Horizons Regional Council: Landforms

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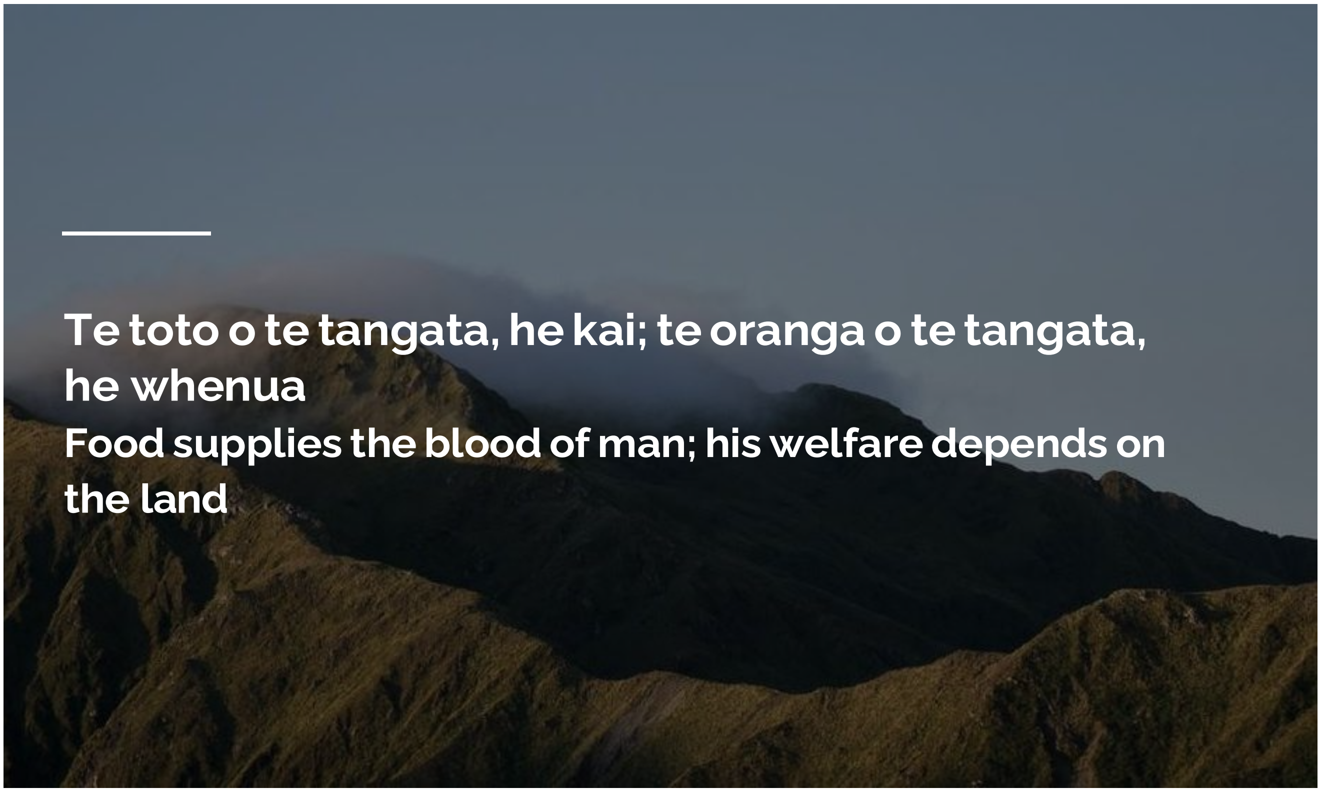
Lesson 1 - Introduction



This document introduces the five major landform types in our region and explains how different landforms drive specific contaminant risks and pathways. As a result, you will understand how to relate field information and paddock-scale information to contaminant risk.

This document looks at the following topics:

1) The relationship between Catchment Context values and risks to contaminant pathways to accurately identify high risk parts of the farm

2) Main regional landforms to enable a focus on relevant pathways and determinants of risk

3) Guidance for field checking the landform and risk to enable a sound risk assessment

4) The recommended process for risk mapping.

Landform assessment is a vital part of the process of determining appropriate action to address catchment issues, because landforms control which of the contaminants might get to the river, how they get to the river and where they can be caught or stopped. Usually a number of different on-farm actions can work to reduce contaminant amounts reaching the river. Of more importance to attaining improvements to water quality, but frequently overlooked, is getting the right actions in the right place.

This document provides a framework for checking that environmental risk is well identified and mapped and actions are well targeted to be effective.

Lesson 2 - Relating the four main contaminants to contaminant pathways

The relationships between catchment values and the four main contaminants are noted in the Catchment Contexts. The various contaminants travel to water by different pathways. If you understand how the contaminant travels then you can check that the right land has been targeted and that appropriate actions have been identified.

Below are two examples of how phosphate loss is related to landform.

A FLAT ROLLING FARM

On a flat to rolling farm, phosphate in sediment or dung travels mainly by overland flow and bypass flow. If phosphate is an issue for the catchment, the land units with the greatest risk of overland flow can be mapped, and appropriate actions chosen to minimise that overland flow or catch that sediment.

A HILL COUNTRY FARM

On a hill country farm the main source of phosphate is likely to be in sediment from slip or earthflow erosion. Dung and sediment from high stock concentrations in swales or tracks can also be major sources. Therefore, identifying land most vulnerable to erosion debris entering water would be the priority.

Below is a summary of how to link risk contaminants for a catchment to vulnerable land on a farm.

N leaching **Key factors that indicate likely risk** Proximity to stream, river, lake, plus vulnerability to N leaching (see landscape DNA) check S-Map or soil layers for sandy or gravelly soils with rapid permeability on plains.
P leaching **Key factors that indicate likely risk** Rare except where there is low ASC/P retention and very high Olsen P, such as on peat soil.
Overland flow (N, P, pathogens, sediment) **Key factors that indicate likely risk** The top priorities in order are: 1) strongly rolling land in cultivation or Intensive Winter Grazing (IWG) 2) gently rolling land in cultivation or IWG 3) poorly drained soils with slowly permeable subsoil in cultivation or IWG 4) other poorly drained soils in cultivation or IWG.
Hill country erosion (sediment and P) **Key factors that indicate likely risk** How to map the top priority land depends on the types of erosion present, but generally target severe gullied earthflows and slumps (if present) followed by large, very steep hills directly over a waterway.

Lesson 3 - Landforms and contaminant pathways in the region

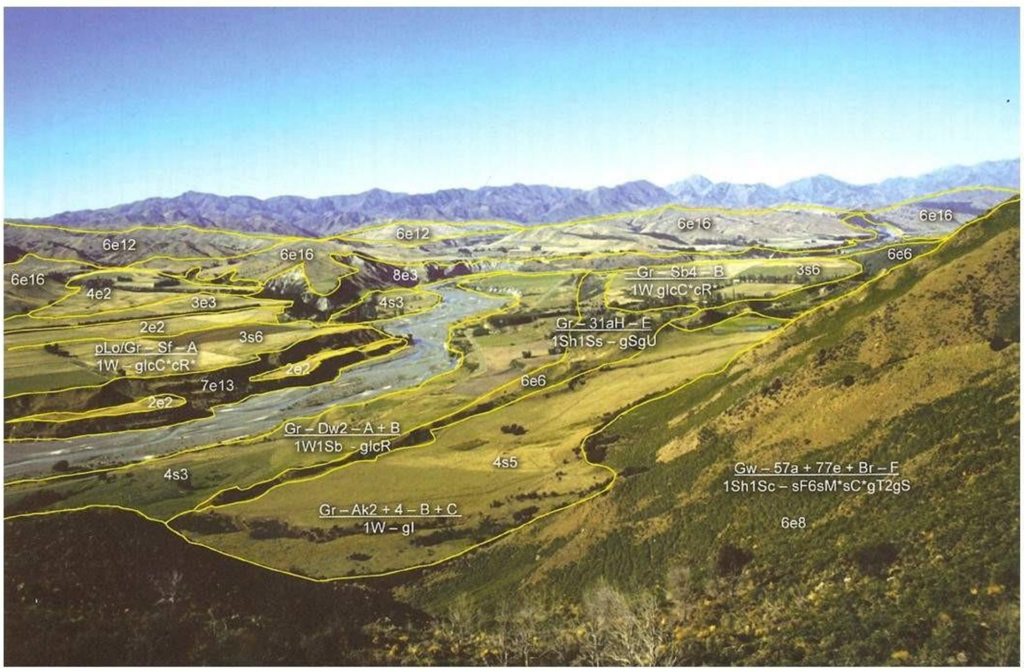
This section summarises the major landforms that might be found on a farm. Each landform has different contaminant pathways, so this will help to identify or check areas of risk on farm. There are five major landforms in Horizons region, based on erosion risk:

- Plains – predominantly flat land on other parent material
- Rolling land – predominantly rolling land on other parent material
- Hill country – predominantly moderately steep to very steep farmable land on other parent material
- Sand country – plains and duneland on windblown sand parent material
- Mountain land – predominantly unfarmable mountain land.

Land Use Capability (LUC)

Each landform is grouped from LUC units (from the New Zealand Land Resource Inventory) with similar contaminant risks and pathways. LUC units are also grouped into suites in the regional LUC classifications. This is to aid understanding of the relationship between landform features and LUC class within a soil parent material, to aid mapping or quality control of mapping.

Example landform features determining LUC class include slope for slip erosion risk, elevation for flood risk, or climate limitations. Most of the suites are based on soil parent material, with limitations to production setting the LUC class within each suite. For example; alluvium suite, loess suite, mudstone suite, sandstone suite.



However, the mountain land landform contains land from a few land suites, as well as steep and rolling land, that is only suitable for catchment protection and is nearly all in the Department of Conservation estate. Meanwhile, the sand country suite contains both duneland and dune plains landforms. Refer to the Regional Information document for references to the main LUC classifications (also known as legends) in Horizons region.

Landform summaries

The landform summaries follow this structure for each landform:

- main farm types
- LUC suites
- contaminant pathways
- determinants of risk for the landform

Guidance on how to confirm the risks through field checking is in Lesson 4, the section entitled: ‘Relate field information and paddock scale information to environmental risk.’ And a recommended process for checking mapping is in Lesson 5, the section entitled: ‘Recommended process for risk mapping.’

LUC suites are mentioned so that information on risk can be looked up from the NZLRI. Refer to the Regional Information document for guidance.

Plains

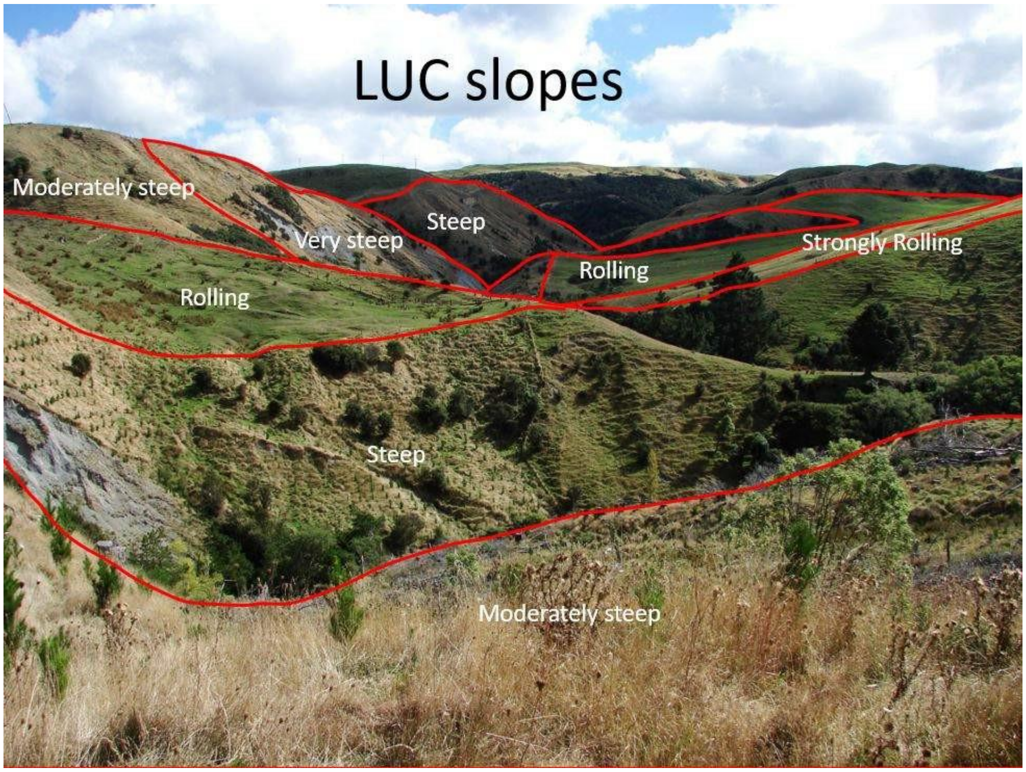
- The majority of farms in the region are on the plains landform. Farms on plains tend to be smaller and more intensive than on other landforms. They include drystock/finishing, dairy, cropping, lifestyle, and some horticulture units.
- Plains Land Use Capability (LUC) units are mainly in the alluvium and gravel rock type suite. There are also plains members for flat land in the loess, pumice, and volcanic ash suites.
- Risks are N leaching, overland flow and streambank erosion.
- There is possible P leaching where there is low ASC/P retention and very high Olsen P, such as on peat soil. Although P leaching is described and mapped in Landscape DNA this is mostly considered low priority by Horizons at this time. Exceptions may be where there is a lake or other particularly sensitive downstream site.

Landscape DNA is introduced in the Regional Information document.

Rolling land

- The major farm types on rolling land are drystock/finishing, dairy, lifestyle, and horticulture.
- Rolling land LUC units are members of the loess, pumice, and volcanic ash rock type suites.
- The main risk is overland flow.
- The main determinant of overland flow risk is paddock scale slope. The risk of sediment loss from intensive winter grazing increases with the slope of the land being winter cropped.
- Flat areas within rolling land may also have a (lower) overland flow risk, and a risk of N leaching.

Hill country



- The major farm types are sheep/beef and forestry. Although there are fewer farms than on the plains and rolling land, hill country farms make up two thirds of the region's farmland.
- The LUC units are from the sandstone, mudstone, argillite, deep-seated erosion suite, limestone, greywacke, and hill country members of the Loess or volcanic ash suites.
- The main environmental risk is sediment.
- The main determinants of sediment risk are paddock-scale slope angle and risk of sediment entering a stream. Other determinants apply to other erosion types – refer to the Erosion document.

Sand country

- The major farm types are drystock/finishing, dairy, lifestyle, and forestry.
- Sand country LUC units are all in the windblown sand rock type suite.
- There is a slight risk of overland flow. Based on recent research and expert advice, it is likely that, although nitrate can leach through dunes, it will be denitrified in the groundwater before reaching waterways.

Mountain land

Mountain land is usually a source of clean water to the catchment, and most mountain landforms don’t occur in farmland. For that reason it does not need to be a focus for freshwater farm plans. However cliff and gorge units are members of the mountain land landform group that do occur in farmland. They have the same risk types and determinants as for the hill country landform. See the Erosion document for details. Where there is tussock country remaining on farmland, keeping it in tussock can have significant water quality benefits of reduced pathogens, nutrients, and sediment.

Lesson 4 - Relate field information and paddock scale information to environmental risk

This section details how to confirm or reject the presence and/or location of the risks on- farm using field evidence, plus outlines additional details that may need to be considered.

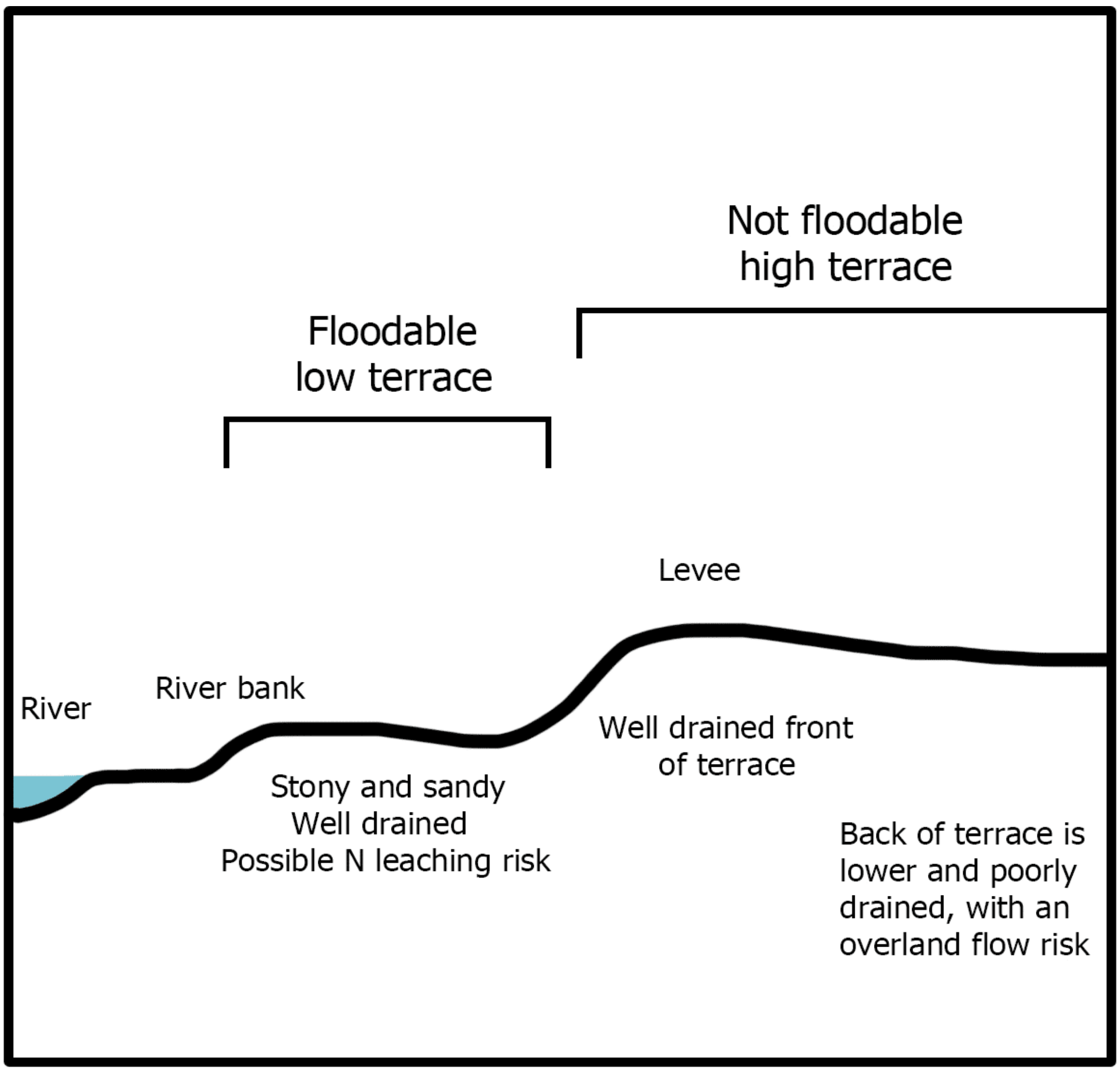
In some cases, actions required to reduce environmental impacts can be very expensive, and therefore due diligence may be required before making this investment to confirm that the mapped risks do actually exist and warrant the action.

In other cases, critical source areas are only small parts of a paddock, and a site inspection is required to delineate them. Paddock scale slope and hill shade information can be very useful for accurately delineating, communicating and cross checking where these areas are.

PLAINS

Soil type sometimes varies over very short distances in the plains (e.g., 20 metres). The risk of N leaching from soils on the plains can be anywhere from high to negligible, and soils can be at risk of either N leaching or overland flow. Understanding the landforms within plains is key to knowing which soil properties to look for to map environmental risk.

Plains landforms are composed of the terrace (the flattish part), the riser (the step up to a higher terrace) and the channel or streambank.



Landscape diagram showing landforms within plains

The riser

The riser is usually a short E or F slope with slight erosion risk where eroded sediment does not enter water. It is often classed as LUC 5e. Refer to LUC slope classes in LUC handbook.

River flats

River flats are composed of:

- The levee, a raised area near the stream or river bank, which slopes gently away from the river to lower ground. The levee is generally sandier and gravellier than the land farther back. It may have a high risk of N leaching depending on the texture, aeration of the soil parent material, and distance from the river or stream. It frequently has a wide range of soil types within a short distance.
- The lower ground farther away from the stream or river is generally of finer texture and poorer drainage than closer to the river. It usually has a low risk of N leaching but can have slight overland flow risk, depending on the texture, permeability and drainage class and position in the overland flow path. The lower areas may be wet for a couple of months per year and are the major source of overland flow on plains. At paddock scale, these areas can be mapped as LUC class 4w or 4E.

Loess flats

Loess flats occur on the high terraces. They are usually of much more uniform texture and vulnerability to overland flow than on the low river flats, however vulnerability to overland flow and bypass flow can vary markedly over short distances in some areas. This occurs where loess soils change from **Pallic** (e.g. Marton soil) to **Brown** (e.g. Kiwitea soil). Pallic soils are much more vulnerable to overland flow and bypass flow than Brown soils. In that zone the two contrasting soil types inter-finger within a paddock, often with the Brown soils on the higher ground and Pallic soils in the lower ground.

The channel

The channel is highly susceptible to overland flow and pathogen transmission to water.

Colluvial fans

Colluvial fans also erode under high intensity rains. They also tend to be poorly drained and thus pugged by stock leading to sediment and dung loss in high intensity rains.

The streambank

The streambank is susceptible to streambank erosion. At farm scale, areas of plains with streambank erosion should be mapped as LUC class 6e. Streambank erosion is a mostly natural process. Refer to the Erosion document for comments on control.

An example of plains (flat ground on the right) versus rolling land

Features for confirming and mapping nitrate leaching risk

Priority land for actions to reduce N leaching is land that is:

- close to a stream or river, and
- has sandy or gravelly texture or rapid permeability, and
- has aerated soil parent material.

Here's further information about prioritising land for N leaching:

Texture

- Find the texture of the mapped soil types from S-Map or the Fundamental Soil layer. Confirm by field testing in a soil hole, cutting or streambank. Refer to description and guide for assessing texture class by feel in the Soil Description Handbook (Milne et al, 1995).
- Note that S-map shows the textures and permeabilities of all the soil layers in an expected soil in a soil map unit. However the older and less accurate Fundamental Soil layer does not show the subsoil texture, only permeability class and depth to a slowly permeable horizon.
- Determine the effect of the texture on risk;
    - gravelly or coarse soil, which has a loamy sand or sand texture has rapid deep drainage (permeability) and therefore has the highest N leaching risk, particularly if close to stream or river.
    - loamy soil has moderate permeability, so there is likely to be a lower risk of N leaching. Refer to the Landscape DNA website for guidance on this.
    - clayey subsoil has negligible leaching risk but overland flow and bypass flow risk (bypass flow is rapid flow down large soil cracks into the drainage network.

Permeability

Permeability class contains three permeabilities:

- S = slow permeability; less than 4mm per hour, e.g., coarse blocky clay loam horizons, iron pan or other types of pans, for example, Kairanga or Marton soils. Soils with coarse blocky clay loam horizons are usually mole drained and therefore suffer from bypass flow. That is rapid transmission of urine and other runoff through the drainage network to waterways.
- M = medium permeability; 4 to 72 mm per hour, e.g., friable, loamy soils such as Kiwitea soil, Dannevirke soil, Ohakune soil, Westmere soil. These soils have a low risk of leaching and runoff.
- R = rapid permeability; over 72 mm per hour, e.g., soils with coarse texture such as pumice, sand dunes, coarse river sand, gravels with a coarse sandy matrix, for example Tukituki stony, Ashhurst stony or Kawhatau stony soils. These soils are high risk for leaching but low risk for runoff.

Many soils have compound permeabilities; for example M/S, S/M, and M/R.

Soil or parent material aeration

The degree of aeration is called drainage class in soil science terminology.

- Drainage class is determined by the depth to an anaerobic soil layer. An anaerobic soil layer is identified by pale grey colours on more than half the material. Refer to the Soil Description Handbook (Milne et al, 1995).
- Poorly drained soils have the anaerobic layer directly under the topsoil or within 30cm of the surface.
- Effect of poor winter aeration/drainage on risk:
    - any poorly drained or slowly permeable soils are susceptible to overland flow
    - on poorly drained sand country or other sandy soils, the risk is only when there is a high-water table
    - on poorly drained loess or alluvium with slowly permeable clay subsoil, lateral flow can be a major issue, with higher overland flow and bypass flow risks, but still less than on rolling steeper land
    - well drained soil can leach nitrogen to the parent material below, but the nitrogen can still be converted to N gas in anaerobic parent material farther down. Check stream cuttings for the presence of light grey colours. If present, these indicate that nitrogen may be partially or fully reduced and therefore not be leaching. This can be further checked by water quality sampling at the site.

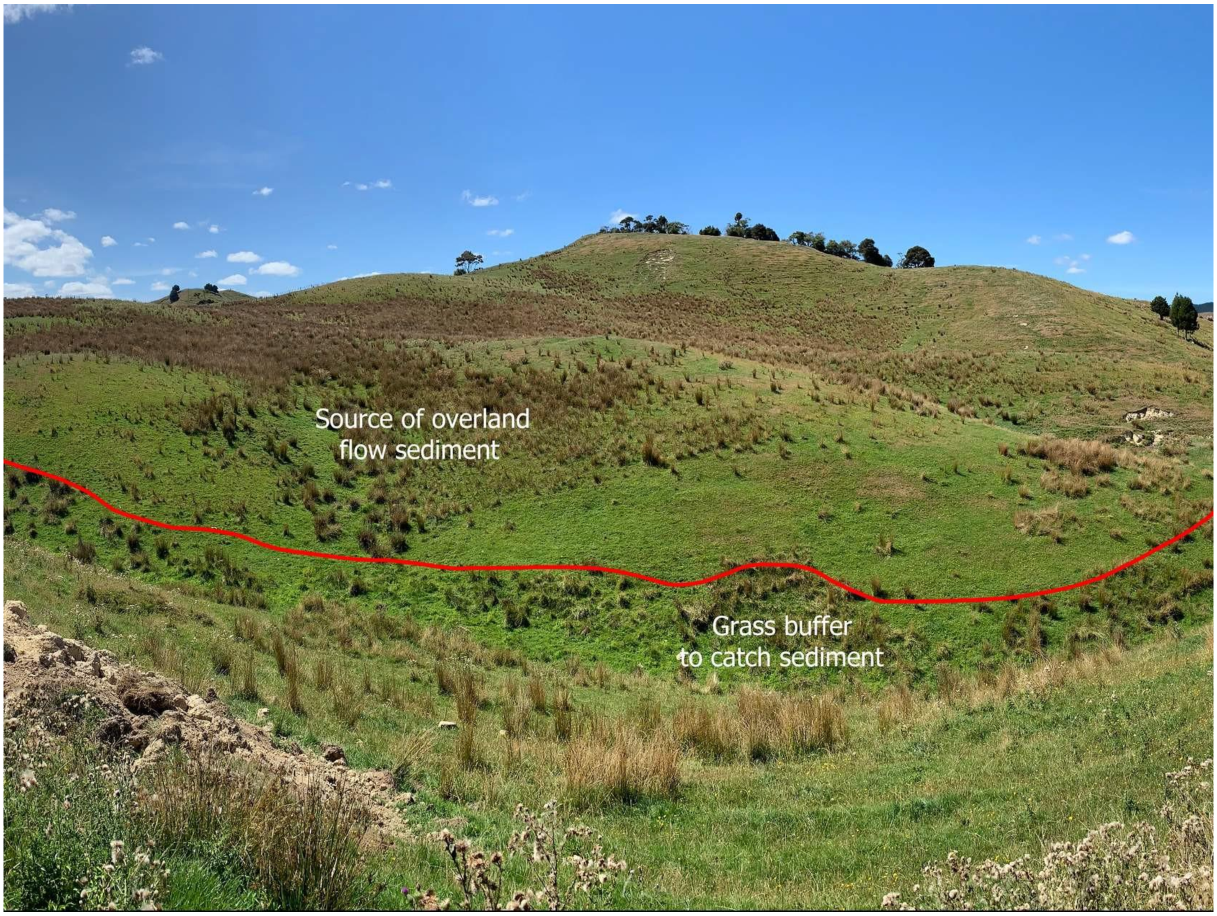
80cm depth of peat over river or estuarine silt, near the Manawatu River.

Relevant features of peat soil

Much of the land originally mapped in the Fundamental Soil layer as peat on the Manawatū plains has been oxidised post-drainage, and now exists as poorly drained Kairanga soil with excellent topsoil. As such, it will have a slight risk of overland flow like other poorly drained soils, and not be at risk of P leaching.

Land that is still peat has a high risk of P leaching. The risk depends on the amount of available phosphate (measured by Olsen P test) and a close proximity to a stream.

Rolling land



Sources and sinks for sediment in rolling land.

The main environmental risk is overland flow, so slope and flow pathways are the most important factors determining where topsoil loss and overland flow are generated from winter grazing or cropping.

Sediment sink areas: Swales and channels, and fans can provide excellent sites for grass buffer strips or sediment traps to catch sediment, pathogens, and nutrients from the rolling slopes above. Use farm inspection, aerial photos, and the paddock scale slope and hillshade layers to inform channel and swale location. You may also be able to obtain draft flow pathways for a farm very quickly from LiDAR elevation data. All the above layers require field checking, as they can have errors, however they remain the best available information to support accurate and consistent risk assessment across a catchment.

Hill country

Refer to the Erosion document for how to map erosion risk and how to choose or judge appropriate actions in hill country.

Sand country

Sand flats/plains contain poorly drained soils and have slight overland flow risks. Grassed strips or wetlands can be placed in the low points to catch nutrients and pathogens travelling from higher flats and dunes before they exit the farm. These make good nitrogen sinks if the drainage is blocked.

Although nitrate can leach through dunes it is expected to be denitrified before reaching waterways.

Most sand country is close to the coast and is easily accessible to migratory fish. Therefore, sand country streams frequently have high fish values.

All landforms

Additional paddock scale features to have regard to when identifying risk include:

- stream crossings
- tracks
- yards
- gateways
- troughs
- stock camps

These have a high risk of overland flow on any soil type because they are compacted and as well as having high concentrations of nutrient contaminants.

Lesson 5 - Recommended process for risk mapping

When mapping risk of erosion, overland flow and/or leaching on-farm, it is recommended that a series of risk assessments be done over the farm, in this order:

1) Hill country erosion – refer to the Erosion document
2) Overland flow – target rolling land as a source and swales and channels as a sink (below)
3) Leaching – target key land and soil factors (below)

Risk mapping for overland flow

Find the possible overland flow source areas

Marton soil with poorly drained (grey colours on left) slow permeability firm coarse blocky clay loam (blocks in dirt pile on right) subsoil

Distinguish strongly rolling from gently rolling from undulating and flat using a **paddock scale slope and hillshade layers**, aerial photos and field checking. Additional details about how to use those are in Regional Information document.

Refer to the table below and soil properties to assess risk of loss. Further detail on the relevant soil properties and other layers is in the previous lesson and the Regional Information document.

Slope (degrees)	Risk of overland flow (severity)	Details
Moderately steep (21-25)	Very severe	There is a **very severe** risk of overland flow under cultivation or IWG (there are small patches of 21-25 degrees within larger areas of rolling land)
Strongly rolling (16-20)	Severe	There is a **severe** risk of overland flow under cultivation or IWG
Gently rolling (8-15)	Moderate	There is a **moderate** risk of overland flow under cultivation or IWG
Undulating to flat (0-7)	Slight	On light volcanic soils, such as Ohakune soil (where topsoil particles are easily detached by raindrops) OR on poorly drained soils with clay loam subsoil with slow permeability, such as Marton, Tokomaru or Kairanga soils

Identify overland flow paths and wet areas

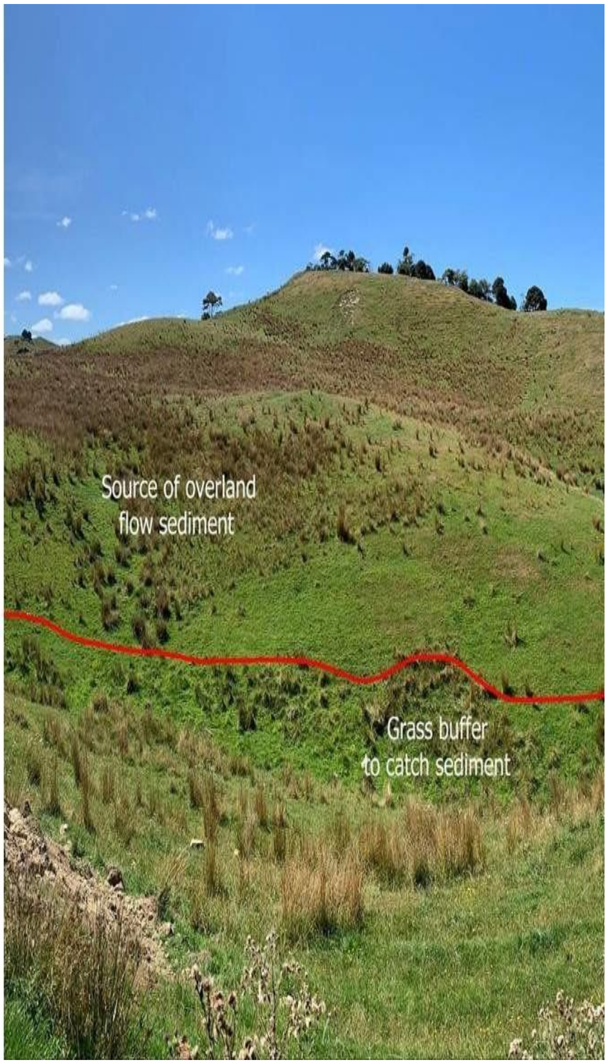
Management practices are a major determinant of whether overland flow paths are a source or sink of sediment, pathogens, and nutrients from overland flow.

The greater the flow in an overland flow path, the greater the potential source.

Stock camps, gateways, troughs, and well-used tracks tend to be both very fertile and very impermeable and so generate the greatest quantities of pathogens and nutrients.

A draft paddock-scale flow path may be generated very quickly for a farm using LiDAR elevation data, and used to check the consistency of mapped or implemented FWFP actions to stop overland flow. It requires field checking because it treats all culverts as blocked, and it requires prioritising for expected flow and sediment or nutrient content. Flow paths can also be field estimated with the aid of a 1m hillshade or 1m slope map. The layers aid rapid, accurate consistent drawing.

Check that farm plan risk mitigation activities target the highest risk areas of overland flow sediment entering waterways



Certainty of sediment loss to stream on the left. Much lower risk of sediment loss on the right.

Check that farm plan risk mitigation activities (such as grass filter strips or sediment traps) target the highest risk areas of overland flow sediment entering waterways. Places where sediment directly enters a stream are higher priority than where it enters a swale or a long ephemeral flow system, where much of the entrained pathogens or particulates may settle out in long grass.

In situations where there is no fixable moderate or severe risk present, a slight risk can be the most important issue on a farm.

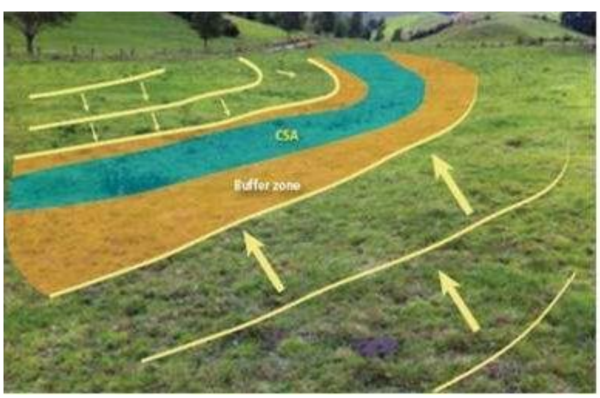
Priorities for actions

Practices for treating overland flow are well described in Beef and Lamb, Dairy NZ, and other websites. The main priorities are to prevent sediment from mobilising or to trap sediment before it leaves the farm.

Sediment can be prevented from mobilising by:

- not cropping ditches, swales, or wet patches
- minimising the time that land is left bare, by replanting as soon as possible or maintaining pasture
- minimising cattle treading on saturated land, e.g., by not grazing breaks in a winter crop until the soil is no longer saturated or by temporary fencing very wet parts of winter pugged pasture
- winter grazing stock spread out on autumn-saved pasture as a lower sediment impact alternative to intensively grazing a winter crop
- deep N testing pre crop and not fertilising more than plant requirements.

Sediment that does travel can be trapped in grass strips, swales, low earth dams or other types of sediment traps. This includes sediment from tracks, yards, swales, and cattle grazing saturated soil.



Examples of good versus bad practice for overland flow; (MPI intensive winter grazing document)

Risk mapping for leaching

Confirmation of leaching risk assessment requires expert landscape interpretation. However this method can be followed to determine if some parts of a farm are particularly prone to leaching and therefore may require additional actions.

If there are farm scale soil maps present, farm scale polygons should be used to update the S-Map soil properties.

If S-Map is not present for the farm, follow the guidance in the Regional Information document on how to determine the soil texture, permeability and drainage class of the mapped soils using the Fundamental Soil layers.

Nitrate leaching

By viewing the soil and topsoil development and using a worm test or ball test you can discern soil with rapid permeability that may be at risk of nitrate leaching. Sandy loam is on the left (Foxton soil with well-formed sandy loam topsoil with medium over rapid permeability) while loamy sand is shown on the right (Motuiti loamy sand over sand with rapid permeability).

To understand whether leaching risk is worth investigating, these four key land and soil features indicating risk all need to be present:

- close proximity to a waterway or wetland
- has gravel texture (or sand texture of the fines)
- rapid permeability
- has aerated soil parent material (well drained and has oxidized groundwater - with no water table between the soil and the waterway.

Phosphate leaching

To understand whether leaching risk is worth investigating, these three key land and soil features indicating risk all need to be present:

- rapid permeability (e.g., gravel, sand, or pumice) or peat soils
- low anion storage capacity (ASC, also known as P retention)
- very high Olsen P, such as on peat soil, some intensively used horticultural or dairy sites, or sites with history of heavy effluent application.

Priority is **highest** where there is:

- close proximity to a stream or river
- rapid permeability or peat soils
- highest Olsen P
- lowest ASC.

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