Freshwater Improvement Scenario Builder for Lakes

WebApp User Guide

DATE

**Freshwater Improvement Scenario Builder for Lakes: WebApp User Guide**

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# Purpose

## Purpose of this User Guide

This User Guide provides background information and instructions for using the Freshwater Improvement Scenario Builder for Lakes web application (henceforth ‘Scenario Builder for Lakes WebApp’ or ‘WebApp’), which can be accessed at <https://www.monitoringfreshwater.co.nz/>. It gives a summary of the purpose of the Scenario Builder for Lakes WebApp, the underlying calculations, assumptions and limitations and a step-by-step user guide.

This document refers to the Freshwater Improvement Scenario Builder for Lakes WebApp version available as of 13 August 2024.

## Glossary of key terms

**Attribute:** a measurable characteristic of freshwater as defined by the National Policy Statement for Freshwater Management 2020 (NPS-FM). NPS-FM attributes are generally defined by more than one component (i.e., multiple statistics calculated from water quality observations). The Scenario Builder for Rivers WebApp only reports and models median values of the indicators and, therefore, does not report or model full attributes or Attribute States. However, for the indicators dissolved reactive phosphorus (DRP) and nitrate nitrogen (NO3-N), the Scenario Builder for Rivers WebApp displays the NPS-FM band thresholds for the median concentration component of the associated NPS-FM attributes.

**Contaminant:** a pollutant; the Scenario Builder for Rivers WebApp models three contaminants of fresh water in New Zealand – nitrogen, phosphorus and *E. coli*. ‘Contaminant loss’ refers to the process of contaminants being generated and transported from land to water, for example via overland flow or leaching processes.

**Improvement**: a change in an indicator to a better state, compared with a current (baseline) state. In the Scenario Builder for Rivers WebApp, improvements correspond to a reduction in the median concentration of nutrients or *E.coli* in rivers relative to the current state (i.e., the current median value). Conversely, an increase in the median values of the indicators is considered a degradation.

**Indicator**: physical, chemical, and biological properties of water that provide information about its suitability for various uses. The six indicators represented in the Scenario Builder for Rivers WebApp are total nitrogen (TN), total phosphorus (TP), nitrate nitrogen (NO3-N), dissolved reactive phosphorus (DRP), *E. coli* and periphyton. The nutrients and *E. coli* are referred to as ‘measured indicators’ in the WebApp – i.e., the WebApp accesses measurements of these indicators – while periphyton is a modelled/estimated indicator, as explained further in Section 1.4.

**Lag:** the time taken for a change in a contaminant discharge at the land surface to reach a corresponding equilibrium at a downstream measuring point or receiving water body.

**Mitigation effectiveness:** in the WebApp, mitigation effectiveness is expressed as a relative change (%) and corresponds to the degree of reduction in contaminant losses from land as a result of mitigation actions.

**River Environment Classification (REC)**: a classification system for rivers and streams based on factors that influence water quality and biology. The primary factors include climate, source of flow, geology and land cover.

**Digital river network:** a geospatial information layer describing the national drainage network including streams and rivers and their associated catchment areas. The Scenario Builder for Rivers WebApp uses version 2.5.

**Segment**: a defined length of river or stream channel represented by the digital network. In the Scenario Builder for Rivers WebApp, river segments are those used in the REC version 2.5.

## Overview of the Freshwater Improvement Scenario Builder for Lakes WebApp

The Freshwater Improvement Scenario Builder for Lakes web application (WebApp) allows the user to simulate on-land mitigations and land use changes in the catchment of lakes and predict the associated changes to key in-lake water quality indicators: nutrients (total nitrogen (TN) and total phosphorus (TP)), phytoplankton biomass and visual clarity (Secchi depth). These types of simulations are important technical information for developing policy in the context of managing lake water quality and implementation of the National Policy Statement for Freshwater Management (NPS-FM). The WebApp includes all North and South Island lakes for which the surface water catchments are reliably defined based on the New Zealand national digital drainage network (DN2.4) and includes both monitored and unmonitored lakes.

The expected audience and users include multi-party catchment groups or stakeholders (including farmers, iwi, NGOs, council catchment management staff), their advisors, and/or any of these parties individually. The Scenario Builder for Lakes WebApp has been designed to be a simple, freely and publicly available analysis system that enables end-users to explore mixes of land mitigations and land use changes for defined areas and predict the effect of these on lake water quality.

The Scenario Builder for Lakes WebApp includes three types of analyses that are integrated and accessed in one application (**Figure 1**). The types and their purpose are:

1. Current state: to give information on the current state of the four lake indicators. The information provided is:
   * The boundary of the lake catchment
   * The current land use composition of the lake catchment
   * The current state of the four indicators for the lake (median TP, TN, phytoplankton and Secchi depth). The current state is based on measured or modelled data, depending on whether there is a monitoring site in the lake.
   * Estimated average annual load of TN and TP discharging to the lake
2. Land Use Mitigation: to estimate and visualise the potential water quality improvements (predicted changes to the indicators) achieved by mitigations applied to existing land in the catchment;
3. Land Use Change: to estimate and visualise potential changes to water quality resulting from changes to the existing land use mix in the catchment.

The ‘current state’ analysis is carried out first, by selecting a lake. The user may then explore scenarios that involve land use mitigation or land use change, or both combined, to estimate the impacts on the selected water quality indicator.



**Figure 1: The three types of analyses that can be performed with the Scenario Builder for Lake WebApp and the associated outputs.**

## Inputs and outputs

The inputs required of the user and outputs provided by the WebApp are outlined in Table 1.

Table 1: Required inputs and description of outputs of each type of analysis that can be performed with the Scenario Builder for Lakes WebApp.

| **Analysis type** | **User-specified inputs** | **Output** |
| --- | --- | --- |
| Current state | * Select lake * Select measured indicator | * Surface water catchment of lake * Summary table of catchment land use composition in terms of eight broad land use categories * Tabulation of the estimated contributions of each land use category to the total load of the contaminant (associated with the selected indicator) discharging to the lake * Current median value of indicator for lake, calculated from recent monitoring data (for lakes with monitored sites) or estimated from a model (for unmonitored lakes) * NPS-FM bands for those indicators that are components of an NPS-FM attribute (TN, TP, and phytoplankton) * Estimate of the reference state for each indicator (i.e., median value of indicator if the catchment was in a reference condition) |
| Land use mitigation | Default or user-specified mitigation effectiveness (%) for each land use type | * Tabulation of the default or user-specified reduction in contaminant losses for each land use category * Tabulation of the estimated contributions of each land use category to the total load of the contaminant (based on the mitigation scenario) at the lake * Estimated median value of the indicator for the lake based on the specified mitigation (and land use change, as below, if relevant) scenario |
| Land use change | User-specified relative proportions (%) of each land use type | * Summary table of user-specified catchment land use composition in terms of eight land use categories * Tabulation of the estimated contributions of each land use category to the total load of the contaminant (based on the user-specified combination of the mitigation and land use composition) at the lake * Estimated median value of the indicator for the lake based on the specified land use change (and mitigation, as above, if relevant) scenario. |

# WebApp methodology

## Lake catchment delineation and land use

## Current state: monitored lakes

The Scenario Builder for Lakes WebApp derives ‘current’ water quality for each lake and measured indicator as the median value of the observations for the monitoring site(s) in the lake for five-year period ending 2022, obtained from LAWA[[1]](#footnote-2). The five-year period is used to ensure a reasonable number of observations are included so that the dataset is representative of current state. The WebApp applies a filtering rule that restricts estimation of current median concentrations to site and variable combinations for which at least 45 observations are available (75% of the monthly sampling intervals in a five-year period).

The analysis of current state for each measured indicator is limited to estimates of median concentrations. NPS-FM attribute states for TP and TN are defined based on one statistic (i.e. the median) and for *phytoplankton based on* two statistics (the median, maximum). The maximum values of phytoplankton are not analysed or displayed by the WebApp. However, for these three indicators, the WebApp displays the NPS-FM band thresholds for the median concentration component of the associated NPS-FM attributes. The user should be aware that the attribute state as indicated by the median value and the NPS-FM band thresholds shown by the WebApp will sometimes differ from attribute states displayed on the LAWA website, which are based on all statistics that are used to define the attribute.

Does LAWA have Secchi depth data? That is NOT an attribute.

## Current state: unmonitored lakes

For unmonitored lakes, the four indicators (TN, TP, phytoplankton, Secchi) are derived from models. Estimates are made by coupling estimates of current input loads of TN and TP (tonnes/year) to lakes with the models described in section 2.5.6.

Estimates of current TN and TP loads are derived from Snelder et al. (2023).

## Reference state

Estimates of the four indicators (TN, TP, phytoplankton, Secchi) for lakes under reference conditions are derived from models. Predictions are made by coupling estimates of reference state input loads of TN and TP (tonnes/year) to lakes with the models described in section 2.5.6.

Estimates of reference state TN and TP loads are derived as follows. To come.

## Modelling catchment management scenarios

To predict the impact of catchment land use or mitigation scenarios on lake water quality, the WebApp models the loss of nutrients from land to a river segment, as described in the following subsections.

### Nutrient loss rates

The loss of nutrients from land is quantified by diffuse source nutrient loss rates. The WebApp uses diffuse source nutrient loss rates (expressed as export coefficients in kg ha-1 yr-1) that were primarily sourced from Srinivasan et al. (2021). Srinivasan et al. (2021) derived a land use typology and associated diffuse source loss rates, which provide nearly complete coverage of New Zealand (all land is assigned to a land use type and a diffuse source loss rate for TN and TP, except for land with a cover type of ‘urban’ or ‘bare’). Land use types comprise a combination of three factors, land use, slope and moisture, each of which is expressed as a category. Land use was defined by combining the national land cover database (LCDB, version 5) with spatial data describing the distribution of Sheep & Beef and Dairy land use[[2]](#footnote-3), based on data obtained from Monaghan et al. (2021). Spatial layers describing the distribution of the Srinivasan et al. (2021) slope and moisture categories were derived based on the descriptions provided in Srinivasan et al. (2021). These were based on slope from the Land Resource Inventory (Newsome et al*.* 2008), mean annual rainfall data provided by Ministry for the Environment[[3]](#footnote-4) and mapped irrigation data obtained from the Ministry for the Environment[[4]](#footnote-5).

Srinivasan et al. (2021) derived loss rates for the land use types representing pastoral agriculture based on application of the OVERSEER® nutrient budgeting model for a sample of farms that belonged to each type. Loss rates for Arable, Cropping, Forestry and Native Bush were also taken from Srinivasan et al. (2021).

For the urban land cover category, TN and TP loss rates for the Scenario Builder for Rivers WebApp were obtained from Moores et al. (2017). Because the remaining land use categories represented bare ground, wetlands, lakes and rivers, which generally have small areal contributions and no estimates were available, TN and TP losses were set to zero. The complete list of land use types and their associated loss rates that were used in the calculations made by the WebApp is shown in Table A1 in Appendix A and are referred to hereafter as the Srinivasan et al. (2021) types.

### Assigning nutrient loss rates to land areas

To assign all land in the catchments of the monitoring sites to a type and an associated loss rate, the LCDB spatial layer was reclassified into the land use categories defined by Srinivasan et al. (2021). That reclassification is shown Table A2 in Appendix A.

The WebApp tabulates the proportion of the catchment area in each land use type but does not display the spatial distribution of the land use types. The WebApp simplifies the description of land use in the catchment of each individual site by aggregating the Srinivasan et al. (2021) types to the eight categories shown in Table 2, but the underlying calculations use the detailed types (as in Srinivasan et al., 2021) and their associated loss rates. When the WebApp is used to simulate land use change the calculations are performed using loss rates for the eight categories shown in Table 2, which are calculated as:

Equation 1

where is the calculated loss rate for the jth (of 8) land use category shown in Table 2 and and are the area and loss rates for the ith (of 36) underlying Srinivasan et al. (2021) land use type.

**Table 2: Simplification of the detailed land use categories, defined primarily by Srinivasan et al. (2021), into the land use categories displayed by the Scenario Builder for Rivers WebApp.**

|  |  |
| --- | --- |
| **Simple land use category displayed by the WebApp** | **Underlying detailed categories** |
| Sheep & Beef | Sheep & Beef land use defined and mapped by Monaghan et al. (2021) combined with the slope and moisture categories defined by Srinivasan et al. (2021). |
| Dairy | Dairy defined and mapped by Monaghan et al. (2021) combined with the slope and moisture categories defined by Srinivasan et al. (2021). |
| Forestry | Forestry defined by Srinivasan et al. (2021) and mapped from LCDB v5 as shown in Table A2 (Appendix A). |
| Short-rotation Crop | All short-rotation Cropland mapped from LCDB v5 assumed to be Arable, as defined by Srinivasan et al. (2021). |
| Perennial Crop | Orchard, Vineyard or Other Perennial Crop mapped from LCDB v5 and Viticulture as defined by Srinivasan et al. (2021). |
| Native Vegetation | Native Bush defined by Srinivasan et al. (2021) and mapped from LCDB v5 as shown in Table A2. |
| Other | LCDB v5 categories: Estuarine Open Water, Mangrove, Gravel or Rock, Sand or Gravel, Lake or Pond, River, Not land. |
| Urban | Urban defined by Srinivasan et al. (2021) and mapped from LCDB v5 as Built-up Area (settlement). |

### Default mitigation effectiveness for nutrients

The Scenario Builder for Rivers WebApp provides ‘default’ nitrogen and phosphorus mitigation effectiveness values (%), representing a potential degree of reduction in the losses of nitrogen and phosphorus from land resulting from mitigation actions. These values may be used or replaced with user-defined values of mitigation effectiveness. It is important to note that the default values provided in the WebApp do not include considerations of the feasibility or achievability of the default mitigation effectiveness in the context of an individual catchment; in particular, the WebApp does not include consideration of the existing level of mitigation / remediation actions already undertaken in the catchment. In a catchment where many mitigation actions have already been undertaken, the potential for further improvements by mitigation may be less than the WebApp’s default values. In all cases, regardless of whether the default or user-defined values are used, users are strongly encouraged to satisfy themselves that their land mitigation inputs are realistic for the catchment.

The default nitrogen and phosphorus mitigation effectiveness values for pastoral agriculture categories (Sheep & Beef, Dairy) were informed by Monaghan et al. (2021) and McDowell et al. (2021). Monaghan et al. (2021) defined a system of land use types that differs to that of Srinivasan et al. (2021) but is associated with nitrogen and phosphorus mitigation effectiveness values resulting from mitigation actions that can be applied to pastoral agriculture (Sheep & Beef, Dairy). The default mitigation effectiveness in nitrogen and phosphorus loss rates from each Sheep & Beef and Dairy type were calculated as the relative reduction in loss rates between 2015 and 2035 as defined by Monaghan et al. (2021) and McDowell et al. (2021).

The WebApp simplifies the different Sheep & Beef and Dairy types defined by Monaghan et al. (2021) in the catchments of each individual river site by aggregating them into two categories (i.e., Sheep & Beef and Dairy). The aggregation means that when the WebApp is used to simulate land mitigations, the underlying calculations are based on the detailed mitigation effectiveness values of Monaghan et al. (2021) but the WebApp displays aggregate mitigation effectiveness values for the two pastoral land use categories. The displayed default values are calculated as:

**Equation 2**

where is the aggregate mitigation effectiveness value (%) for the two pastoral agriculture categories (Sheep & Beef, Dairy), and and are the area and mitigation effectiveness values for one of the *p* underlying Monaghan et al. (2021) types.

For non-pastoral land uses, mitigation effectiveness values were either sourced from literature, set at an arbitrary level, or set at zero (for native vegetation, urban and other) (Table 3).

Table 3: Default mitigation effectiveness values for each simplified non-pastoral land use category in the Scenario Builder for Rivers WebApp.

|  |  |  |  |
| --- | --- | --- | --- |
| **Simple land use category displayed by the WebApp** | **Default mitigation effectiveness (%)** | | **Source / comment** |
| N | P |
| Forestry | 0 | 30 | No mitigation expected for nitrogen.  Edwards and Williard (2010) cite 30-60% reduction in P losses from a range of best management practices. 30% selected as the low end of the range given the unknown applicability to NZ context. |
| Short-rotation Crop | 30 | 50 | N: mid-point of values reported in Auckland Council (2021)  P: unknown, inferred from potential sediment reductions (Barber, 2014) |
| Perennial crop | 15 | 50 |  |
| Native Vegetation | 0 | 0 | No mitigation expected |
| Other | 0 | 0 | No mitigation expected |
| Urban | 0 | 0 | Unknown / undocumented N and P mitigation options |

### Estimating total current nutrient loss

The current total nitrogen and total phosphorus loss rates in the catchment of a monitoring site are calculated as the sum of the products of land use category areas and loss rates as shown by Equation 3:

**Equation 3**

Where is a mass per unit time (kg/year), is the area of the *j*th land use category, and is the current loss rate of the *j*th land use category.

The contribution of each land use category to the at each monitoring site is calculated as:

**Equation 4**

where is the contribution of the *j*th land use category to the (%) of total nitrogen or total phosphorus.

### Estimating the total scenario nutrient loss

For a scenario in which mitigation of current total nitrogen or phosphorus loss from one or more land use categories in the catchment of a monitoring site occurs, the total scenario loss rate is calculated as:

**Equation 5**

where is the catchment loss of total nitrogen or total phosphorus as a mass per unit time (kg/year) under the prescribed mitigation scenario and is the assumed reduction in loss rate for the *j*th land use category under the mitigation scenario.

For a scenario that specifies mitigation of nitrogen or phosphorus loss from one or more land use categories, and the proportional area of two or more of the land use categories is changed from the current proportional area, the total scenario loss is calculated by Equation 5 with the proportional areas of the relevant land use categories changed to that assumed by the scenario.

### Predicting scenario indicator values for lakes

The predicted values for the lake indicators for a scenario is calculated as follows.

By default, predictions of in-lake concentrations of TN and TP are made by coupling estimated input loads with empirical lake nutrient loading models of Abell et al. (2019). Modification to these models were used in some regions and these are described below.

The primary input to the models of Abell et al. (2019) is the mean flow weighted concentration of TN and TP (hereafter and ). These values are obtained by dividing the estimated input loads of TN and TP by the mean annual inflow volume. Annual inflow volumes for each lake is obtained from estimates of mean flow made for every segment of the drainage network by Booker and Woods (2014).

By default, for each lake, the in-lake concentration of TN and TP is predicted using the following models from Abell et al. (2019, equation 8 and equation 6):

Equation 1

Equation 2

where *TPlake* and *TNlake* are median concentrations of TN and TP (mg m-3), k1, Δk1, k2, and all β are fitted parameters, τw is water residence time (years) derived from the FENZ database (Leathwick *et al.* 2010), and is the maximum depth of the lake derived from the FENZ database. The variable 𝑑 is a dummy variable that indicates whether a lake is shallow (𝑑 = 0) or deep (𝑑 = 1). The same threshold as (Abell *et al.* 2019) of >7.5m were used to define deep lakes. The coefficients k1, Δk1, and k2 are values of 0, 0.44, and 0.13, respectively. The coefficients , , are 1.6, 0.54 and -0.41, respectively.

Note that when the predictions from these models are back transformed, by raising to the power of 10, the results are multiplied by retransformation bias correction factors of 1.34 (TP) and 1.16 (TN). These values were obtained from Table 5 and Table 8 of Abell and van Dam-Bates (2018), respectively.

Note that the above two models are the *default*. In the Waikato region, alternative models were used based on recent work by (Abell *et al.* In prep). For each lake in the Waikato region, the in-lake concentration of TN and TP is predicted as:

Equation 3

Where i represents either nutrient TN or TP and *Tilake* is are median in-lake concentrations of (mg m-3), and is the mean flow weighted concentration of TN or TP. The coefficients , are 2.3969 and 0.3564 respectively for the TN model and 0.9217 and 0.6172 respectively for the TP model. As for the default equations, when the Waikato region model predictions are back transformed, by raising to the power of 10, the results are multiplied by retransformation bias correction factors of 1.24 (TN) and 1.34 (TP), respectively.

In the Canterbury region, we used alternative coefficients for Equation 2 that were fitted by (Fraser 2024). The coefficients k1, Δk1, and k2 for Canterbury are 0.09288, 0.826, and 0.0205, respectively. As for the default equations, when the Canterbury region TP model predictions are back transformed, by raising to the power of 10, the results are multiplied by retransformation bias correction factors of 1.696.

Predictions of in-lake concentrations chlorophyll and lake Secchi depth made by coupling in-lake concentrations of TN and TP with empirical models of (Abell and van Dam-Bates 2018).

For each lake, the in-lake concentration of chlorophyll and lake Secchi depth is predicted using the following default models from Abell et al. (2019, equation 8 and equation 6):

Equation 4

Equation 5[[5]](#footnote-6)

For Equation 4, *TPlake* and *TNlake* are median concentrations of TN and TP (mg m-3) that can be either observed values or predicted values derived using Equation 1 and 2. The coefficients , , in Equation 3 are -1.8, 0.70(TN) and 0.55(TP), respectively (Abell and van Dam-Bates 2018). Note that when the predictions from Equation 3 are back transformed, by raising to the power of 10, the results are multiplied by retransformation bias correction factors of 1.12.

For Equation 5, is the median concentrations of chlorophyll (mg m-3) that can be either observed values or predicted values derived using Equation 4. The variable 𝑑 is a dummy variable that indicates whether a lake is shallow (𝑑 = 0) or deep (𝑑 = 1), where shallow lakes are defined as z*max* ≤ 20 m. The last term of Equation 5 represents resuspension (in shallow lakes). In this term, the variable *Fetch* is the maximum lake fetch (m), and *U* is the mean windspeed (m s-1), based on analysis of regional climate data by Leathwick et al. (2010). Both of these variables are obtained for each lake from the FENZ database. The coefficients , , and in Equation 5 are 3.46 (intercept), -0.74(Chla), -0.79 (Chla x d) and -0.35 (resuspension) (Abell and van Dam-Bates 2018).

# Examples of outputs for selected scenarios

# User Guide

This section provides step-by-step instructions on how to use the Freshwater Improvement Scenario Builder for Lakes web application.

## Using the WebApp to explore water quality current state

## Using the WebApp to assess catchment scenarios

This subsection contains instructions on how to use the Scenario Builder for Lakes WebApp to predict how a catchment scenario that consist of land mitigation and/or land use change will impact the current state median of a selected indicator. Note that before carrying out a scenario assessment, the steps in a ‘Current state’ analysis (Section 4.1) must be carried out, i.e., a lake and a measured indicator must be selected.

### Land mitigation scenario

### Land use change scenario

### Exporting the results

The Scenario Builder for Lakes WebApp results can be exported in PDF format. This can only be done once a scenario has been run. The button ‘Download pdf report’ will appear blue once a scenario has been run.

Note: the PDF report will be based on the most recent scenario run by the user. Only one scenario will be included in the report.

## Example

The box below contains an example of how to use the Scenario Builder for Lakes WebApp. Note that the mitigation and land use change scenarios in the example are purely hypothetical and were devised for the purpose of illustrating the WebApp functions.

## Troubleshooting

To report any problems using the Scenario Builder for Lakes WebApp, please get in touch using the Contact form on the Monitoring Freshwater Improvements website.

# Acknowledgements

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# Appendix A: Land use types and loss rates

Table A1: Complete list of land use types and their associated loss rates (kg/ha/year) used in the Scenario Builder for Rivers WebApp.

| **Land Use** | **Slope** | **Moisture** | **Type** | **TN Loss Rate** | **TP Loss Rate** |
| --- | --- | --- | --- | --- | --- |
| Dairy | Flat | Dry | Dairy-Flat-Dry | 29.5 | 0.85 |
| Dairy | Flat | Moist | Dairy-Flat-Moist | 39 | 1.05 |
| Dairy | Flat | Wet | Dairy-Flat-Wet | 48.5 | 1.25 |
| Dairy | Flat | Irrigated | Dairy-Flat-Irrigated | 55.5 | 0.95 |
| Dairy | Rolling | Dry | Dairy-Rolling-Dry | 27 | 1 |
| Dairy | Rolling | Moist | Dairy-Rolling-Moist | 32 | 1.5 |
| Dairy | Rolling | Wet | Dairy-Rolling-Wet | 45 | 1.8 |
| Dairy | Rolling | Irrigated | Dairy-Rolling-Irrigated | 52 | 1.3 |
| Dairy | Easy Hill | Dry | Dairy-Easy Hill-Dry | 28 | 1 |
| Dairy | Easy Hill | Moist | Dairy-Easy Hill-Moist | 32 | 1.5 |
| Dairy | Easy Hill | Wet | Dairy-Easy Hill-Wet | 45 | 1.8 |
| Dairy | Easy Hill | Irrigated | Dairy-Easy Hill-Irrigated | 52 | 1.3 |
| Dairy | Steep | Moist | Dairy-Steep-Moist | 32 | 1.5 |
| Dairy | Steep | Wet | Dairy-Steep-Wet | 45 | 1.8 |
| Dairy | Steep | Irrigated | Dairy-Steep-Irrigated | 52 | 1.3 |
| Sheep and Beef | Flat | Dry | Sheep and Beef-Flat-Dry | 7 | 0.4 |
| Sheep and Beef | Flat | Moist | Sheep and Beef-Flat-Moist | 18 | 0.6 |
| Sheep and Beef | Flat | Wet | Sheep and Beef-Flat-Wet | 24 | 0.75 |
| Sheep and Beef | Flat | Irrigated | Sheep and Beef-Flat-Irrigated | 20 | 0.6 |
| Sheep and Beef | Rolling | Dry | Sheep and Beef-Rolling-Dry | 7.5 | 0.35 |
| Sheep and Beef | Rolling | Moist | Sheep and Beef-Rolling-Moist | 11.5 | 0.7 |
| Sheep and Beef | Rolling | Wet | Sheep and Beef-Rolling-Wet | 17.5 | 0.8 |
| Sheep and Beef | Rolling | Irrigated | Sheep and Beef-Rolling-Irrigated | 11.5 | 0.7 |
| Sheep and Beef | Easy Hill | Dry | Sheep and Beef-Easy Hill-Dry | 5 | 0.5 |
| Sheep and Beef | Easy Hill | Moist | Sheep and Beef-Easy Hill-Moist | 8.5 | 1 |
| Sheep and Beef | Easy Hill | Wet | Sheep and Beef-Easy Hill-Wet | 9 | 1.6 |
| Sheep and Beef | Easy Hill | Irrigated | Sheep and Beef-Easy Hill-Irrigated | 8.5 | 1 |
| Sheep and Beef | Steep | Dry | Sheep and Beef-Steep-Dry | 4.5 | 0.6 |
| Sheep and Beef | Steep | Moist | Sheep and Beef-Steep-Moist | 6 | 1.6 |
| Sheep and Beef | Steep | Wet | Sheep and Beef-Steep-Wet | 6.5 | 2.8 |
| Sheep and Beef | Steep | Irrigated | Sheep and Beef-Steep-Irrigated | 6 | 1.6 |
| Arable | All | All | All | 13.5 | 0.1 |
| Vegetable\* | All | All | All | 72 | 1.9 |
| Viticulture | All | All | All | 10 | 0.2 |
| Forestry | All | All | All | 4 | 0.4 |
| Native Bush | All | All | All | 2 | 0.3 |
| Urban | All | All | All | 11 | 1 |

\*Vegetable class is not represented in the WebApp. Refer to Section 2.6.

Table A2: Re-classification of LCDBV5 Name\_2018 classes to Srinivasan et al. (2021) land use classes.

|  |  |  |
| --- | --- | --- |
| **LCDBV5 Name\_2018** | **Class\_2018** | **Reclass** |
| Indigenous Forest | 69 | Native Vegetation |
| Deciduous Hardwoods | 68 | Native Vegetation |
| Low Producing Grassland | 41 | Pasture |
| Manuka and/or Kanuka | 52 | Native Vegetation |
| Exotic Forest | 71 | Forestry |
| Built-up Area (settlement) | 1 | Urban |
| Forest – Harvested | 64 | Forestry |
| Broadleaved Indigenous Hardwoods | 54 | Native Vegetation |
| Gravel or Rock | 16 | Native Vegetation |
| Lake or Pond | 20 | Native Vegetation |
| Gorse and/or Broom | 51 | Native Vegetation |
| High Producing Exotic Grassland | 40 | Pasture |
| Landslide | 12 | Native Vegetation |
| Mixed Exotic Shrubland | 56 | Forestry |
| Orchard, Vineyard or Other Perennial Crop | 33 | Viticulture |
| Short-rotation Cropland | 30 | Arable |
| Sand or Gravel | 10 | Native Vegetation |
| Herbaceous Freshwater Vegetation | 45 | Native Vegetation |
| River | 21 | Native Vegetation |
| Surface Mine or Dump | 6 | Urban |
| Urban Parkland/Open Space | 2 | Native Vegetation |
| Transport Infrastructure | 5 | Urban |
| Flaxland | 47 | Native Vegetation |
| Estuarine Open Water | 22 | Native Vegetation |
| Fernland | 50 | Native Vegetation |
| Sub Alpine Shrubland | 55 | Native Vegetation |
| Tall Tussock Grassland | 43 | Native Vegetation |
| Herbaceous Saline Vegetation | 45 | Native Vegetation |
| Matagouri or Grey Scrub | 58 | Native Vegetation |
| Alpine Grass/Herbfield | 15 | Native Vegetation |

1. Land, Air and Water Aotearoa. [www.lawa.org.nz](http://www.lawa.org.nz) accessed February 2024. [↑](#footnote-ref-2)
2. Where LCDB specifies high or low producing exotic grassland but Monaghan et al. (2021) has not assigned to Sheep and Beef or Dairy, LCDB ‘low producing grassland’ was assigned as Sheep and Beef and LCDB ‘high producing grassland’ was assigned as Dairy. [↑](#footnote-ref-3)
3. data.mfe.govt.nz/layer/89421-average-annual-rainfall-19722016 [↑](#footnote-ref-4)
4. https://data.mfe.govt.nz/layer/105407-irrigated-land-area-raw-2020-update/ [↑](#footnote-ref-5)
5. Note that this equation is derived from Model 3Secchi of Abell and van Dam-Bates (2018). However, Equation 4 has the third term of Model 3Secchi removed following the results presented in Table 21 of Abell and van Dam-Bates (2018). [↑](#footnote-ref-6)