SOUTHLAND
PHYSIOGRAPHIC ZONES

WATER AND LAND 2020 & BEYOND

RIVERINE
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

RIVERINE
physiographic zone

Riverine zone

VARIANTS

Overland flow

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

Riverine Physiographic Zone

APPROXIMATE AREA

122,930 hectares

GEOGRAPHIC DISTRIBUTION

Floodplains adjacent to main rivers and tributaries.

MAIN SURFACE WATERWAYS

Mataura, Waikaia, Oreti, Aparima, Waiau, Whitestone and Mararoa Rivers, Lill Burn and the headwaters of their major tributaries.

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

Overview

The Riverine physiographic zone occurs along the margins of Southland's major river systems. This zone is characterised by large volumes of pristine water from alpine headwaters that is carried down major river systems to the coast.

Key features

- Water is sourced from a mixture of discharge from the Alpine zone (major component) and infiltration of precipitation on land adjacent to main rivers (minor component).
- Soil water drains quickly through shallow, stony soils to underlying shallow aquifers.
- Aquifers and rivers are highly connected, with large volumes of water flowing through the aquifer system.
- Soils and aquifers have low denitrification potential.

Water quality implications

- Rivers and aquifers are diluted by pristine water from the Alpine zone.
- The potential for export of phosphorus, sediment and microbial contamination is generally low.
- Aquifers are susceptible to nitrogen loss and can contribute significant nitrogen loads to downstream environments in main stem rivers due to flushing from high volumes of pristine river recharge.
- This zone transports contaminants to coastal estuaries and lagoons.

WATER QUALITY RISK	RIVERINE	RIVERINE(o)
Contaminant pathways	Deep drainage	Deep drainage and overland flow
Dilution and attenuation processes	Some dilution from alpine runoff	Some dilution from alpine runoff
Primary receiving environments	Aquifers	Aquifers and surface waterways
Water quality risk	Nitrogen	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.

The Riverine physiographic zone has one identified variant.

Associations

The Riverine physiographic zone is associated to all other physiographic zones in Southland (Figure 1).

Alpine

The Alpine zone is hydraulically connected to the Riverine zone, and provides large volumes of relatively pristine water as recharge to the Riverine zone.

All other zones

All other physiographic zones ultimately drain into the main stem rivers in the Riverine zone.

Riverine(o) – Overland Flow variant

Areas that have an elevated potential for overland flow due to a combination of slope, soil drainage properties and higher rainfall. This variant is generally located in the upper reaches of the major catchments, which receive more precipitation. This variant is typically associated with steeper slopes and soils that are less well drained due to silt accumulation from frequent flooding.

Approximate area: 24,400 ha

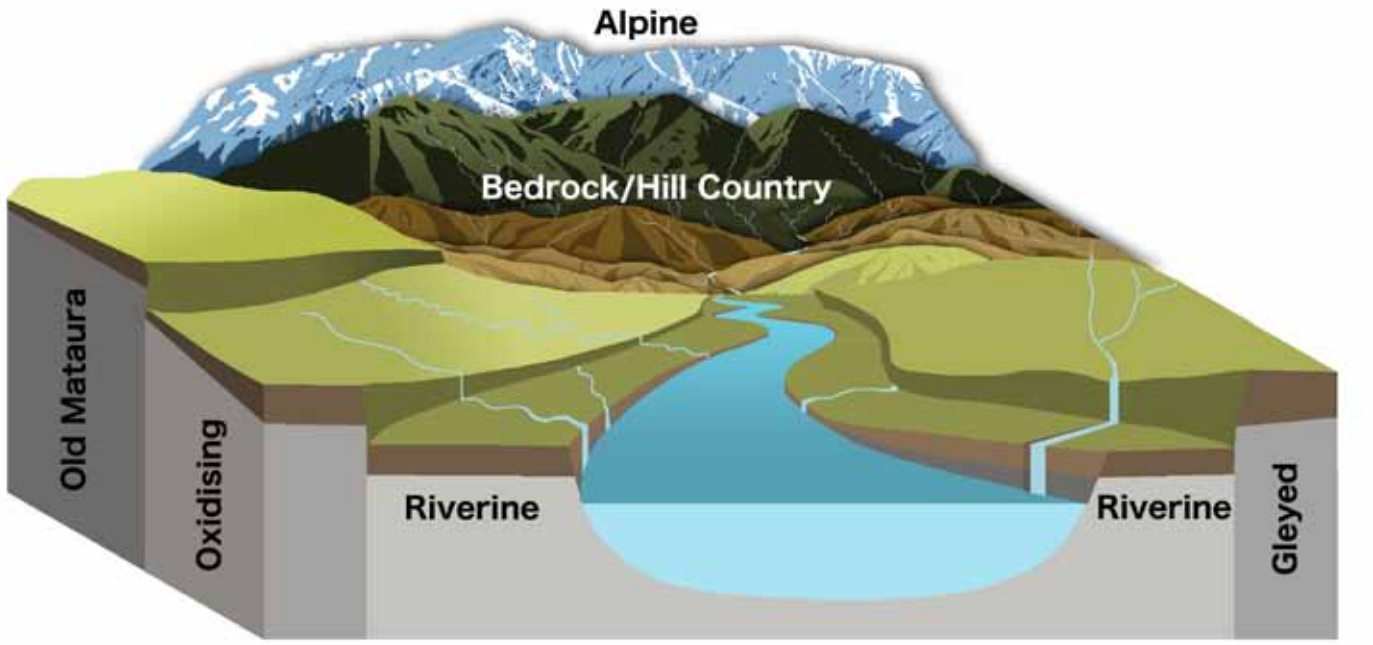
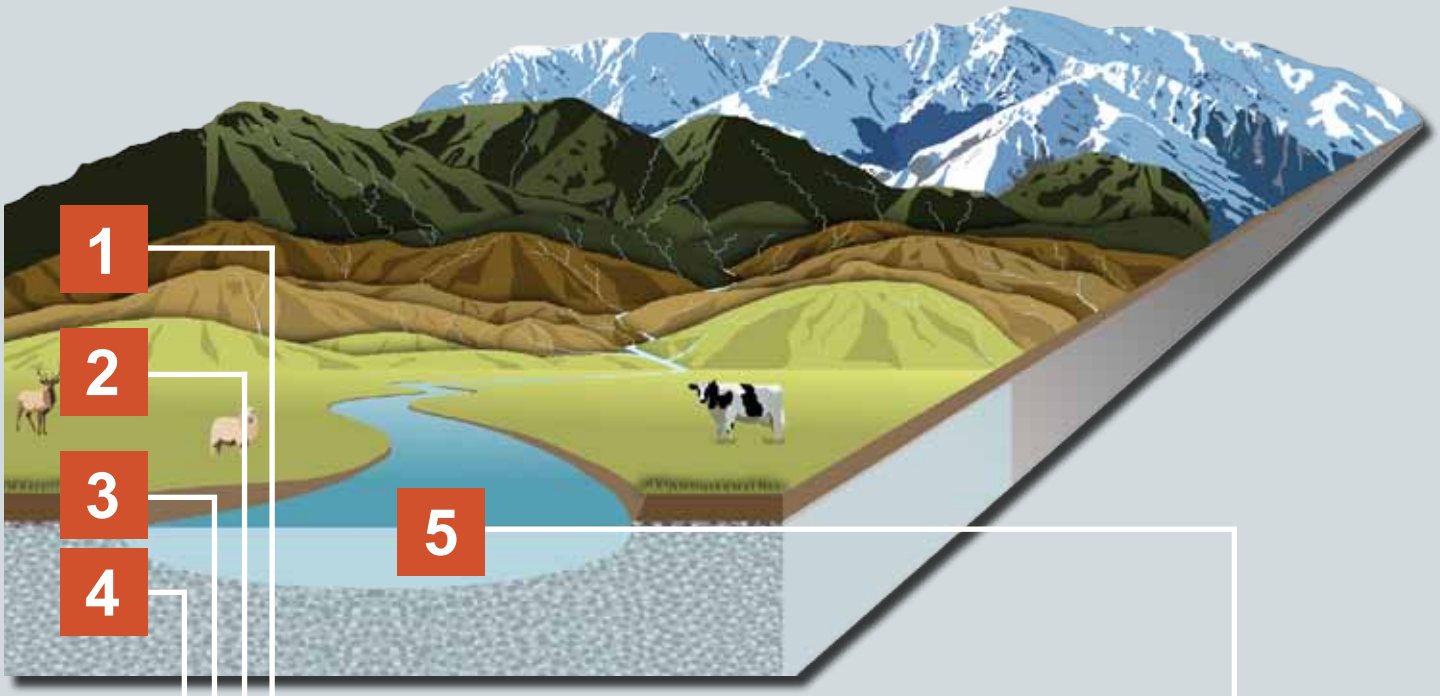


Figure 1: Landscape context Image illustrating the relationship between the Riverine zone and neighbouring zones. The Riverine zone occurs along main-stem rivers and major tributaries, extending from alpine areas less than 800 m elevation to the coast. All other zones discharge into the Riverine zone.

Dominant characteristics that affect water quality



Landscape characteristics

Surface zone characteristics

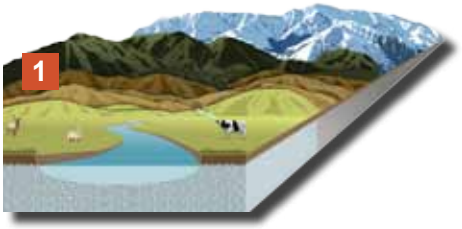
Soil zone characteristics

Saturated zone characteristics

Water quality implications

1 Landscape characteristics

The Riverine physiographic zone occupies floodplains adjacent to major river systems and their tributaries and extends from the Alpine physiographic zone to the coast.



Topography

Elevation

Most of this zone occurs below 400metres elevation relative to sea level (m RSL), in the middle reaches of the major rivers.

The Overland Flow variant (Riverine (o)) is predominantly found in upper catchment areas.

Slope

Most of the Riverine zone occurs on flat to gently undulating alluvial floodplains (≤3° slope).

Slopes in the Overland Flow variant are generally steeper.

Geology

Geology is typically comprised of recent alluvial deposits of poorly sorted gravel in a coarse sand matrix. Lensoidal deposits of finer sand and silt materials are interspersed within the gravel matrix, reflecting extensive reworking of alluvial materials on active river floodplains.

Age

The alluvial materials are mostly young (Q1) and generally exhibit limited weathering. They occupy areas of valley-fill alluvium, alluvial terraces, alluvial fans and outwash surfaces, which are located along the margins of major river systems.

Climate

Average annual rainfall in this zone varies spatially from less than 800mm in inland basins to over 9,000mm in areas of Fiordland.

Although the Riverine (o) variant occupies higher elevations, it has lower average rainfall because it has a more restricted distribution in Fiordland. .

Riverine LANDSCAPE zone characteristics

ELEVATION
0 – 420 m RSL

SLOPE
Flat to gently undulating

GEOLOGY
Quaternary sediments

LANDFORM AGE
Q1

AVERAGE ANNUAL RAINFALL
2,896 mm per year

Riverine(o) LANDSCAPE zone characteristics

ELEVATION
120 – 660 m RSL

SLOPE
Flat to rolling

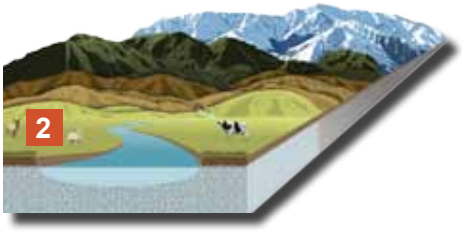
GEOLOGY
Quaternary sediments

LANDFORM AGE
Q1

AVERAGE ANNUAL RAINFALL
2,198 mm per year

2 Surface zone characteristics

Recharge to the Riverine physiographic zone occurs from a combination of high altitude alpine runoff and low altitude (local) land surface recharge.



Dilution

Water in this zone comprises a mix of alpine derived runoff and local, low elevation land surface recharge. Land surface recharge typically accounts for between 10 to 25% of the water balance in this zone.

The proportion of recharge from alpine sources decreases towards the coast, and with distance away from main stem rivers.

A more rapid reduction in the proportion of alpine-sourced water occurs in catchments with smaller alpine headwaters and lower precipitation (e.g. the Aparima and Oreti Rivers).

Surface waterways

Discharge from this zone occurs via an extensive stream and river network. Most streams drain adjacent physiographic zones, then flow across the Riverine zone into main stem rivers. In some areas streams may also gain appreciable flow from groundwater as they traverse this zone.

Streams that originate wholly within the Riverine zone are usually spring-fed. Discharge in such streams varies according to groundwater levels in the surrounding aquifer and increases downstream towards their confluence with main stem rivers.

Hydrology

Flow in main stem rivers are highly influenced by snowpack accumulation and melt in the Alpine zone. Median flows peak during spring (snow-melt) and are lowest during summer and autumn.

During extended periods of low flow, local groundwater discharge from the Riverine zone comprises a significant proportion of total flow in some reaches of the main stem rivers.

Overland flow

Localised ponding may occur in response to extreme or sustained rainfall events. These effects are typically of short duration and do not result in significant overland flow except in the Overland Flow variant.

Overland flow is more likely to occur in the Overland Flow variant, due to:

- increased slope
- imperfectly to poorly drained soils.

Riverine SURFACE zone characteristics

DILUTION POTENTIAL
High mixing potential

DRAINAGE DENSITY
Very high

STREAM ORDER
Predominately large

OVERLAND FLOW POTENTIAL
Low

Riverine(o) SURFACE zone characteristics

DILUTION POTENTIAL
High mixing potential

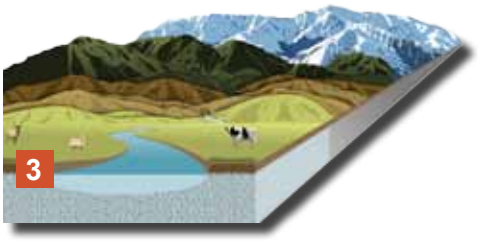
DRAINAGE DENSITY
Very high

STREAM ORDER
Predominately large

OVERLAND FLOW POTENTIAL
Moderately high

3 Soil zone characteristics

Soils in this physiographic zone are generally shallow, stony and well drained. They form along active floodplains in gravelly alluvium which is deposited by the major river systems.



Soils

Recent soils are the most common soil type in this zone and in the Overland Flow variant (>90% of the area).

Recent soils are moderately fertile with a silty, sandy or silt loam texture. However, these soils are also stony, prone to drought and have a high flood risk, which limits their versatility.

Ponding can occur on soils that contain silt or are adjacent to rivers and streams where the water table is near the surface. Where these soils are sloping, this can result in overland flow (i.e. the Overland Flow variant).

Reduction potential

Due to their rapid permeability and good internal drainage, soils in this zone have low reduction potential. This results in a severe to very severe risk of nutrient leaching.

Artificial drainage

This zone has low potential for artificial drainage due to good soil drainage and large areas of undeveloped land.

Lateral drainage

Lateral drainage through the soil profile is restricted to localised areas where soils have lower subsoil permeability.

Riverine SOIL zone characteristics

SOIL ORDER
Recent

PROFILE DRAINAGE
Well drained*

PERMEABILITY
Rapid over rapid*

ANION STORAGE CAPACITY
Low*

REDUCTION POTENTIAL
Low

ARTIFICIAL DRAINAGE DENSITY
None to very low

LATERAL DRAINAGE POTENTIAL
Localised

Riverine(o) SOIL zone characteristics

SOIL ORDER
Recent

PROFILE DRAINAGE
Well drained*

PERMEABILITY
No data**

ANION STORAGE CAPACITY
No data**

REDUCTION POTENTIAL
Low

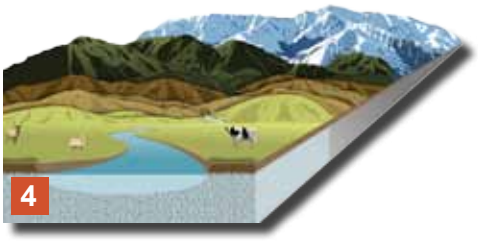
ARTIFICIAL DRAINAGE DENSITY
None (not agriculture)

LATERAL DRAINAGE POTENTIAL
Localised

*A significant proportion (>50%) of the zone does not have available data.
**A majority (>90%) of the zone does not have available data.

4 Saturated zone characteristics

The Riverine physiographic zone is characterised by unconfined aquifers, which are highly permeable and occur along the margins of major rivers. Aquifers within this zone exhibit a high degree of connection with major stem rivers.



Groundwater

Groundwater throughflow is rapid in this zone due to the high permeability of alluvial materials.

Groundwater levels

Aquifers typically have a shallow water table that is often connected to surface waters, reflecting their proximity to major rivers.

Groundwater levels vary in response to infiltration of local precipitation and changes in river levels (often mirroring the river hydrograph).

Groundwater discharge occurs as:

- baseflow to larger rivers and streams via stream-bed infiltration
- discharge to spring-fed streams.

Groundwater recharge and discharge may occur along different sections of the river channel, depending on the relative hydraulic gradient between groundwater and surface water.

Reduction potential

Aquifers within this zone have low reduction potential predominantly due to their low levels of organic carbon and the high throughflow of oxic water. As a result, there is low potential for denitrification to occur within the groundwater system.

Deep drainage

Deep drainage to groundwater is the main drainage mechanism in this zone due to the predominantly flat-lying topography and well-drained, rapidly permeable soils.

Deep drainage is typically seasonal. Most recharge occurs when soil moisture is at or near field capacity, generally between late autumn and spring.

However, drainage to the water table can occur at any time of the year in response to heavy or sustained rainfall.

Riverine SATURATED zone characteristics

WATER TABLE DEPTH
Shallow*

AQUIFER PERMEABILITY
High

ACTIVE GROUNDWATER STORAGE
Extensive

REDUCTION POTENTIAL
Low

DEEP DRAINAGE POTENTIAL
High

Riverine(o) SATURATED zone characteristics

WATER TABLE DEPTH
Shallow*

AQUIFER PERMEABILITY
High

ACTIVE GROUNDWATER STORAGE
Extensive

REDUCTION POTENTIAL
Low

DEEP DRAINAGE POTENTIAL
High

*A significant proportion (>50%) of the zone does not have available data.

5 Water quality implications

Nitrate leaching from overlying land use is the main water quality issue for this physiographic zone. The oxidising nature of soils and groundwater results in little denitrification. Rapid throughflow of groundwater exports nitrate to surface waterways.

Influencing factors

Water quality in the Riverine zone is strongly influenced by:

- large volumes of dilute, strongly oxidised alpine-sourced water
- rapid drainage through gravelly, well drained soils to shallow aquifers which are hydraulically connected to surface waterways.

Water quality issues

Overall, waters in the Riverine zone are dilute relative to lowland surface and ground waters. This reflects the contribution of dilute recharge from the Alpine zone (Figures 2 and 3).

The influence of alpine-fed rivers and streams recharge on groundwater prevents nitrate concentrations from becoming elevated. However, the large volumes of water flowing through the groundwater system may convey a significant nitrogen load to hydraulically connected rivers and streams.

Abundant fine materials within the soil gravel matrix (such as silt, sand and minor clay), have a filtering effect by:

- trapping sediment
- filtering out microbes
- assisting with the sorption and retention of phosphorus.

When the water table is near ground level, microbes and phosphorus may be leached to groundwater under intensive wintering of stock. The effects on groundwater quality are generally localised due to die-off and filtering of microbes, and sorption and retention of phosphorus.

Groundwater

A small proportion of relatively concentrated soil zone recharge has a significant effect on groundwater quality.

Land surface recharge can increase the dissolved solute load in groundwater depending on land use. However, the large volume of water flowing through unconfined aquifers can reduce concentrations in contaminants associated with soil zone recharge.

The amount of aquifer dilution varies both:

- Spatially – reducing with increasing distance from the main stem rivers
- Temporally – peaking in spring when discharge in alpine-sourced rivers is highest.

Surface waters

Rivers and aquifers are highly connected in this zone.

Baseflow discharge from aquifers can make a significant contribution to nitrogen loads in main stem rivers and subsequent coastal environments (such as estuaries).

Rivers in this zone also drain surrounding physiographic zones. The contribution from these zones, and their effect on water quality, progressively increases downstream.

The risk of microbial and sediment contamination is low in this zone, except in the Overland Flow variant where episodic losses may occur.

Key HYDROCHEMICAL features

- Mixed-altitude recharge waters that reflect a mix of a large volume of dilute alpine-derived water with a smaller contribution from concentrated mid to low altitude land surface recharge
- Spatial variation in hydrochemistry shows a relatively small proportion of land surface recharge can significantly increase the dissolved solute load in ground and surface waters
- Water in this zone has low dissolved sodium (Na) and chloride (Cl) concentrations due to low marine aerosol load in alpine-sourced waters
- While solute concentrations are low cumulative contaminant loads can be high due to the large volumes of water flowing through this zone

What affects water quality in the Riverine zone?

WHERE	KEY CHARACTERISTICS	CONTAMINANT PATHWAYS	ATTENUATION PROCESSES	WATER QUALITY RISK
All areas	Receives high volumes of alpine runoff Aquifers and rivers are highly connected Well-drained shallow soils	Lateral flow through the soil matrix when soils are wet	Filtration and adsorption removes virtually all particulate and microbial contaminants	Low water quality risk due to limited occurrence in well drained soils
		Deep drainage through soil and saturated zone when soils are wet	Low denitrification potential in soils and aquifers Lower contaminant concentrations due to pristine alpine runoff	Nitrogen Elevated potential for nitrate losses to groundwater. Potential for localised elevation of particulate or microbial contaminants close to source in coarse-grained soils
		Artificial drainage	Limited attenuation potential	Low water quality risk due to limited occurrence in well drained soils
Overland Flow variant	Steeper topography	Overland flow in response to sustained or heavy precipitation events	Lower contaminant concentrations due to pristine alpine runoff	Nitrogen Phosphorus Microbes Sediment Contaminants discharged rapidly to surface water

CONTAMINANT PATHWAY	MITIGATION OBJECTIVES
Deep drainage	Reduce the accumulation of surplus nitrogen in the soil, particularly during autumn and winter
Overland flow	Protect soil structure, particularly in gullies and near stream areas Manage critical source areas Reduce phosphorus use or loss

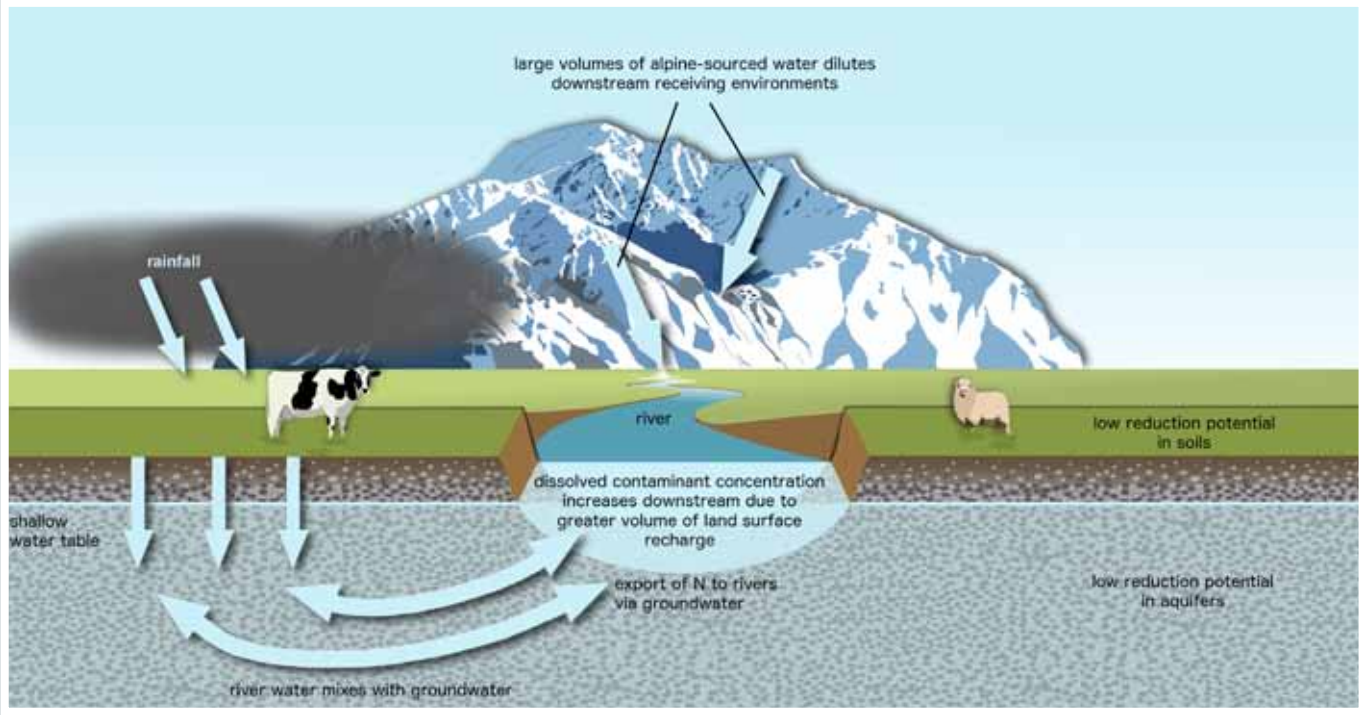


Figure 2: **Main zone.** Dissolved contaminant concentrations in the Riverine physiographic zone are generally low due to the large volume of pristine, alpine– sourced water. However, where there are anthropogenic inputs, nitrogen (N) loads from groundwater can be high due to the large volume of water moving through this zone. Risk of P and M leaching can also occur under intensive land use when the water table is near the surface.

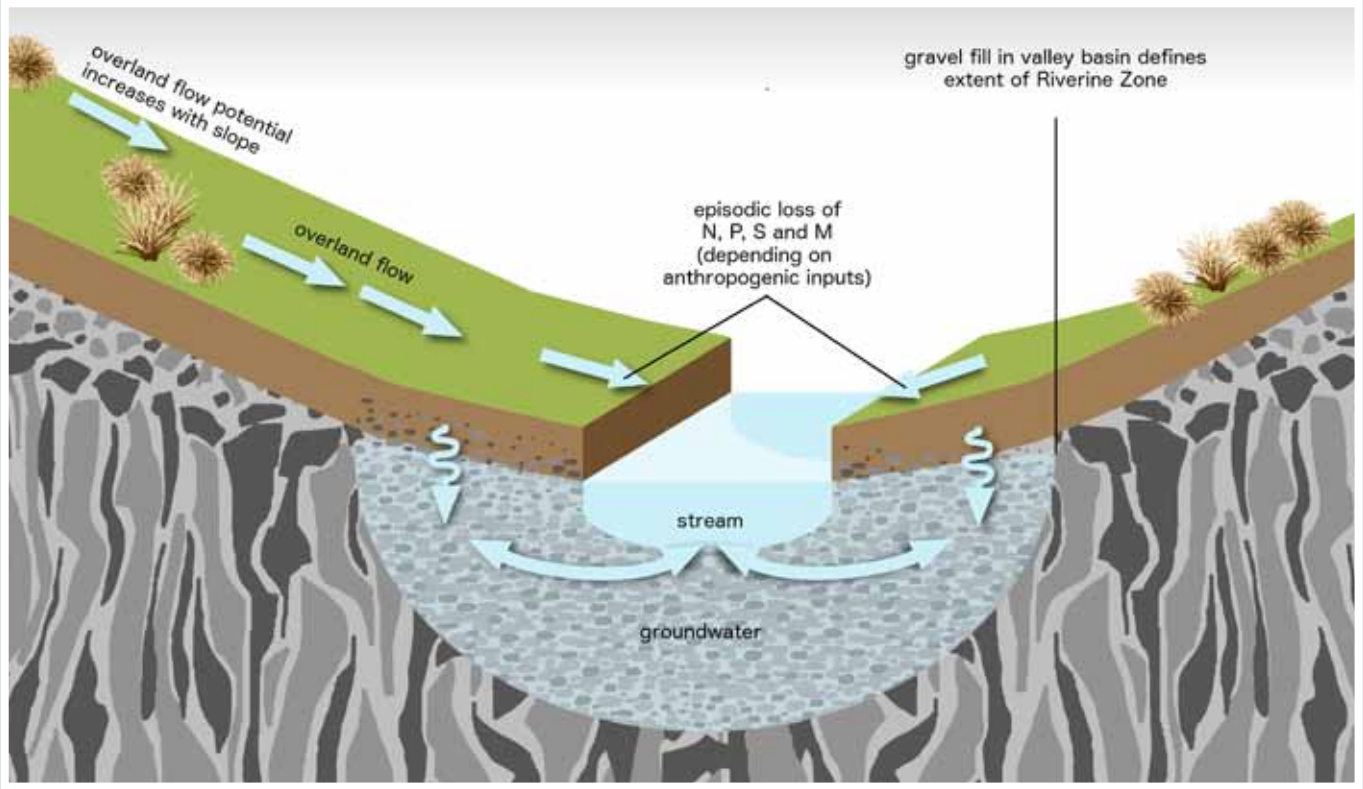


Figure 3: **Overland Flow variant.** In sloping areas, overland flow can occur in response to heavy or sustained precipitation. Where there are anthropogenic inputs, nitrogen (N), phosphorus (P), sediment (S) and microbial (M) loads to surface water can be high.