SOUTHLAND
PHYSIOGRAPHIC ZONES

WATER AND LAND 2020 & BEYOND

PEAT WETLANDS
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

- Overview and map of the Peat Wetlands zone
- Variants and associations
- Landscape characteristics
- Surface zone characteristics
- Soil zone characteristics
- Saturated zone characterisitcs
- Water quality implications

environment SOUTHLAND REGIONAL COUNCIL
Te Taiao Tonga

PEAT WETLANDS
physiographic zone

Peat Wetlands zone

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

Peat Wetlands Physiographic Zone

APPROXIMATE AREA

61,870 hectares

GEOGRAPHIC DISTRIBUTION

Along the south coast and in remnant inland wetland areas.

MAIN SURFACE WATERWAYS

Home Creek, Carran Creek, Mokotua Stream, Waimatuku Stream headwaters.

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

Overview

The Peat Wetlands physiographic zone is characterised by high organic carbon content in soils and underlying geology, which exerts a strong influence over water quality. This zone predominantly occurs in close proximity to the coast and accounts for 2% of the total land area of Southland.

Key features

- Poorly drained, peaty soils, which are extremely acidic.
- The limited mineral content of organic soils and aquifers results in low P retention capacity.
- An elevated water table requiring extensive artificial drainage where land is developed.
- High soil and aquifer denitrification potential.
- A predominantly coastal location, with surface water and groundwater discharge often occurring into lagoons, estuaries and coastal lakes.

Water quality implications

- Episodic contaminant losses via artificial drainage to surface waterways occurs following heavy rainfall or when the water table is near the surface.
- Soluble phosphorus concentrations are elevated in acidic, oxygen-depleted ground- and surface waters.
- Nitrate concentrations are low in groundwater and surface waters due to extensive denitrification.

WATER QUALITY RISK	OXIDISING
Contaminant pathways	Deep drainage, lateral drainage, and artificial drainage where land is developed
Dilution and attenuation processes	Reducing soils and aquifers
Primary receiving environments	Surface waterways and aquifers
Water quality risk	Phosphorus, 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 Peat Wetlands physiographic zone.

Associations

There are three physiographic zones commonly associated with the Peat Wetlands zone (Figure 1).

Central Plains

The Peat Wetlands zone occurs around the periphery of the Central Plains zone where drainage is impeded by the underlying geology (for example Bayswater Bog).

The Peat Wetlands zone discharges to streams draining the Central Plains zone.

Gleyed

Small areas of the Peat Wetlands zone occur across the Gleyed zone reflecting remnants of historically extensive wetland areas that occurred in flat-lying areas, with poorly drained soils.

The peat Wetlands zone discharges to streams draining the Gleyed zone.

Lignite/Marine Terraces

Areas of Peat Wetlands occur adjacent to the Lignite/Marine Terraces zone along the south coast.

The Peat Wetlands zone discharges to streams draining the Lignite/Marine Terraces zone.

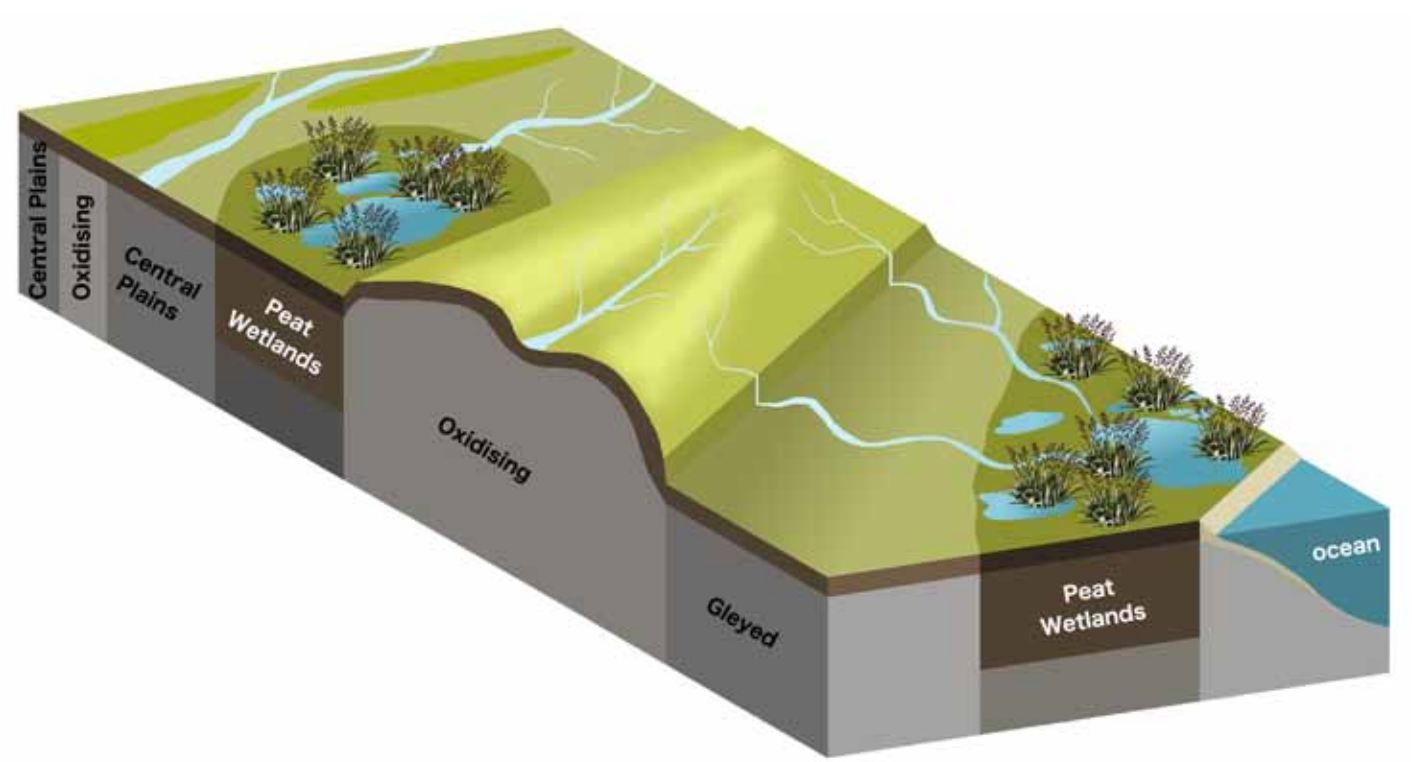
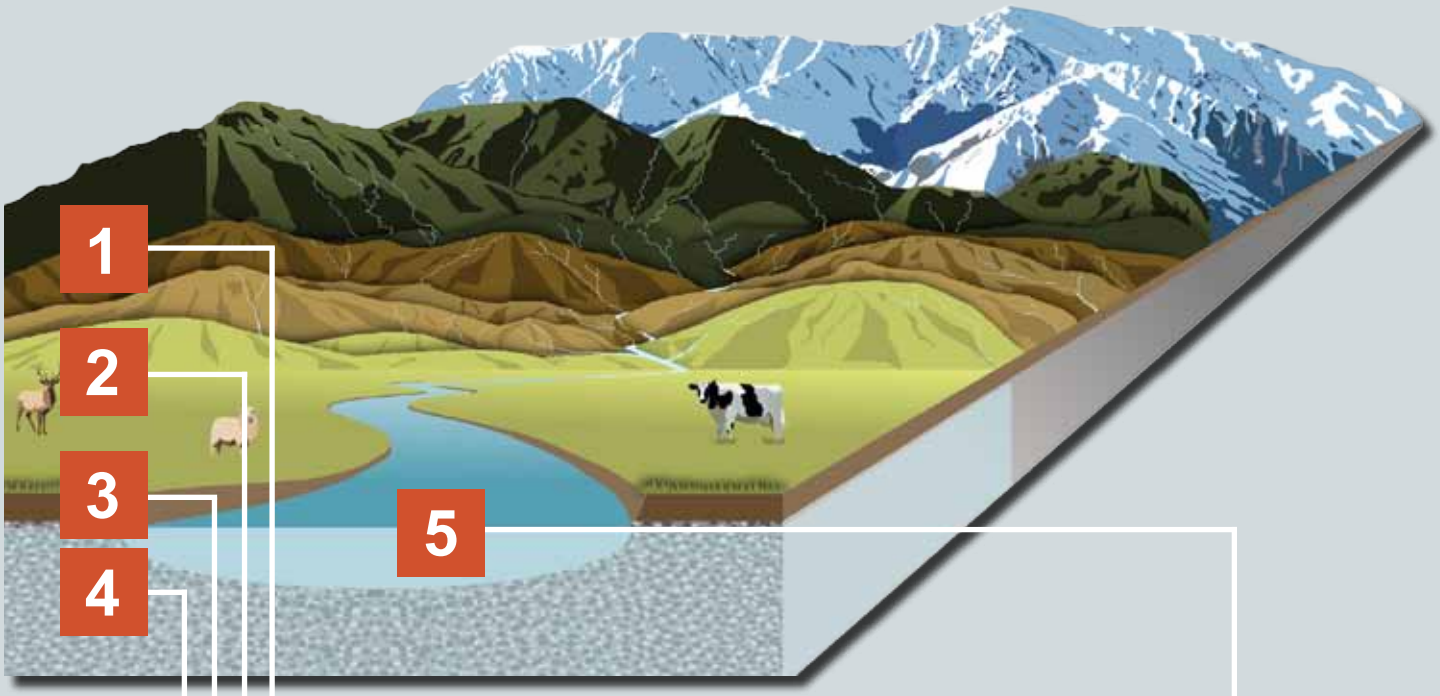


Figure 1: Landscape context image showing neighbouring zones. The Peat Wetlands zone occupies wetland, boggy, swampy or mire areas where partially decayed vegetation has accumulated. In Southland, most of these areas occur along the southern coast however Peat Wetlands are also found in sub-alpine areas in some catchments. Undeveloped Peat Wetlands often develop extensive convex domes where the middle of the wetland is raised above the local topography.

Dominant characteristics that affect water quality



Landscape characteristics

Surface zone characteristics

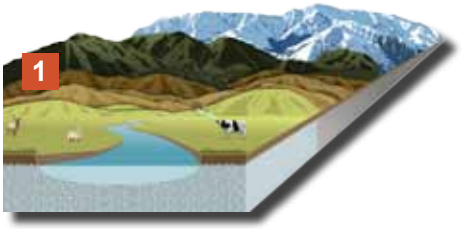
Soil zone characteristics

Saturated zone characteristics

Water quality implications

1 Landscape characteristics

The Peat Wetlands zone occurs in low-lying coastal areas between the Catlins and Orepuki. Isolated wetland remnants also occur in sub-alpine areas of the Oreti, Aparima and Waiau catchments.



Topography

Peat wetlands once extended across a significant area of Southland prior to agricultural development. However, today this zone accounts for 2% of the total land area.

Elevation

Most of this zone occurs at elevations of less than 200 metres.

Peat Wetland areas at higher elevations are mainly restricted to remnant areas in the upper reaches of the Aparima catchment and the mid to upper reaches of the Waiau catchment.

Slope

Most of the zone is flat to gently undulating (≤3° slope). Remaining areas are generally restricted to sub-alpine areas, which are undulating to steep.

Geology

This zone is mainly comprised of peat underlain by fine alluvium. However, in some areas along the south coast the proportion of alluvial materials may increase.

The thickness of overlying peat deposits varies from less than 1 metre to over 10 metres.

A majority of Peat Wetland zone occurs in areas that are relatively recent in origin (Q2 to Q4), reflecting extensive wetland development across the Southland region over the late Holocene period.

Climate

Most of the zone occurs in lowland and coastal areas where annual rainfall typically ranges between 1,000 to 1,300mm. However, annual rainfall of over 6,000mm may occur in some wetland areas in Fiordland.

Peat Wetland LANDSCAPE zone characteristics

ELEVATION
0 – 300 m RSL

SLOPE
Flat to gently undulating

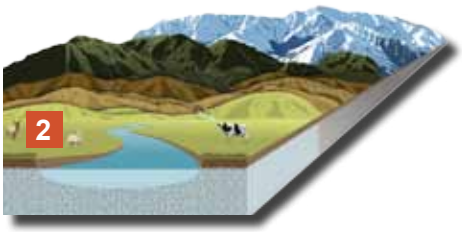
GEOLOGY
Quaternary sediments

LANDFORM AGE
Q2–Q4

AVERAGE ANNUAL RAINFALL
1,396 mm per year

2 Surface zone characteristics

Recharge to the Peat Wetlands zone occurs exclusively via local precipitation infiltrating through the soil matrix.



Dilution

This zone is predominately recharged via land surface recharge (matrix flow). There is limited potential for dilution of contaminant concentrations associated with this recharge mechanism.

Surface waterways

Surface waterways are characterised by a high number of moderately sized streams, which can form a dense stream network. This is augmented by extensive artificial drainage, comprising mainly open drains, in developed areas.

Surface waters have a mixed redox state due to re-aeration with atmospheric oxygen and periodic rapid discharge via artificial drainage networks which reduce the time available for reduction to occur.

Overland flow

In some wetland systems, the water table can become elevated above ground level (seasonally or permanently) resulting in surface ponding.

However, due to the predominately flat topography, overland flow occurs only in localised areas.

Peat Wetlands SURFACE zone characteristics

DILUTION POTENTIAL
Low recharge flux

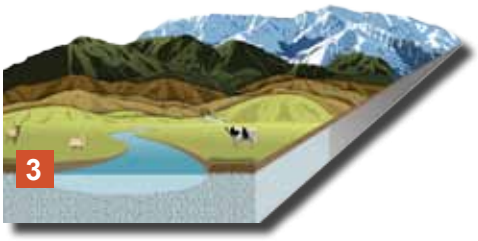
DRAINAGE DENSITY
High

STREAM ORDER
Mixed

OVERLAND FLOW POTENTIAL
Low

3 Soil zone characteristics

Artificial drainage to surface waterways is the main drainage mechanism where land has been developed, due to the flat topography, poorly drained soils and high water tables.



Soils

Soils in this zone are classified as Organic. Between 50-90% of the soil mass is composed of weakly to moderately decomposed organic material.

Loose fibrous peat near the land surface often grades to denser, amorphous peat with depth.

Soils are generally structureless with low bulk density. These soils have very poor internal drainage and are susceptible to waterlogging, particularly where the water table is shallow.

Soils are also extremely acidic, limiting their versatility for agricultural use and often resulting in sparse vegetation cover.

These soils are susceptible to phosphorus leaching due to a combination of limited mineral ability to sequester or sorb phosphorus out of solution and their strongly reducing characteristics.

Reduction potential

Soils in this zone have high reduction potential due to their high organic carbon content and high water table. As a result, waters are strongly reducing.

Artificial drainage

Due to the high potential for waterlogging within this zone, agriculturally developed areas are extensively drained.

Artificial drainage is used to remove excess soil water and help maintain the water table below ground level.

Artificial drainage occurs as:

- closely spaced open drains
- tile drains (generally located in areas where soils have a more loamy texture).

Lateral drainage

Lateral drainage through the soil profile is an important pathway for this zone.

Lateral flow occurs in waterlogged soils where there is sufficient slope due to topography or mounding within the wetland.

Where land is developed, lateral drainage is intersected by artificial drainage.

Peat Wetlands SOIL zone characteristics

SOIL ORDER
Organic

PROFILE DRAINAGE
Very poorly drained

PERMEABILITY
Moderate over slow*

ANION STORAGE CAPACITY
Very low to moderate

REDUCTION POTENTIAL
High

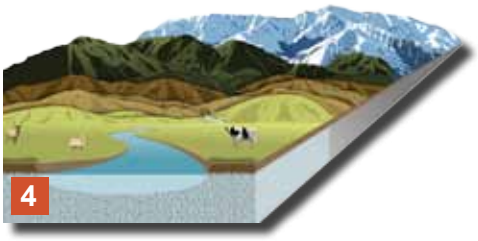
ARTIFICIAL DRAINAGE DENSITY
Very high

LATERAL DRAINAGE POTENTIAL
Localised

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

4 Saturated zone characteristics

Groundwater mainly occurs in low permeability unconfined aquifer systems, which can become increasingly confined with depth. Aquifers exhibit little or no direct connectivity with main stem river systems.



Groundwater

Groundwater levels

Groundwater levels are shallow and often occur at, or near, ground level.

Groundwater levels exhibit a regular seasonal pattern. They peak in spring following progressive recharge during winter and spring, and decline over summer and autumn as aquifer storage is progressively depleted by baseflow discharge to streams draining this zone.

Groundwater discharge

Due to the raised topography and high water table, groundwater discharge occurs as:

- Baseflow to rivers and streams often via artificial drains.
- Throughflow to aquifers in adjacent zones.

Reduction potential

Aquifers in this zone have high reduction potential (i.e. waters are strongly reducing).

This results in elevated ferrous iron (Fe^{2+}) and ammoniacal nitrogen concentrations in groundwater (naturally derived through ammonification of organic matter under reducing conditions).

Aquifers have low phosphorus sorption capacity due to the organic composition of aquifer materials. Reducing conditions can enhance phosphorus mobility in groundwater through the formation of microscopic phosphorus-colloids.

Deep drainage

As soils dry, deep drainage to groundwater becomes the primary drainage mechanism.

Deep drainage to groundwater occurs at a slow rate due to slow soil and aquifer permeability.

Peat Wetlands SATURATED zone characteristics

WATER TABLE DEPTH
Shallow

AQUIFER PERMEABILITY
Low

ACTIVE GROUNDWATER STORAGE
Moderate

REDUCTION POTENTIAL
High

DEEP DRAINAGE POTENTIAL
Low

5 Water quality implications

There are two main water quality issues for the Peat Wetlands physiographic zone:

1. Phosphorus loss to ground and surface waters, due to a combination of low anion storage capacity of organic soils and aquifer materials and strongly reducing conditions.
2. Microbial contaminants in surface water due to the dense network of artificial drains, prolonged surface ponding and lateral flow through fibrous peat.

Influencing factors

Water quality in the Peat Wetlands zone is influenced by the limited capacity of organic soils and aquifer materials to retain phosphorus and strongly reducing conditions in soils and underlying aquifers (Figure 2).

Water quality issues

Groundwater

With intensive land use, phosphorus concentrations in groundwater can become elevated due to low phosphorus retention in soils and aquifers.

Reducing soils and aquifers further enhance phosphorus mobility through the formation of microscopic phosphorus-colloids.

Both dissolved and particulate forms of phosphorus can become elevated in groundwater.

Groundwater discharge from this zone has a high potential to add to phosphorus levels in surface waterways.

Nitrate concentrations are very low in groundwater due to rapid denitrification rates in the soil zone and underlying aquifers.

Surface water

Where land is developed, contaminants that accumulate in the upper soil layers can become mobilised and exported with excess soil water to streams via artificial drains.

Discharge of dissolved and particulate contaminants may also occur via the artificial drainage network and lateral drainage in surficial layers of fibrous peat.

The high water table and predominately coastal climate increases the risk of episodic of discharges contaminants (phosphorus, microbes and sediment) when soils are wet.

During high flow events, phosphorus concentrations increase markedly in surface waters in catchments with intensive land use but remain largely unchanged in undeveloped peat wetland catchments.

Key HYDROCHEMICAL features

- Waters are acidic due to the high organic acid content in peat sediments and low pH buffering capacity. This also results in low alkalinity in surface waters.
- Despite the low base saturation in soils, total dissolved solute concentrations are high, reflecting the predominately coastal precipitation and a greater abundance of reduced ions (e.g. iron and zinc) and dissolved organic carbon.
- Dissolved calcium concentrations are low due to low soil base saturation of the soil.
- Potassium is elevated in groundwater due to the limited mineral material for regulation of potassium though ion exchange (so it is very leachable).
- Iron concentrations are elevated in ground- and surface waters due to the strongly reducing conditions in soils and aquifers.

What affects water quality in the Peat Wetlands zone?

WHERE	KEY CHARACTERISTICS	CONTAMINANT PATHWAYS	ATTENUATION PROCESSES	WATER QUALITY RISK
All areas	Localised precipitation Land surface recharge Predominantly flat topography Soils and aquifers have high organic carbon content High water table Low phosphorus retention in soils and aquifers	Lateral flow through the soil matrix when soils are wet and where shallow fibrous peat overlies finer-grained lower permeability sediments	High denitrification due to strongly reducing soils	Phosphorus Microbes Contaminants discharged to surface waterways
		Artificial drainage in developed areas	Low denitrification potential in soils and aquifers	Nitrogen Phosphorus Microbes Sediment Contaminants rapidly exported to surface waterways
		Deep drainage through soil and saturated zone when soils are wet	Denitrification due to strongly reducing aquifers	Phosphorus Contaminants discharged to groundwater
		Overland flow in response to high precipitation	Limited contaminant attenuation	Low water quality risk due to limited occurrence and restricted spatial extent

CONTAMINANT PATHWAY	MITIGATION OBJECTIVES
Lateral and deep drainage	Reduce phosphorus use or loss Reduce transport of microbes
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

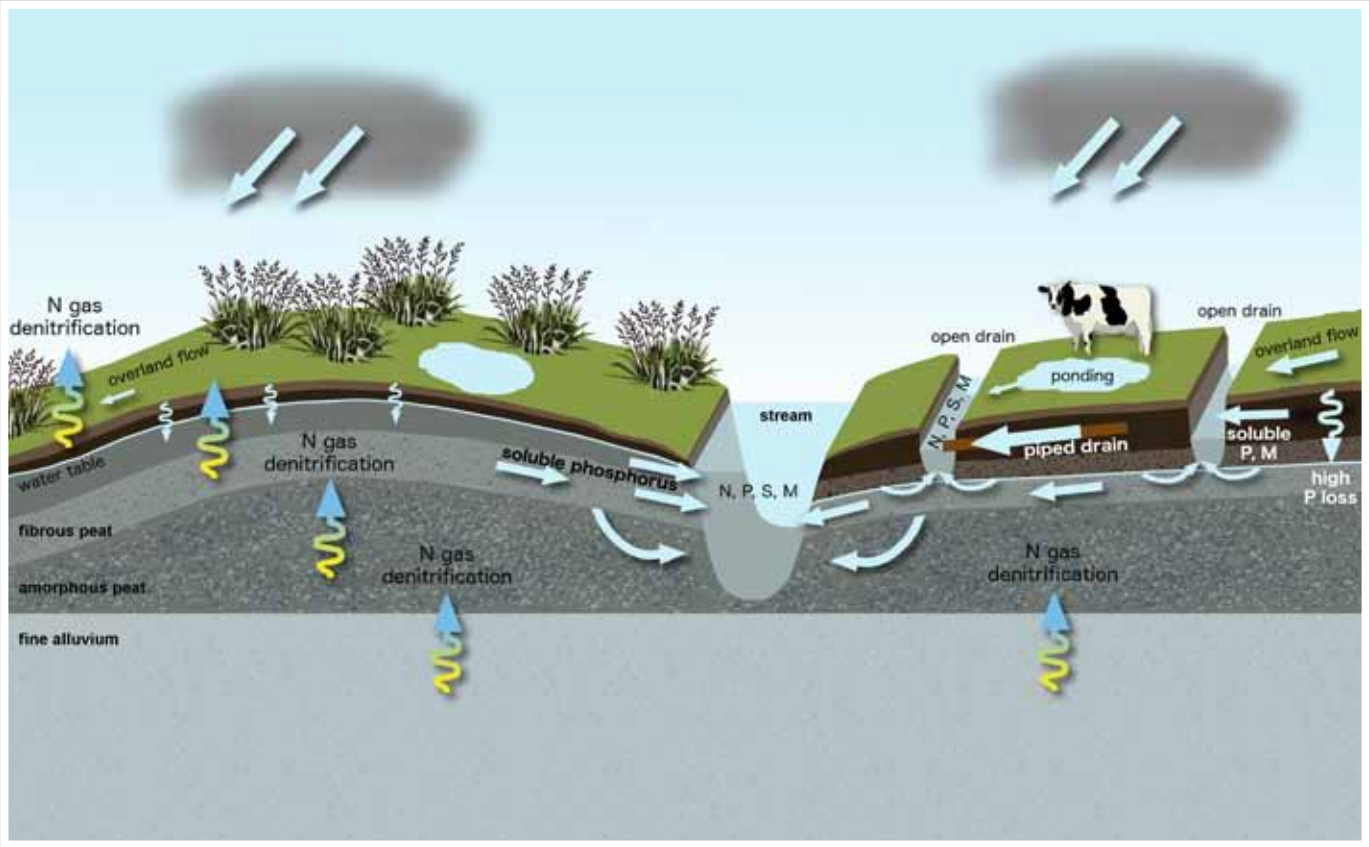


Figure 2: Nitrate losses from the Peat Wetlands physiographic zone are minor due to strongly reducing soils and aquifers. However, the combination of reducing conditions and the organic composition of soils and aquifers mobilises soluble and particulate phosphorus, which can become elevated in groundwater and surface water. Extensive artificial drainage also allows episodic losses of nitrogen (N), phosphorus (P), sediment (S) and microbes (M) to surface waterways.