SOUTHLAND
PHYSIOGRAPHIC ZONES

WATER AND LAND 2020 & BEYOND

ALPINE
Technical Information

Physiographic zones are part of the *Water and Land 2020 & Beyond* project that aims to maintain and improve water quality in the Southland region, and to help us as a community achieve our goals for water.

Understanding our water

The Physiographics of Southland project was developed to better understand the evolution of water across Southland. By understanding where water comes from and the processes it undergoes as it moves through drainage networks, we can better understand the reasons for different water quality outcomes across the region.

The findings of the Physiographics of Southland project have been published in two reports, which identify the key drivers of hydrochemistry and water quality variability in Southland (Rissmann *et al.*, 2016), and describe a classification system for managing land use effects on water quality (Hughes *et al.*, 2016).

Physiographic zones and water quality

Physiographic zones represent areas of the landscape that have a common influence over water quality. The proposed Southland Water and Land Plan identifies nine physiographic zones in Southland that can be used to manage land use effects on water quality.

Physiographic zone technical information

The purpose of this booklet is to describe generalised water quality risks associated with individual physiographic zones. A companion booklet titled *Guide for using the Southland physiographic zones technical information* explains the terms and source data used in this booklet.

What's inside

environment SOUTHLAND
REGIONAL COUNCIL
Te Taiao Tonga

ALPINE
physiographic zone

Alpine zone

Milford Sound
Te Anau
Manapouri
Lumsden
Gore
Winton
Mataura
Tuatapere
Riverton
Invercargill
Bluff
Oban

Alpine Physiographic Zone

APPROXIMATE AREA

684,300 hectares

GEOGRAPHIC DISTRIBUTION

Garvie, Umbrella, Livingstone, Eyre, Takitimu and Fiordland Mountains

MAIN SURFACE WATERWAYS

Headwaters of major river systems

Go to our online BEACON mapping service to view the physiographic zones of Southland in more detail.

Overview

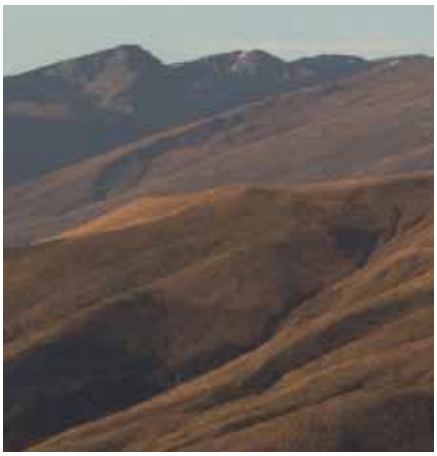
The Alpine physiographic zone is characterised by high elevation, steeply sloping land with thin soils or bare bedrock which receives high volumes of dilute precipitation. This zone is the second largest in Southland and occurs only at elevations above 800 metres.

Key features

- Occupies land above 800m elevation
- Steeply sloping topography with thin soils or bare bedrock
- High volumes of precipitation, including snowpack accumulation during winter
- Discharges high volumes of dilute drainage into the mid to upper reaches of Southland's major river systems
- Soils and aquifers have low denitrification potential
- Groundwater is a minor component of the water balance

Water quality implications

- Limited losses of nutrients and microbial contaminants due to low intensity of land use
- Sediment losses may occur in response to changes in landcover and extreme climatic events
- Provides large volumes of pristine water to downstream physiographic zones



WATER QUALITY RISK	ALPINE ZONE
Contaminant pathways	Overland flow
Dilution and attenuation processes	Lower contaminant concentrations due to high precipitation volumes
Primary receiving environments	Surface waterways
Water quality risk	Nitrogen, phosphorus, sediment, microbes

Variants and associations

Variants

Variants identify areas within physiographic zones where there is increased water quality risk when soils are wet. Contaminant losses from variants occur along alternate drainage pathways that have lower attenuation potential.

No variants are identified for the Alpine physiographic zone.

Associations

There are two physiographic zones commonly associated with the Alpine zone (Figure 1):

Riverine

The Riverine zone conveys large volumes of water from the Alpine zone to lowland areas and the coast.

Bedrock/hill country

The Alpine zone provides overland flow to sub-alpine areas of the adjoining Bedrock/Hill Country zone across the main mountain ranges.

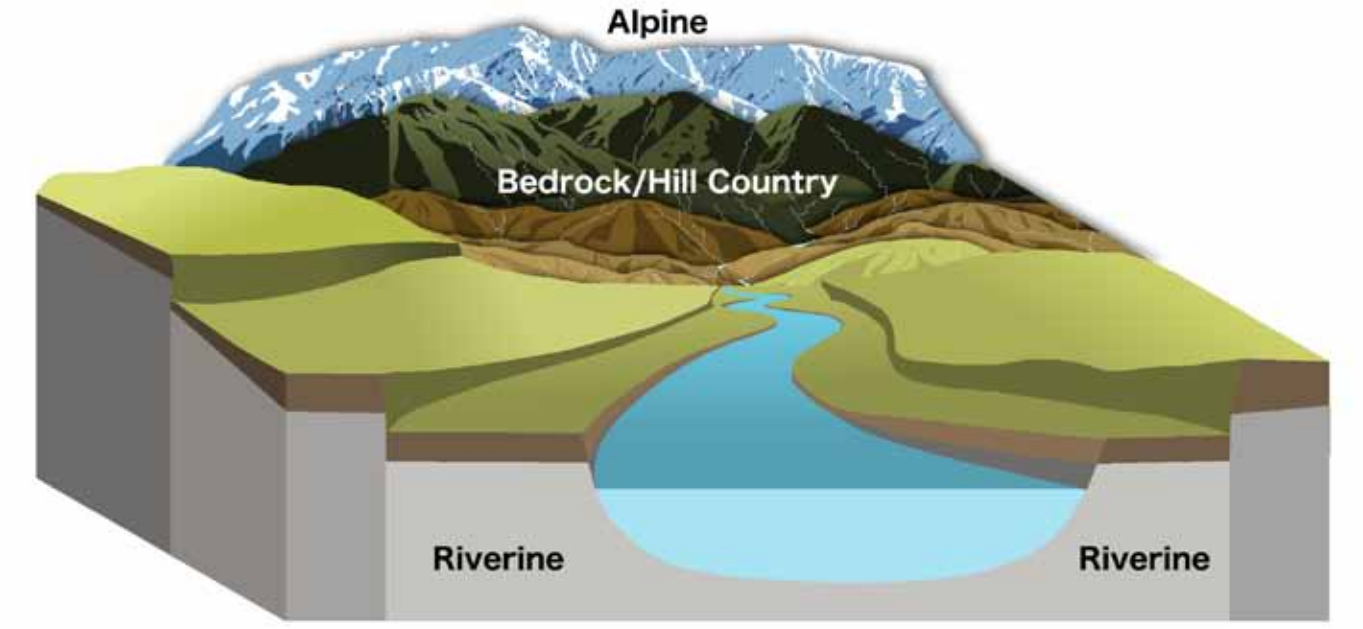
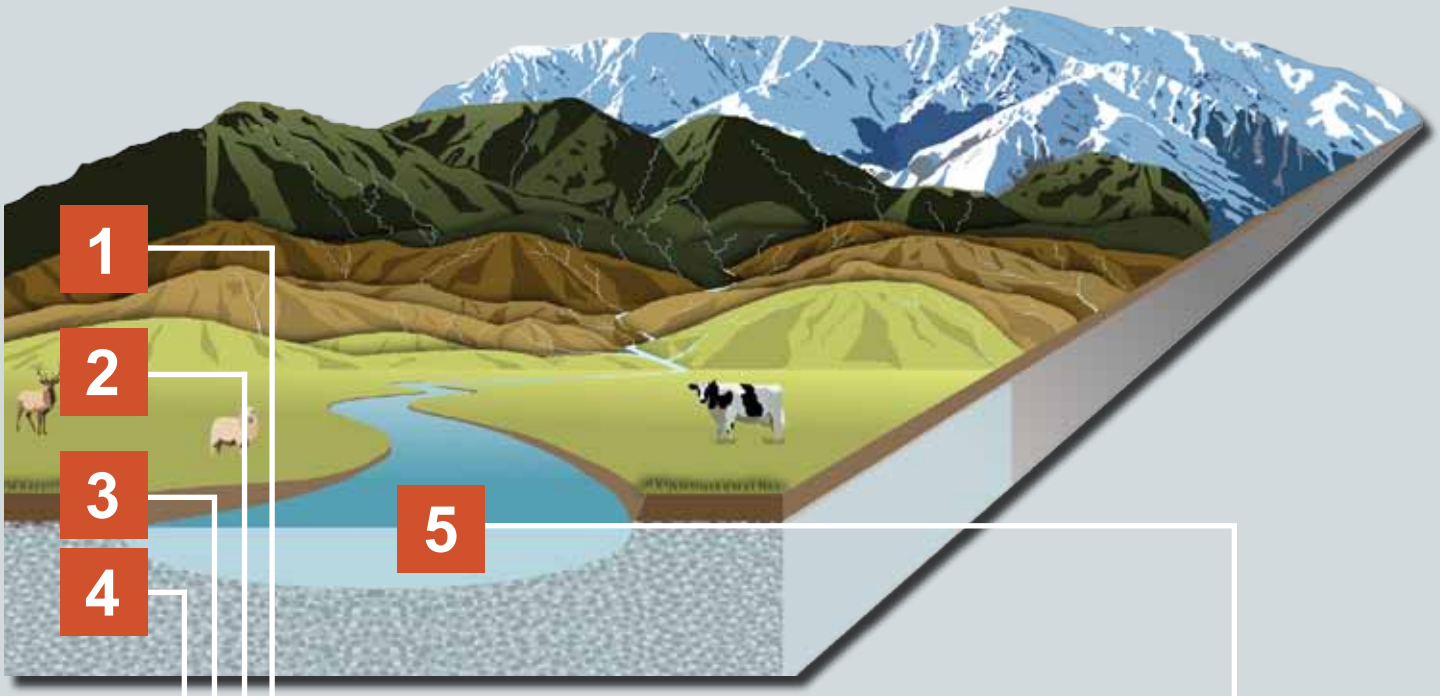


Figure 1: Landscape context image illustrating the relationship between the Alpine zone and neighbouring zones. The Alpine zone occurs at elevations above 800 metres where precipitation is high and snowpack accumulation occurs during winter. Runoff of pristine water from the Alpine zone provides a majority of discharge in the mid to upper reaches of the major river systems.

Dominant characteristics that affect water quality



Landscape characteristics

Surface zone characteristics

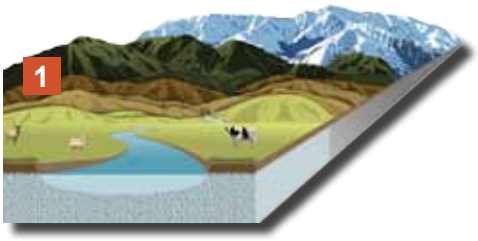
Soil zone characteristics

Saturated zone characteristics

Water quality implications

1 Landscape characteristics

The Alpine physiographic zone occurs at elevations above 800 metres on the main mountain ranges. This includes the Garvie, Umbrella, Livingstone, Eyre and Takitimu Mountains in northern Southland and the mountains of Fiordland to the west.



Topography

Elevation

This zone extends above the nominal bush line where land cover is predominantly tussock, alpine scrub or bare rock/scree. However, areas of native forest can also be found in some parts of the zone.

Slope

Most of this zone is steep to very steep (≥26° slope). Only a small portion of this zone (<4%) has flat to undulating slopes (≤7° slope).

Geology

The geology is comprised of a variety of rock types, ranging from sandstones, metasandstone and schist, through to igneous rocks of various composition.

Rock types represent several geological terranes, including the Caples, Dun Mountain-Matai, Murihiku, Brook Street and Median Batholith terranes. These rock units are juxtaposed together in a relatively complex geological setting along the active Australian-Pacific plate boundary.

Igneous rocks, such as diorite and granite are the most widespread rock type in this zone. These rocks are distributed throughout the Fiordland mountains.

Sandstone of the Dun Mountain-Matai and Caples Terranes also occurs extensively throughout the Takitimu, Eyre and Livingstone Mountains.

Metamorphic schist and **metasandstone** are generally restricted to the Garvie Mountains and northern portion of the Eyre Mountains.

Due to the topography and climate, the majority of this zone consists of erosional surfaces (bare rock) with limited accumulation of soils and sedimentary deposits over the basement rocks.

Climate

Average annual rainfall for this zone ranges from 1,300 to 2,000mm in the central and northern ranges, to over 9,000mm at higher elevations in the Fiordland area.

Differences in annual rainfall reflect a pronounced west to east rainfall gradient. In the Fiordland area, high rainout occurs where alpine areas intercept weather systems associated with the predominant westerly airflow.

Monthly rainfall totals tend to be:

- highest in spring and summer when westerly airflow predominates
- lowest in winter when southerly fronts result in snowfall at higher elevations.

Alpine LANDSCAPE characteristics

ELEVATION
>800 m RSL

SLOPE
Steep to very steep

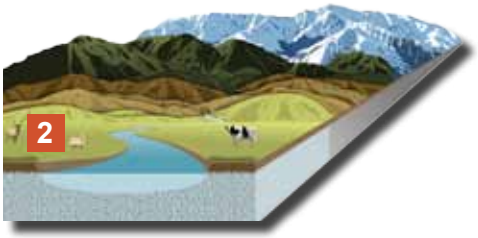
GEOLOGY
Hard rock

LANDFORM AGE
Pre-Quaternary

AVERAGE ANNUAL RAINFALL
4,279 mm per year

2 Surface zone characteristics

Recharge to the Alpine physiographic zone occurs via high altitude precipitation. Discharge from this zone predominately occurs via a network of small streams.



Dilution

Due to orographic enhancement, elevated precipitation results in higher recharge volumes (and consequently reduced contaminant concentrations) compared to lowland areas.

Frequent high intensity precipitation events increase the incidence of overland flow.

Surface waterways

Drainage in the Alpine zone occurs rapidly in response to precipitation events due to the steep terrain. After an initial peak, rivers and streams recede quickly.

Temporal variations in surface water drainage from this zone are highly seasonal:

- Snowpack accumulation results in low flows in rivers and streams during the winter months.
- Spring snowmelt results in extended periods of elevated flows in rivers and streams.

During high flow events, the proportion of flow in main stem rivers derived from alpine headwaters increases. This is due to higher rainfall and more rapid overland flow occurring in steep alpine areas, compared to lowland catchments.

Discharge from the Alpine zone contributes a large volume of water to downstream physiographic zones, with the Bedrock/Hill Country and Riverine zones being the main recipients.

Overland flow

Overland flow is the main drainage pathway for the Alpine zone, due to the steep topography, thin soils overlying bedrock and high precipitation.

Overland flow occurs rapidly in response to individual precipitation events. Water is then discharged via a network of rivers and small streams that are strongly influenced by topography.

Alpine SURFACE zone characteristics

DILUTION POTENTIAL
High to moderate recharge flux

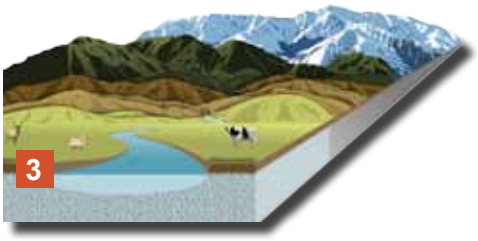
DRAINAGE DENSITY
Very low

STREAM SIZE
Very small

OVERLAND FLOW POTENTIAL
Very high

3 Soil zone characteristics

Much of the Alpine physiographic zone consists of bare rock and rock debris, such as scree or talus. Soil development is limited by rapid erosion and strong winds, particularly on steep slopes.



Soils

Podzol and Brown soils are the most common soil types in areas where soil development occurs. However, there is limited information available to characterise the physical and chemical properties of soils in this zone.

Soils are typically thin, coarse-grained and rapidly permeable. They contain low amounts of clay minerals and generally have low organic carbon content.

The above factors, combined with high precipitation volumes, result in soil zone processes exerting a limited influence on water quality within the Alpine zone.

Reduction potential

Most soils and areas of bare ground in this zone have low reduction potential due to their low organic carbon content (being above the nominal bush line) and drainage properties. As a result, there is limited potential for denitrification to occur.

Artificial drainage

The potential for artificial drainage is low due to most this zone being undeveloped, steep and having limited soil development.

Lateral drainage

Lateral drainage is an important flow pathway for this zone.

Lateral flow occurs in soils that have an internal drainage restriction, such as Podzol soils, or where soils are underlain by geology with lower permeability. Water moves laterally along the top of less permeable layers under the influence of gravity and may make a significant contribution to surface water discharge over the period after precipitation events.

Alpine SOIL zone characteristics

SOIL ORDER
Podzol, Brown

PROFILE DRAINAGE
No data**

PERMEABILITY
No data**

ANION STORAGE CAPACITY
No data**

REDUCTION POTENTIAL
Low

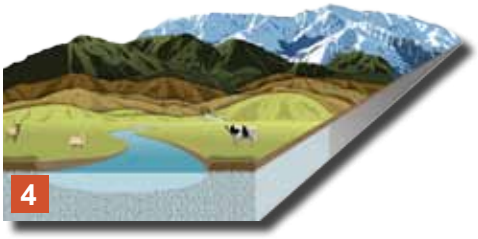
ARTIFICIAL DRAINAGE DENSITY
None (non-agricultural)

LATERAL DRAINAGE POTENTIAL
Extensive

**A majority (>90%) of the zone does not have available data

4 Saturated zone characteristics

The Alpine physiographic zone has a limited groundwater resource hosted within fractured rock aquifers in bedrock.



Groundwater

Groundwater typically occurs where secondary porosity is developed in discontinuities within the rock mass (e.g. jointing and fracturing).

The extent and nature of these fractured rock aquifers can vary considerably within individual geological zones. However, groundwater circulation forms a minor component of the overall water balance in this zone.

The limited groundwater resource is also reflected in low baseflow in streams draining this zone.

Groundwater circulation through bedrock material may take 10s to 100s of years in some places.

Reduction potential

Aquifers within this zone have low reduction potential due to their low organic carbon content, therefore groundwaters are oxidising.

Deep drainage

Deep drainage is a minor pathway in this zone due to the limited permeability of the rock materials.

Alpine SATURATED zone characteristics

WATER TABLE DEPTH
No data**

AQUIFER PERMEABILITY
Low

ACTIVE GROUNDWATER STORAGE
Minor

REDUCTION POTENTIAL
Low

DEEP DRAINAGE POTENTIAL
Low

**A majority (>90%) of the zone does not have available data

5 Water quality implications

The main water quality issues for the Alpine physiographic zone are contaminant losses via overland flow, depending on land use. Where land use is modified from the natural state, rapid loss of contaminants to streams can occur in response to precipitation events.

Influencing factors

Factors influencing water quality in the Alpine zone include:

- high volumes of dilute precipitation
- limited residence time within the soil and underlying colluvial materials
- water quality risks associated with overland flow are mitigated by the low intensity of land use

Dominant contaminant pathways are shown in Figure 2.

Water quality issues

Groundwater

Low risk to groundwater quality as deep drainage is a minor component of the water balance in this zone and recharge is dilute and low in contaminants (where landuse is at natural state).

Surface water

Most of the Alpine zone is currently undeveloped however under more intensive land use, episodic discharge of contaminants to surface waterways may occur.

Contaminant concentrations are unlikely to accumulate to high concentrations in this zone due to the high precipitation volumes. However, contaminant loads and sediment loss have the potential to be water quality issues.

Land use change in this zone of a sufficiently large scale has the potential to reduce water quality in down-gradient physiographic zones.

CONTAMINANT PATHWAY	MITIGATION OBJECTIVES
Overland flow	Protect soil structure, particularly in gullies and near stream areas Manage critical source areas Reduce phosphorus use or loss

Key HYDROCHEMICAL features

- Very dilute high altitude recharge waters reflecting orographic rainfall enhancement, rainout of marine aerosol load (especially with increased distance from the coast), and weathered (well flushed) colluvium.
- Water facies reflect dilute snowmelt and/or rainfall percolating through talus, scree and weathered soils with low base saturation. Typical surface water facies are Mg-HCO_3 and Ca-HCO_3.
- Water draining through the soil matrix is almost exclusively oxidising with concentrations of manganese and iron below detection limits. Nitrate concentrations are typically very low (dependent on land use).

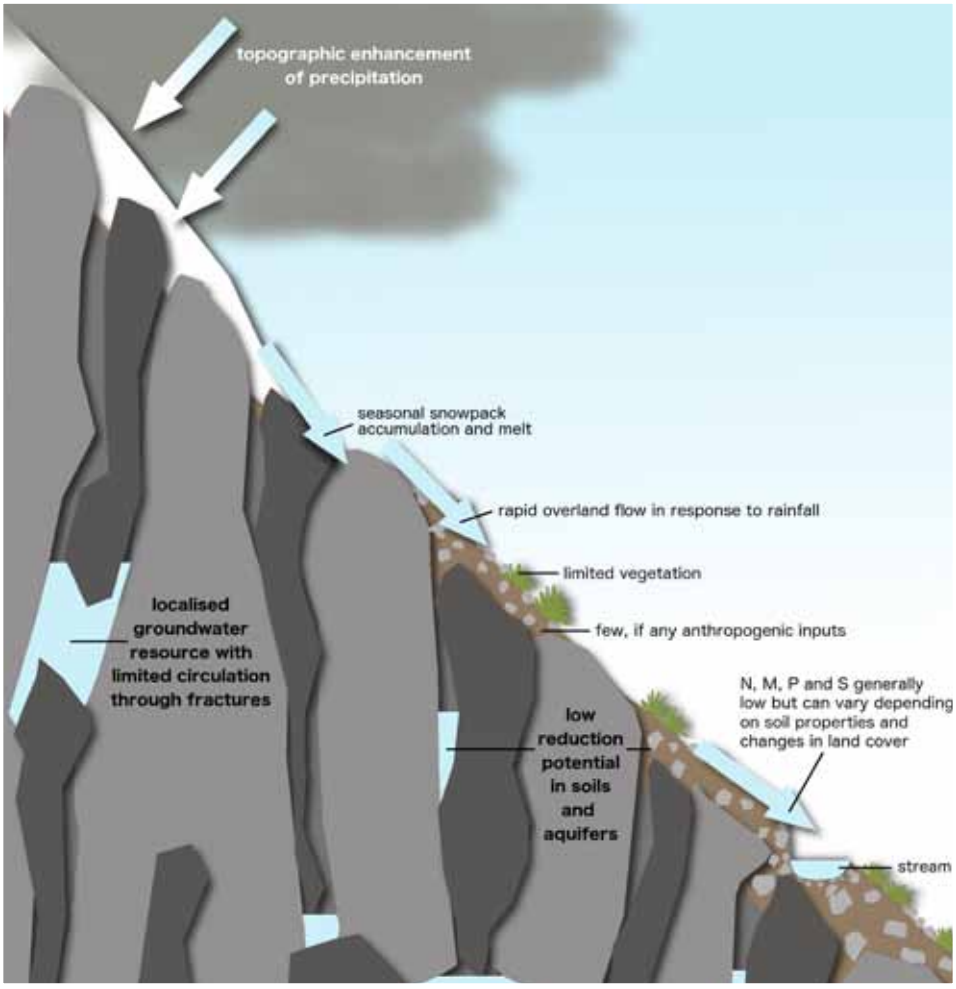


Figure 2: The dominant contaminant pathway in the Alpine zone is via overland flow, with contaminant loss mitigated by low intensity land use and large volumes of pristine precipitation. Where land use is modified from its natural state, this zone has potential to add to contaminant loads in down-gradient areas.

What affects water quality in the Alpine zone?

WHERE	KEY CHARACTERISTICS	CONTAMINANT PATHWAYS	ATTENUATION PROCESSES	WATER QUALITY RISK
All areas	Steep topography Large volumes of dilute precipitation	Overland flow in response to heavy or sustained precipitation events	High precipitation volumes dilute contaminant concentrations	Nitrogen Phosphorus Microbes Sediment High water quality risk where land is developed
All areas	Fractured rock aquifers Thin to bare soils Largely undeveloped land	Deep drainage, lateral flow and artificial drainage relatively minor pathways	Limited attenuation potential	Low