psychrophila obtusa
Ranunculus brevis (a buttercup)
Ranunculus cheesemanii (a buttercup)
Ranunculus crithmifolius (scree buttercup)
Ranunculus foliosus (a buttercup)
Ranunculus foliosus × *R. glabrifolius*
Ranunculus glabrifolius (a buttercup)
Ranunculus gracilipes (a buttercup)
Ranunculus gracilipes × *R. insignis*
Ranunculus haastii (scree buttercup)
Ranunculus insignis (korikori)
Ranunculus insignis × *R. verticillatus*
Ranunculus limosella (a buttercup)
Ranunculus 'chloophilys' (a buttercup)

Ranunculus reflexus (mārūrū, a buttercup)
Ranunculus sceleratus (a buttercup)*
Ranunculus trichophyllus (water buttercup)*
Ranunculus verticillatus (a buttercup)
Rumex acetosa (sheep's sorrel)*
Rumex crispus (curled dock)*
Rumex flexuosus (runa, native dock)
Rumex obtusifolius (broad dock, paewhenua)*
Sagina procumbens (pearlwort)*
Schizeilema haastii
Schizeilema nitens
Schizeilema pallidum
Schizeilema roughii
Schizeilema trifoliolata
Scleranthus brockiei
Scleranthus uniflorus (kohukohu)
Stackhousia minima
Stellaria alsine (bog stitchwort)*
Stellaria decipiens
Stellaria gracilenta
Stellaria graminea (stitchwort)*
Stellaria roughii
Trifolium arvense (haresfoot trefoil)*
Trifolium dubium (suckling clover)*
Trifolium pratense (red clover)*
Trifolium repens (white clover)*
Urtica aspera (ongaonga)
Utricularia dichotoma (bladderwort)
Verbascum thapsus (woolly mullein)*
Verbascum virgatum (moth mullein)*
Veronica anagallis-aquatica (water speedwell)*
Veronica arvensis (field speedwell)*
Veronica serpyllifolia (turf speedwell)*
*Veronica verna**
Vicia sativa (vetch)*
*Viola arvensis**
Viola cunninghamii (haka, white violet)
Viola filicaulis
Viola lyallii
Wahlenbergia albomarginata subsp.*albomarginata* (harebell)
Wahlenbergia albomarginata subsp. *flexilis*
Wahlenbergia cartilaginea

18.5.1.11 *Mosses*

Polytrichum juniperinum (tetere whete)
Racomitrium lanuginosum (woolly moss)
Sphagnum cristatum (sphagnum)

18.5.2 *Fauna species*

18.5.2.1 *Birds*[1]

Australasian bittern, matuku (*Botaurus poiciloptilus*)
Australasian harrier, kāhu (*Circus approximans*)
Australasian shoveler, kuruwhengi (*Anas rhynchotis*)
Australian magpie (*Gymnorhina tibicen*)*
Banded dotterel, pohowera (*Charadrius bicinctus bicinctus*)
Bellbird, kōparapara (*Anthornis melanura melanura*)
Black shag, kawau pū (*Phalacrocorax carbo novaehollandiae*)
Black swan (*Cygnus atratus*)*
Blackbird (*Turdus merula*)*
Black-billed gull (*Larus bulleri*)
Black-fronted tern, tara, tarapirohe (*Chlidonias albostriata*)
Brown creeper, pī pipi (*Mohoua novaeseelandiae*)
California quail (*Callipepla californica brunnescens*)*
Canada goose (*Branta canadensis maxima*)*
Caspian tern, taranui (*Sterna caspia*)
Chaffinch (*Fringilla coelebs*)*
Chukar (*Alectoris chukar*)*
Goldfinch (*Carduelis carduelis*)*
Greenfinch (*Carduelis chloris*)*
Grey duck, pārera (*Anas superciliosa superciliosa*)
Grey warbler, riroriro (*Gerygone igata igata*)
Hedge sparrow, dunnock (*Prunella modularis occidentalis*)*
Kākā (*Nestor meridionalis meridionalis*)
Kārearea, New Zealand falcon (*Falconovaeseelandiae*)
Kea (*Nestor notabilis*)
Mallard (*Anas platyrhynchos platyrhynchos*)*
New Zealand pipit, pīhoihoi (*Anthus novaeseelandiae novaeseelandiae*)
New Zealand scaup, pāpango (*Aythya novaeseelandiae*)
Paradise duck, pūtakitaki (*Tadorna variegata*)
Pied stilt, poaka (*Himantopus himantopus leucocephalus*)
Pūkeko, swamp hen (*Porphyrio melanotus melanotus*)
Red poll (*Carduelis flammea cabaret*)*
Shining cuckoo, pīpwharauroaī (*Chrysococcyx lucidus lucidus*)
Silvereye, tauhou (*Zosterops lateralis lateralis*)
Skylark (*Alauda arvensis arvensis*)*
Song thrush (*Turdus philomelos*)*
South Island fantail, pīwakawaka (*Rhipidura fuliginosa fuliginosa*)
South Island pied oystercatcher, tōrea (*Haematopus finschi*)
South Island rifleman, tītitipounamu (*Acanthisitta chloris chloris*)
South Island tomtit, miromiro (*Petroica macrocephala macrocephala*)
Southern black-backed gull, karoro (*Larus dominicanus dominicanus*)
Southern crested grebe, kāmana (*Podiceps cristatus australis*)
Spur-winged plover (*Vanellus miles novaehollandiae*)
Starling (*Sturnus vulgaris*)*
Welcome swallow (*Hirundo tahitica neoxena*)
White heron, kōtuku (*Ardea modesta*)
White-faced heron, matukumoana (*Ardea novaehollandiae novaehollandiae*)
Wrybill, ngutu pare (*Anarhynchus frontalis*)
Yellowhammer (*Emberiza citrinella*)*

1 Includes only those species that are dominant in some communities.

18.5.2.2 *Lizards*

Common gecko, mokopāpā (*Woodworthia maculatus* 'maxi' agg. (3 spp.?))
Common gecko (*Woodworthia maculatus* 'mini' agg. (2 spp.?))
Common skink, mokomoko (*Oligosoma nigriplantare polychroma*)
Green-spotted skink (*Oligosoma lineoocellatum*)
Long-toed skink (*Oligosoma longipes*)
Scree skink (*Oligosoma waimatense*)

18.5.2.3 *Fish*

Alpine galaxias (*Galaxias paucispondylus*)
Brown trout (*Salmo trutta*)*
Chinook salmon (*Oncorhynchus tshawytscha*)*
Common bully (*Gobiomorphus cotidianus*)
Dwarf galaxias (*Galaxias divergens*)
Koaro (*Galaxias brevipinnis*)
Longfin eel/tuna (*Anguilla dieffenbachii*)
Northern flathead galaxias (*Galaxias* 'northern')
Shortfin eel/tuna (*Anguilla australis*) #
Tarndale bully (*Gobiomorphus alpinus*)
Torrentfish (*Cheimarrichthys fosteri*) #
Upland bully (*Gobiomorphus breviceps*)

18.5.2.4 *Introduced mammals (domestic and feral)*

Cat (*Felis catus*)
Cattle (*Bos taurus*)
Chamois (*Rupicapra rupicapra*)
Dog (*Canus familiaris*)
Ferret (*Mustela putorius*)
Goat (*Capra hircus*)
Hare (*Lepus europaeus*)
Hedgehog (*Erinaceus europaeus*)
Horse (*Equus ferus caballus*)
Mouse (*Mus musculus*)
Pig (*Sus scrofa*)
Possum (*Trichosurus vulpecula*)
Rabbit (*Oryctolagus cuniculus*)
Rat (*Rattus* spp.)
Red deer (*Cervus elaphus*)
Sheep (*Ovis aries*)
Stoat (*Mustela erminea*)
Weasel (*Mustela nivalis*)

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