# ENVIRONMENT SOUTHLAND'S "PHYSIOGRAPHICS OF SOUTHLAND" PROJECT - WHAT DO PHYSIOGRAPHIC ZONES MEAN FOR YOUR FARMING OPERATION?

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## Summary

The Physiographics of Southland project has been undertaken to better understand where our region's ground and surface water comes from, the processes it undergoes as it moves through the landscape and how and why we see variation in water quality across the region. Through this understanding, we can then identify the most effective management options to improve water quality for different land areas and target our responses accordingly.

A team of scientists has spent the last 18 months working with a comprehensive dataset to identify and map nine different physiographic zones for the Southland region. Each zone contains land areas that respond in a similar manner to land use in terms of water quality. The physiographic zones form the basis for new land use and wintering rules in Environment Southland's Proposed Water and Land Plan (due to be notified in June) and will underpin targeted management actions in Farm Environmental Management Plans in the region in future.

The physiographic zones provide a comprehensive understanding of the factors influencing water quality and the main transport pathways for contaminants. This means that management actions can be targeted to be the most effective and efficient for your farming operation.

## Background

Water quality varies across both space and time. This variability occurs despite similar or identical land uses and is a result of different chemical, physical, geological and biological factors. For example, the same type and level of intensity of land use over deep free draining

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gravels versus heavy soils will result in very different water quality outcomes. The free draining gravels will be likely to be prone to nitrate leaching to groundwater while the heavy soils will have a risk of contaminants entering surface water via overland flow or artificial drainage during rainfall events. This is but one example of the factors or "drivers" influencing water quality.

The Physiographics of Southland project assesses the role that different chemical, physical, geological and biological factors have in water quality variation and divides Southland into nine physiographic zones. Each zone represents areas of the landscape with common drivers of water quality. Zones differ in the way that nutrients (e.g. nitrogen and phosphorus) sediment and microbes (e.g. *E.coli*) build up and move through the soil, aquifers (areas of groundwater) and into our rivers and streams.

As outlined above, the physiographic zones form the basis for new land use and wintering rules in Environment Southland's Proposed Water and Land Plan (due to be notified in June) and will underpin targeted management actions in Farm Environmental Management Plans in the region in future.

## The science behind the physiographic zones

The Physiographics of Southland project makes use of a comprehensive dataset that has been collected through Environment Southland's monitoring programmes. Environment Southland has a number of long-term state of the environment monitoring programmes in place to better understand and manage our region's water resources. For the last five years, these programmes have been extended to collect a much more comprehensive suite of hydro-chemical and water quality measurements than traditional state of environment monitoring programmes. This has enabled the chemical constituents in soil, ground and surface waters across the region to be better characterised and has included measuring a range of isotopes, major ions in both ground and surface water along with sampling and characterisation of precipitation, soil water and a range of discharges (effluents, fertilisers and animal urine/manure).

A team of Environment Southland and consultant scientists, supported by scientists from various research agencies, has spent the last 18 months working with this dataset and existing spatial frameworks to identify the key drivers of water quality. Close to 30,000 individual water samples were analysed and cross-referenced against existing spatial frameworks (i.e. soils, geology, topography, hydrology, hydrogeology and geomorphology) to identify these key drivers. The key drivers specific to the Southland context were identified as follows:

- Precipitation source and composition
- Recharge mechanism(s) and water source (e.g. riverine, land surface recharge)
- Geomorphic setting and substrate (rock and biological sediments including soils) composition

- Redox control (combined soil zone and geological reduction potential).

The understanding of the spatial location of drivers and the interaction between groupings of drivers provided the basis for classifying and mapping nine different physiographic zones for the region. These zones are land areas with similar groupings of key water quality drivers (i.e. land areas that respond in a similar manner to land use in terms of water quality outcomes).

## Overview of the physiographic zones

The following sections provide an overview of each physiographic zone and the main transport pathways for contaminants within that zone.

### *Alpine*

The Alpine physiographic zone includes all land above 800 m elevation, and is mainly found in northern and western parts of Southland. This zone is characterised by steep slopes with thin soils or bare bedrock. Its high elevation results in high precipitation (snow and rainfall), which provides large volumes of pristine water to downstream physiographic zones. Contaminant loss is limited due to low intensity of land use.

### *Bedrock/Hill country*

The Bedrock/Hill Country physiographic zone is the largest in the Southland Region, covering half the mapped area (approximately 1.6 million hectares). It is characterised by rolling to steep land below 800 m elevation. This zone has high rainfall due to elevation, which results in a dense network of streams that flow to lowland areas. Streams in developed areas of this zone are at risk of receiving contaminants from surface runoff and lateral flow through the soil zone.

Main transport pathways for contaminants:

- Surface runoff – nitrogen, phosphorus, sediment and microbes to streams
- Lateral flow through the soil zone – phosphorus to streams.

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### *Central Plains*

The Central Plains Physiographic zone extends across flat to gently undulating terraces in the lower reaches of the Aparima and Oreti Catchments in Central Southland. This zone has many small streams and has an extensive underlying aquifer system. Soils are characteristically rich in clays that swell when wet and crack when dry. When soils are wet, contaminants move quickly through artificial drainage networks to surface waterways. When soils are dry, cracks allow water and contaminants to rapidly drain down through the soil to groundwater.

Main transport pathways for contaminants:

- Artificial drainage – nitrogen, phosphorus, sediment and microbes to streams
- Deep drainage (through cracks when soil is dry) – nitrogen to aquifers
- Lateral drainage (in some areas) – microbes and phosphorus to artificial drainage and streams.

### *Gleyed*

The Gleyed physiographic zone extends across flat to gently undulating land across the plains of both northern and southern Southland. It is generally found in areas that were once wetlands, has a dense network of streams and has a high water table during winter. Soils are prone to waterlogging and have some denitrification ability, which reduces build-up of soil nitrogen. However, an extensive network of artificial drainage rapidly transports contaminants to surface water, particularly during heavy rain.

Main transport pathways for contaminants:

- Artificial drainage – nitrogen, phosphorus, sediment and microbes to streams
- Lateral drainage through soil zone – nitrogen to streams.

### *Lignite/Marine Terraces*

The Lignite/Marine Terraces physiographic zone is distributed along Southland's south coast and in areas of Eastern and Western Southland where the underlying geology has elevated organic carbon (such as lignite or coal). There is little nitrogen build-up in soils and aquifers due to high denitrification potential. Phosphorus build-up in soils is also low where lignite and marine sediments are close to the surface.  Artificial drainage is extensively used where soils are poorly drained.

Main transport pathways for contaminants:

- Artificial drainage – nitrogen, phosphorus, sediment and microbes to streams
- Lateral drainage – microbes and dissolved phosphorus to streams
- Deep drainage – phosphorus to aquifers.

### *Old Mataura*

The Old Mataura physiographic zone is located on the older, high terraces in the Mataura catchment. Soils and aquifers in this zone have high risk of nitrogen build-up due to low denitrification potential. The combination of flat land and well drained soils results in high rates of nitrogen leaching (deep drainage) to underlying aquifers. Groundwater in this zone discharges into springs, streams and aquifers in lower parts of the Mataura catchment, adding to their contaminant levels.

Main transport pathways for contaminants:

- Deep drainage – nitrogen to aquifers
- Artificial drainage - nitrogen, phosphorus, sediment and microbes to surface drainage network.

### *Oxidising*

The Oxidising physiographic zone is located on intermediate terraces along the margins of major river systems. Many surface waterways draining this zone originate from headwaters in neighbouring physiographic zones. Soils and aquifers in this zone have high risk of nitrogen build-up due to low denitrification potential. The combination of flat land and well drained soils results in high rates of nitrogen leaching (deep drainage) to underlying aquifers. Artificial drainage and surface runoff (overland flow) are also key transport pathways in some parts of this zone.

Main transport pathways for contaminants:

- Deep drainage – nitrogen to aquifers
- Surface runoff (overland flow) - nitrogen, phosphorus, sediment and microbes to streams
- Artificial drainage - nitrogen, phosphorus, sediment and microbes to streams.

### *Peat Wetlands*

The Peat Wetlands physiographic zone was once extensive across Southland. However, today it accounts for is less than 2% of the total land area.  This zone is characterised by highly

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acidic peaty soils and a naturally high water table. Developed areas have an extensive artificial drainage network, comprised of open and mole-pipe drains. There is little nitrogen build-up in soils and aquifers due to high denitrification potential. However, acidic conditions result in elevated concentrations of soluble phosphorus in both soils and aquifers.

Main transport pathways for contaminants:

- Deep drainage – phosphorus to aquifers
- Artificial drainage - nitrogen, phosphorus, sediment and microbes to streams
- Lateral drainage – microbes and phosphorus to streams.

### *Riverine*

The Riverine physiographic zone occurs along the margins of Southland’s major river systems. Rivers and streams within this zone carry large volumes of pristine alpine water to the coast. However, river water in this zone also contains soil water drainage from adjacent land.

Soil water drains quickly through shallow, stony soils to underlying shallow aquifers, which are highly connected to rivers. This, combined with the low denitrifying potential of soils and aquifers results in aquifers and adjacent rivers being at risk of nitrogen build-up from soil leaching (deep drainage). Therefore, nitrogen loss from aquifers can contribute significant nitrogen loads to downstream environments.

Main transport pathways for contaminants:

- Deep drainage – nitrogen to aquifers
- Overland flow (in some areas) - nitrogen, phosphorus, sediment and microbes to streams.

## The benefits of the physiographic zones for your farming operation

The physiographic zones provide a comprehensive understanding of the factors influencing water quality and the main transport pathways for contaminants. This means that management actions can be targeted to be the most effective and efficient for your farming operation.

A key mechanism for using physiographic information to tailor on-farm management actions is through a Farm Environmental Management Plan. These plans outline farm-specific good management practices and recommendations for your property. Environment Southland’s Land Sustainability team are available to assist in the preparation of these plans.

Some of the benefits of having a Farm Environmental Management Plan include:

- Identifying the environmental risks specific to your property.
- Minimising soil, water and nutrient losses, which cost you money (i.e. what is good for the environment is generally also good for your wallet)

- Demonstrating that your management practices are having a positive impact on the environment.

Farmers who have had a plan compiled for their property are also able to apply for funding to assist with their implementation.

## Case study – Oxidising physiographic zone

This section highlights how physiographic information can be used to tailor on-farm management actions. The main transport pathway for contaminants across most of the oxidising physiographic zone is leaching of nitrogen to groundwater. This flow pathway is depicted in the diagram below:

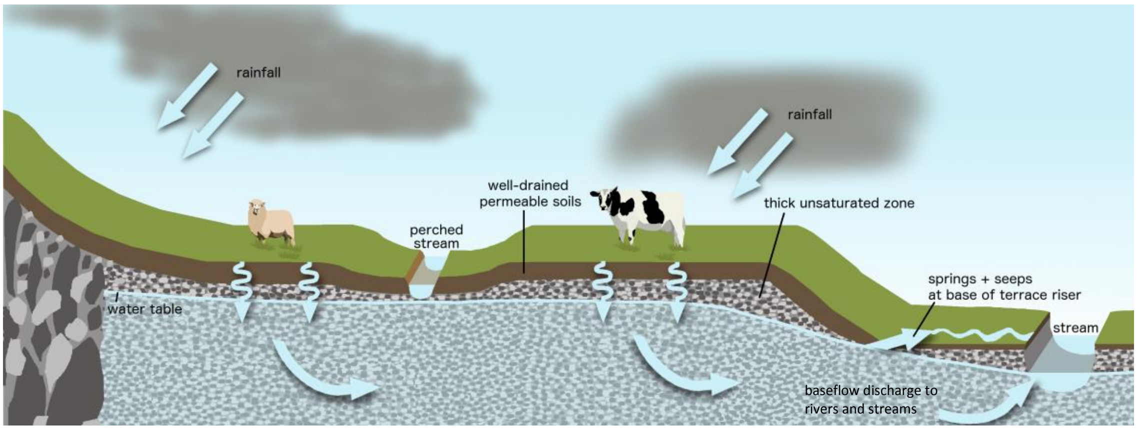


**Figure 1.** Deep drainage of nitrogen to groundwater in the oxidising physiographic zone

Some examples of good management practices relevant to the oxidising physiographic zone which could be included in a Farm Environmental Management Plan to address the above are as follows:

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| Mitigation | Example Good Management Practices |
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| **Reduce the accumulation of surplus N in the soil, particularly during autumn and winter** | Reduce inputs of N, such as fertiliser or nitrogen contained in imported feed. |
| | Control the duration of grazing of pasture and forage crops (on-off grazing) |
| | Winter stock off-paddock |
| | Plant catch crops to capture N from grazed winter forages (e g  barley and triticale) |
| | Optimize timing and amounts of irrigation input |
| | Substitute autumn diets with low-N feed (such as whole crop silage) |
| | Reduce stocking rate |
| | Cut and carry fodder crops if practical and affordable |
| | Use gibberellic acid to boost pasture growth to reduce overall N inputs. |
| | Re-sow areas of bare or damaged soil as soon as possible |