SOUTHLAND
PHYSIOGRAPHIC ZONES

WATER AND LAND 2020 & BEYOND

GLEYED
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

GLEYED
physiographic zone

Gleyed zone

VARIANTS

Overland flow

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

Gleyed Physiographic Zone

APPROXIMATE AREA

308,270 hectares

GEOGRAPHIC DISTRIBUTION

Alluvial terraces and downlands of the Southland Plains and inland basins away from the major river systems

MAIN SURFACE WATERWAYS

Makarewa River, Waimea Stream, Otautau Stream, Dipton Stream, Winton Stream, Otapiri Stream, Bog Burn

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

Overview

The Gleyed physiographic zone occupies mostly flat to gently undulating land across the plains of both northern and southern Southland. This zone is characterised by imperfectly to poorly drained soils that exhibit redoximorphic features such as mottling and gleying.

Key features

- Soils are fine-textured and imperfectly to poorly drained.
- Soils exhibit redoximorphic features (e.g. mottling and gleying).
- Extensive use of artificial drains (mole-pipe) due to soils being prone to waterlogging.
- Deep drainage to groundwater occurs at a low rate through slowly permeable subsoils.

Water quality implications

- Some denitrification occurs in the soil zone so groundwater nitrate concentrations are typically low to moderate.
- Artificial drains rapidly export excess soil water and contaminants to surface waterways, when soils are wet or in response to heavy or sustained precipitation.
- Where the potential for overland flow is elevated, episodic contaminant losses (nitrogen, phosphorus, sediment and microbes) may occur to surface waterways.

WATER QUALITY RISK	GLEYED	GLEYED(o)
Contaminant pathways	Artificial drainage	Artificial drainage
Dilution and attenuation processes	Reducing soils	Variably reducing soils
Primary receiving environments	Surface waterways	Surface waterways
Water quality risk	Nitrogen, phosphorus, sediment, microbes	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 Gleyed physiographic zone has one identified variant.

Gleyed(o) – Overland Flow variant

Areas where there is elevated potential for overland flow resulting from a combination of slope and soil drainage properties. The Overland Flow variant generally occurs on steeper areas around the margins of alluvial terraces.

Approximate area: 96,850 ha

Associations

The Gleyed physiographic zone is commonly associated with four other physiographic zones in Southland (Figure 1).

Bedrock/Hill Country

The Gleyed zone occurs along the margins of the Bedrock/Hill Country zone where poorly drained soils occur along the base of hillslopes.

Discharge from the Bedrock/Hill Country zone provides flow to the headwaters of many small streams that drain the Gleyed zone.

Oxidising

The Oxidising zone occupies intermediate alluvial terraces that occur between the Gleyed and Riverine zones.

The Oxidising zone has similar geomorphic origins to the Gleyed zone, but is characterised by well drained soils overlying comparatively unweathered alluvium.

Streams draining the Gleyed zone commonly flow across the Oxidising zone to the main stem rivers.

Peat Wetlands

Small remnants of the Peat Wetlands zone occur extensively across the Gleyed zone where land remains undeveloped.

Areas of Peat Wetlands discharge to streams draining the Gleyed zone.

Central Plains

The Gleyed zone surrounds much of the Central Plains zone. However, there is limited hydrological interaction between the two zones due to catchment drainage patterns.

The Gleyed and Central Plains zones share similar characteristics, except soils in the Gleyed zone do not exhibit the same shrink/swell characteristics as those in the Central Plains zone.

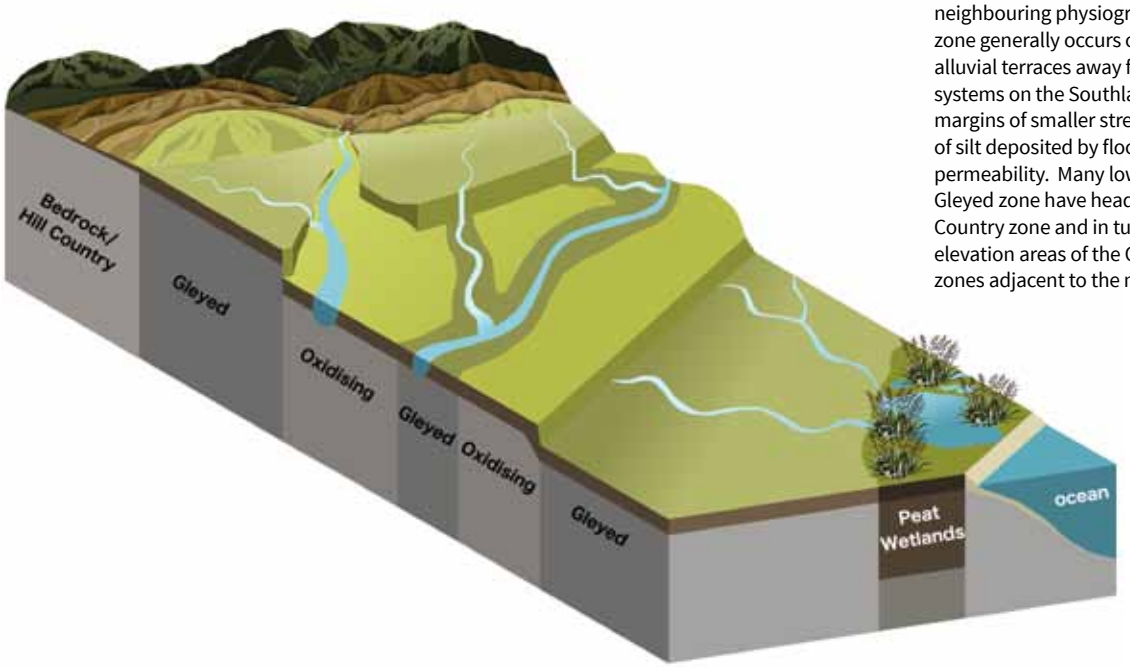
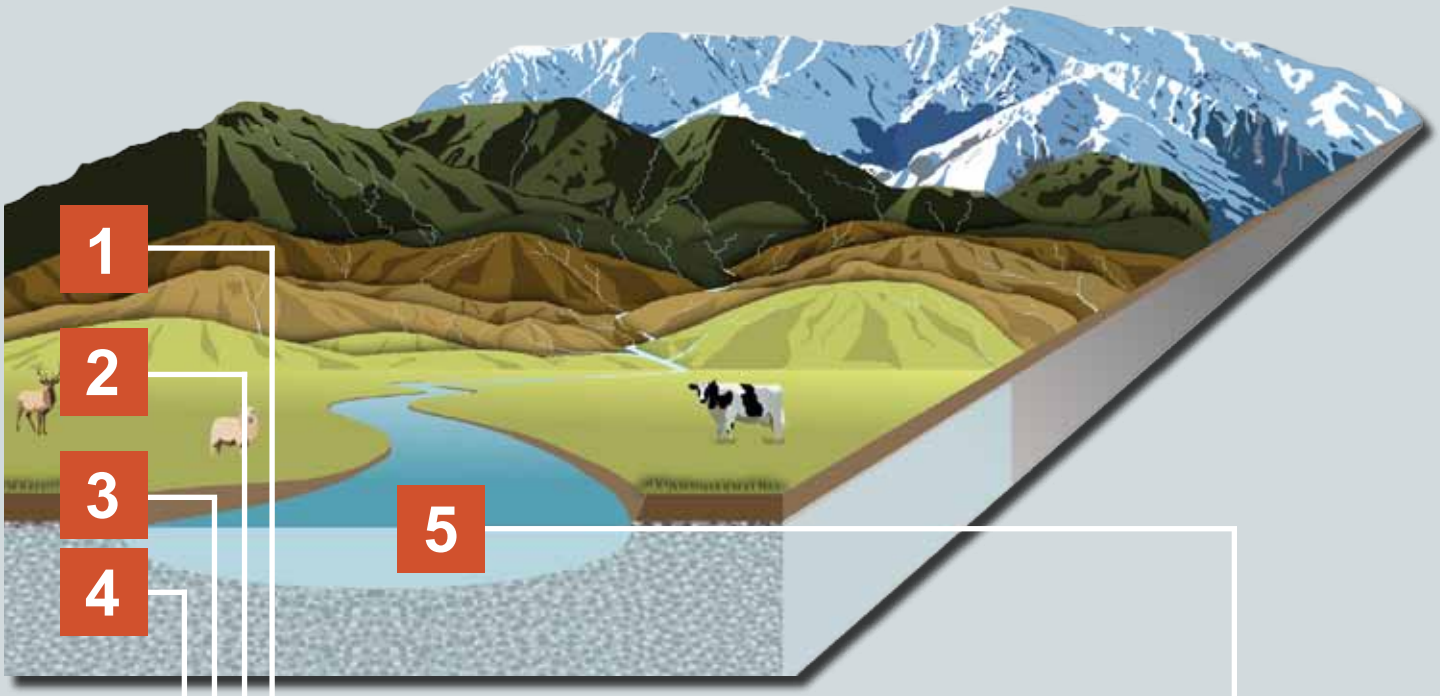


Figure 1: Landscape context image illustrating the relationship between the Gleyed zone and neighbouring physiographic zones. The Gleyed zone generally occurs on older, slightly elevated alluvial terraces away from the major river systems on the Southland Plains and along the margins of smaller streams where accumulation of silt deposited by flood events reduces soil permeability. Many lowland streams draining the Gleyed zone have headwaters in the Bedrock/Hill Country zone and in turn provide runoff to lower elevation areas of the Oxidising and Riverine zones adjacent to the major river systems.

Dominant characteristics that affect water quality



Landscape characteristics

Surface zone characteristics

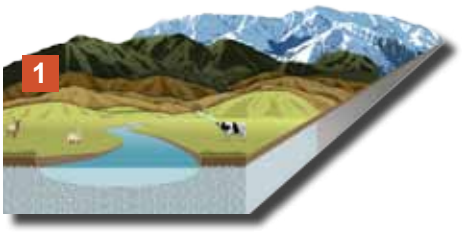
Soil zone characteristics

Saturated zone characteristics

Water quality implications

1 Landscape characteristics

The Gleyed zone occupies alluvial terraces and downlands away from the major river systems in lowland areas and inland basins, excluding the Waiau catchment.



Topography

Elevation

Most of this zone occurs at elevations less than 300 metres relative to sea level (m RSL). Areas at higher elevations are mainly restricted to the margins of the Oreti Basin and upper reaches of the Aparima River.

The Overland Flow variant (Gleyed(o)) is predominantly found in upper catchment areas (up to 600m RSL)

Slope

Most of this zone occurs on flat to gently undulating land (≤3° slope). Steeper areas generally occur in the Overland Flow variant, which occupies undulating to strongly rolling areas (≤20° slope)

Geology

Geology is typically comprised of Quaternary alluvial and terrace deposits, which range in age from Q1 to >Q10. Also included are areas of older alluvium (eQ to mQa) on higher terraces near Gore and Mossburn. These deposits consist of poorly sorted sand and gravel, with abundant fine material (silt and clay) in the gravel mix.

The texture of these alluvial deposits reflects limited reworking of the alluvial materials by the major river systems. Extensive weathering of the alluvial materials occurs on older surfaces.

Climate

Across lowland Southland average annual mean rainfall varies between 750mm in parts of the Waimea Plains to around 1,630mm along the western slopes of the coastal Longwoods. Average annual rainfall totals exceeding 5,000mm/year occur in the Fiordland area.

Gleyed LANDSCAPE zone characteristics

ELEVATION
0 – 300 m RSL

SLOPE
Flat to gently undulating

GEOLOGY
Quaternary sediments

LANDFORM AGE
Q2-Q4 and Q7-Q9

AVERAGE ANNUAL RAINFALL
1,953 mm per year

Gleyed(o) LANDSCAPE zone characteristics

ELEVATION
0 – 600 m RSL

SLOPE
Undulating to strongly rolling

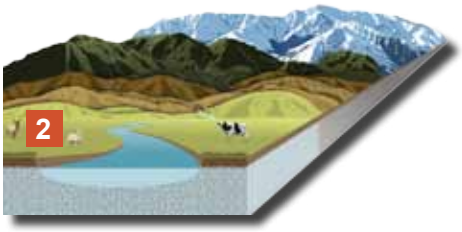
GEOLOGY
Quaternary sediments

LANDFORM AGE
Q1-Q6

AVERAGE ANNUAL RAINFALL
3,967 mm per year

2 Surface zone characteristics

Recharge to the Gleyed physiographic zone occurs from local precipitation infiltrating through the soil matrix. Runoff from adjacent higher elevation areas (mainly the Bedrock/Hill Country zone) provides minor recharge in some inland areas. Recharge from runoff is seasonally biased towards winter and spring.



Dilution

This zone is predominately recharged via land surface recharge (matrix flow), augmented in places by runoff from higher elevation areas. There is limited potential for dilution of contaminants associated with this recharge mechanism.

Surface waterways

This zone has a dense surface drainage network, which typically exhibits a low gradient. In places, streams form an extensive sub-parallel drainage network, augmented by artificial drainage.

Event driven flow (or quick flow) occurs in response to individual precipitation events during winter and spring when soils are wet for prolonged periods.

Most streams drain shallow groundwater from adjacent unconfined aquifers. Baseflow may decline appreciably in small streams during summer and autumn as the water table declines.

Overland flow

The generally steeper topography of the Overland Flow variant increases the potential for overland flow to occur. This typically occurs as saturation excess during prolonged wet periods.

Gleyed SURFACE zone characteristics

DILUTION POTENTIAL
Low recharge flux

DRAINAGE DENSITY
High

STREAM ORDER
Mixed

OVERLAND FLOW POTENTIAL
Low

Gleyed(o) SURFACE zone characteristics

DILUTION POTENTIAL
Low recharge flux

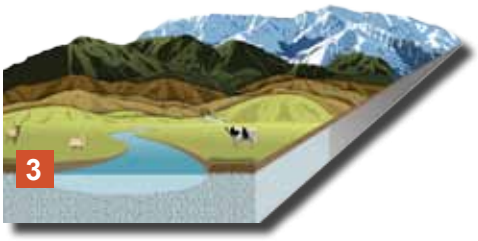
DRAINAGE DENSITY
High

STREAM ORDER
Mixed

OVERLAND FLOW POTENTIAL
Moderately high to high

3 Soil zone characteristics

A key feature of the Gleyed physiographic zone is the extensive network of artificial drainage used to remove seasonal excess water from flat-lying, imperfectly to poorly drained that are prone to waterlogging.



Soils

The Gleyed zone is mainly comprised of Gley, Pallic and Podzol soils, which share similar physical and chemical characteristics, including:

- poor internal drainage;
- low permeability;
- moderate to high water holding capacity;
- an elevated topsoil organic matter content that reflects their origin in historical wetland areas;
- poor aeration during sustained wet periods.

The Overland Flow variant includes a significant proportion of poorly drained Podzol soils.

Drainage events tend to be episodic, occurring rapidly in response to precipitation events when soils are wet. As soils dry, the magnitude of rainfall required to initiate rapid drainage increases.

Reduction potential

Soils typically exhibit moderate to high reduction potential due to their poor drainage properties.

As a result, significant nitrate removal via denitrification may occur in water infiltrating through the soil matrix. However, the amount of denitrification that occurs is dependent on the residence time of water within the soil matrix.

Soils in this zone characteristically exhibit redoximorphic features such as mottling and gleying, which indicate reducing conditions.

Artificial drainage

Artificial drainage is used extensively in this zone to prevent waterlogging, which occurs due to the combination of flat topography and poor soil drainage.

Bypass flow via artificial drainage can reduce soil residence time reducing the potential for denitrification to occur.

Artificial drainage is generally less extensive in the Overland Flow variant, although it may be used to remove excess soil water along the base of hillslopes.

Lateral drainage

In soil types that have restricted drainage, lateral flow may occur along slowly permeable layers within the soil profile.

However, the spatial extent of lateral flow is limited by the artificial drainage network.

Gleyed SOIL zone characteristics

SOIL ORDER
Gley, Pallic, Podzol

PROFILE DRAINAGE
Poorly to imperfectly drained

PERMEABILITY
Moderate over slow

ANION STORAGE CAPACITY
Moderate

REDUCTION POTENTIAL
Moderate to high

ARTIFICIAL DRAINAGE DENSITY
High

LATERAL DRAINAGE POTENTIAL
Localised

Gleyed(o) SOIL zone characteristics

SOIL ORDER
Podzol

PROFILE DRAINAGE
Poorly drained*

PERMEABILITY
Moderate over slow*

ANION STORAGE CAPACITY
Moderate to low*

REDUCTION POTENTIAL
Low

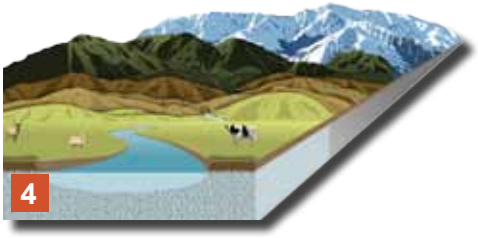
ARTIFICIAL DRAINAGE DENSITY
None (not agriculture)

LATERAL DRAINAGE POTENTIAL
Localised

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

4 Saturated zone characteristics

Groundwater in the Gleyed physiographic zone is typically hosted in low permeability unconfined aquifer systems, which have little or no connectivity with main stem rivers. However, aquifers in this zone exhibit significant interconnection with the local surface drainage network.



Groundwater

Groundwater levels

Aquifers typically have a shallow water table, which reflects the historic occurrence of wetlands in this zone.

Water levels demonstrate a characteristic seasonal fluctuation ranging between 1.0 and 1.5 metres, with highest water levels occurring during the winter months. This is followed by a steady decline to a minimum level in autumn.

Groundwater discharge

Groundwater discharge occurs via two separate mechanisms:

Localised drainage of shallow groundwater to surface waterways is a major component of the overall water balance, which provides baseflow to numerous lower order streams and maintains groundwater levels within a well-defined range.

Sub-regional circulation through deeper levels of the unconfined aquifer following the wider catchment drainage pattern is a relatively minor component of the water balance.

Reduction potential

Aquifers within this zone have low reduction potential due to their low organic carbon content. As a result, there is low potential for denitrification to occur within the aquifer.

However, groundwater within this zone typically exhibit a mixed redox state reflecting the influence of reducing soil conditions on water infiltrating through the soil zone.

Deep drainage

Deep drainage to groundwater comprises a significant component of the water balance in this zone. However, deep drainage is not a major contaminant pathway due to denitrification and physical attenuation of particulate contaminants within the soil profile.

Gleyed SATURATED zone characteristics

WATER TABLE DEPTH
Shallow

AQUIFER PERMEABILITY
Low

ACTIVE GROUNDWATER STORAGE
Moderate

REDUCTION POTENTIAL
Low

DEEP DRAINAGE POTENTIAL
Moderate to low

Gleyed(o) SATURATED zone characteristics

WATER TABLE DEPTH
Shallow*

AQUIFER PERMEABILITY
Low

ACTIVE GROUNDWATER STORAGE
Minor

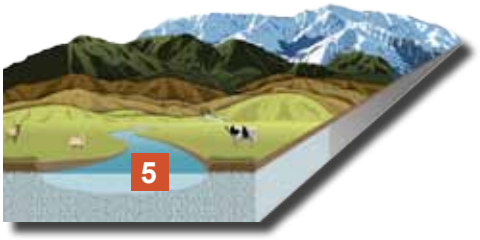
REDUCTION POTENTIAL
Low

DEEP DRAINAGE POTENTIAL
Moderate

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

5 Water quality implications

Contaminant loss via artificial drainage is the main water quality issue for this physiographic zone. Contaminants can accumulate in the upper soil layers and become mobilised during precipitation events. During these events contaminants are carried with soil water through mole-pipe drains to receiving surface waterways. Where land is more steeply sloping, contaminant loss may also occur via overland flow.



Influencing factors

Water quality in the Gleyed zone is influenced by the hydraulic properties and reduction potential of soils (Figure 2).

Water quality issues

Nitrogen loss from this zone is moderated by soil denitrification.

However, the actual extent of denitrification depends on the nutrient load and residence time of water within the soil zone.

The greatest nitrate losses tend to occur through mole-pipe drainage. The magnitude of nitrate leaching via mole-pipe drainage will vary according to water residence time

Groundwater

Nitrate concentrations in deep drainage to groundwater are typically low, due to high soil zone denitrification potential.

Consequently, groundwater discharge to surface waters (baseflow) is not a significant source of nitrogen.

Surface water

Nutrient concentrations (nitrogen and phosphorus), microbes and sediment in surface waters can increase by orders of magnitude during episodic drainage events (Figure 3).

Key HYDROCHEMICAL features

- Waters in this zone are varied: Ca-HCO_3, Mg-HCO_3 or Na-Cl type. Major influences on water type in this zone include soil base saturation and marine aerosol loading as a function of distance to the coast.
- Nitrate concentrations in groundwater and stream baseflow are generally low. Surface waters may exhibit large increases in nitrate concentrations in response to heavy or sustained precipitation events.

What affects water quality in the Gleyed zone?

WHERE	KEY CHARACTERISTICS	CONTAMINANT PATHWAYS	ATTENUATION PROCESSES	WATER QUALITY RISK
All areas	Low subsoil permeability Flat topography	Artificial drainage in response to sustained or heavy precipitation events	Limited filtration, adsorption and denitrification may occur in water moving through the soil matrix	Nitrogen Phosphorus Microbes Sediment Contaminants discharged rapidly to surface water
		Deep drainage to groundwater when soils are wet	Filtration, adsorption and denitrification in the soil zone	Low water quality risk
		Lateral drainage	Filtration, adsorption and denitrification in the soil zone	Low water quality risk
Overland flow variant	Sloping Low subsoil permeability	Overland flow in response to sustained or heavy precipitation events	Reduction of contaminant concentrations may occur where there are higher precipitation volumes	Nitrogen Phosphorus Microbes Sediment Contaminants discharged rapidly to surface water

CONTAMINANT PATHWAY	MITIGATION OBJECTIVES
Artificial drainage	Protect soil structure, particularly in gullies and near stream areas Reduce phosphorus use or loss Reduce the accumulation of surplus nitrogen in the soil, particularly over autumn and winter Avoid preferential flow of effluent through drains Capture contaminants at drainage outflows
Overland flow	Protect soil structure, particularly in gullies and near stream areas Manage critical source areas Reduce phosphorus use or loss

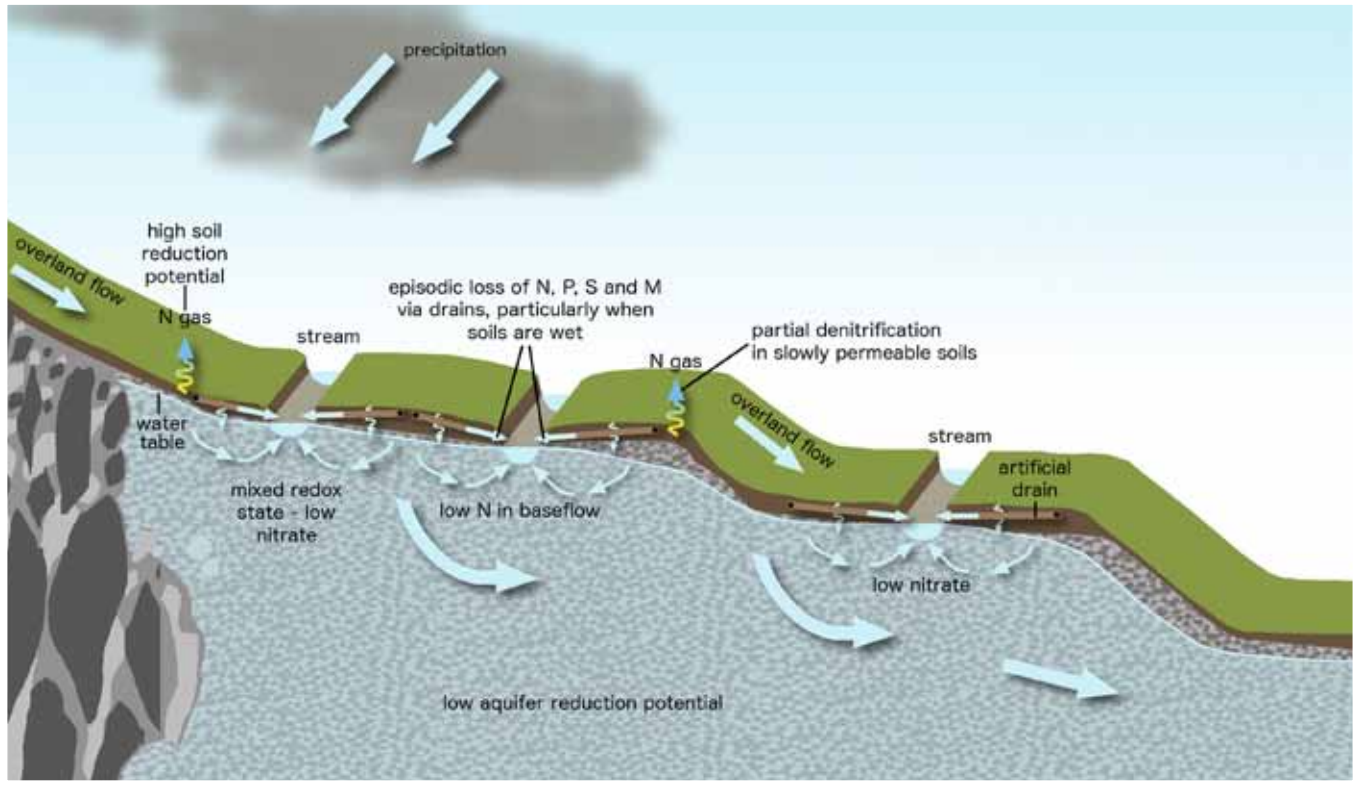


Figure 2: **Main zone** – Deep drainage to groundwater typically contains low nitrate concentrations due to denitrification within poorly drained soils.

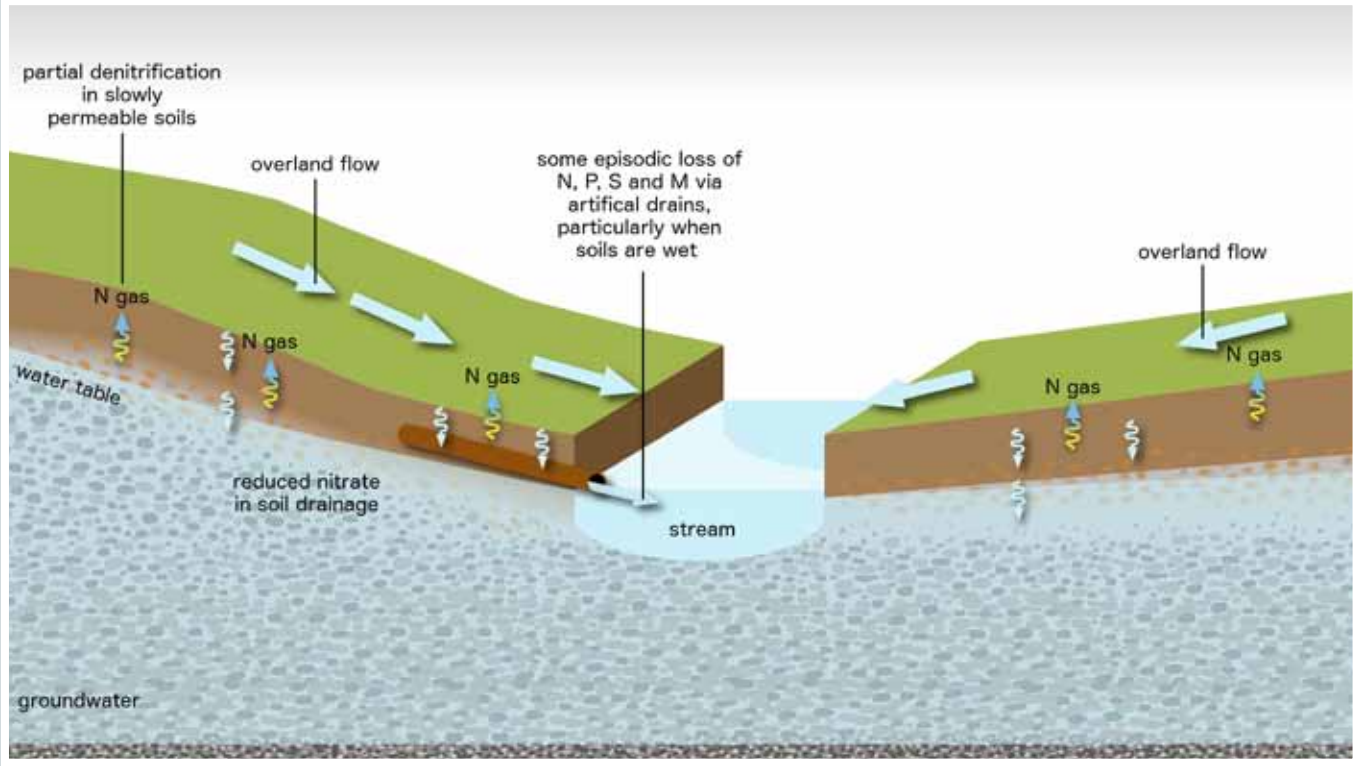


Figure 3: **Overland Flow variant** – Episodic losses of nitrogen (N), phosphorus (P), sediment (S) and microbes (M) to surface waterways occurs in response to heavy or sustained precipitation events.