Assessment of the eutrophication susceptibility of New Zealand Estuaries

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Contents

Tables

Figures

Executive summary

The Ministry for the Environment (MfE) is seeking to provide a body of knowledge that can help decision-makers effectively manage water quality and flows under the National Policy Statement for Freshwater Management (2014). MfE has commissioned NIWA to provide information on how nutrient loads from freshwater affect nutrient concentrations and trophic condition in New Zealand's coastal water bodies where fresh and salt waters mix, including estuaries, fjords, coastal embayments, and coastal lakes (hereafter collectively termed 'estuaries'). In this report, we provide:

- maps of 'potential' nitrogen concentrations (i.e., the concentration that would exist in the absence of biological processes that result in nutrient loss within estuaries) for all estuaries in NIWA's coastal database, considering loads from land and processes of freshwater flow and mixing with salt water that depend on physical processes in each estuary;
- maps of susceptibility to eutrophication as manifested by excess growth of macro-algae and phytoplankton for all these estuaries resulting from these nitrogen loads, using methods developed for the NZ Estuary Trophic Index (ETI);
- a comparison of nitrogen loading and susceptibility to eutrophication under current conditions with conditions before arrival of humans in New Zealand.

In this report, we use the CLUES (Catchment Land Use and Environmental Sustainability) model and tools developed for the NZ Estuary Trophic Index (ETI) to estimate current estuarine nitrogen (N) concentrations and susceptibility to eutrophication in New Zealand's estuaries ('current' scenario). Current conditions are baselined to the year 2008 using LCBD v3. We then compare current conditions to two modelled scenarios to understand how human-induced eutrophication has changed New Zealand's coastal waters. In the first of these two scenarios ('pre-human land cover' scenario), we estimate N concentrations and eutrophication susceptibility in New Zealand estuaries given New Zealand's land cover as it was before the arrival of humans. Because this scenario does not incorporate changes to atmospheric N deposition that have occurred since the arrival of humans to New Zealand, we conduct a second analysis using N loads from the 'pre-human land cover scenario' scaled to match those of rivers flowing to coasts from pristine catchments worldwide; this scenario is referred to as the 'pristine' scenario.

Total loads (i.e., summed across all estuaries) of N exported to estuaries calculated using NIWA's CLUES model for current conditions were 91% and 320% above those of the 'pre-human land cover' and 'pristine' scenarios, respectively. These anthropogenic increases in yields above natural levels were unevenly distributed across New Zealand, with the greatest increases around the central and southern North Island, and the eastern South Island.

Our results and maps show clearly that physical characteristics of estuaries affect their response to N loading, in terms of water N concentrations and eutrophication susceptibility. Estuaries with high sensitivity to increases in N loads typically have high proportions of intertidal area, low dilution, or long flushing times.

Many more estuaries are now susceptible to eutrophication due to anthropogenic increases in N loads to freshwater. Under current N loading conditions, 35% of estuaries fit within C or D (high or very high) ETI bands of eutrophication susceptibility. In the 'pre-human land cover' scenario, 17% of estuaries fit a C or D (high or very high) class of eutrophication susceptibility. In the 'pristine' scenario, 4.5% of estuaries fit a C or D (high or very high) class of eutrophication susceptibility.

Shallow, intertidal-dominated estuaries had the greatest increase in C and D bandings, rising from 0% and 11% under 'pristine' and 'pre-human land cover' scenarios to 42% under current conditions. A high susceptibility does not indicate that an estuary is or was eutrophic but indicates that nutrient concentrations and flushing times provide suitable conditions for eutrophication to occur.

The eutrophication susceptibility bandings were developed for estuaries and may not be directly applicable to freshwater dominated or low salinity systems such as coastal lakes. Susceptibility bandings to macroalgae are based on a regression fitted to observations, which provides a good distinction between estuaries with A/B bandings and those with C/D bandings but does not clearly distinguish between A and B bands. We consider the threshold between B and C bands to be the most important for indicating when eutrophic conditions are likely to develop. Phytoplankton susceptibility is based on an analytical model that predicts chlorophyll-*a*, but this model has not been validated due to insufficient observational data, and bandings are based on interim values.

This report indicates how susceptibility of estuaries has been altered by changes in nutrient load but does not consider other factors that may have changed such as estuary geometry, infilling and freshwater inflows. Furthermore, the model does not consider the denitrification effects of wetlands, which have reduced substantially from pre-human to current (2008) conditions. Only nitrogen loads have been considered because this is almost always the limiting nutrient in New Zealand estuaries and coastal waters. However, phosphorus loads may be an issue for freshwater dominated systems such as coastal lakes. The dilution modelling approach provides a time- and space-averaged assessment of susceptibility and does not provide any spatial or temporal resolution. To apply the model across New Zealand, estuary data were obtained from a database that may contain inaccuracies at the scale of individual estuaries. Thus, results for individual estuaries should be refined with precise volume and tidal prism measurements where accurate assessments are critical.

The predictions of loads to estuaries and their impacts on estuaries reported here may be useful in developing strategies to manage the effects of land use change on coastal waters.

1 Introduction

1.1 Background

Increased input of nutrients to land, and their subsequent passage via freshwater flows to estuaries and other coastal waters have caused worldwide increases in coastal eutrophication, the process whereby a water body becomes enriched with nutrients that stimulate excessive primary production (Vitousek, Aber et al. 1997; Fowler, Coyle et al. 2013). Eutrophication is a global issue confronting all types of aquatic ecosystems from rivers to ocean basins (Vitousek, Aber et al. 1997). In estuaries, prolific growth of phytoplankton and opportunistic macroalgae, changes in water chemistry and reduction in biodiversity are common responses (Morand and Briand 1996; Howarth and Marino 2006).

In New Zealand, rates of fertiliser application to pasture, stock densities and human populations – processes that alter nutrient input, losses from land and loading to aquatic ecosystems – have followed these global upward trends (Ministry for the Environment 2007; Howard-Williams, Davies-Colley et al. 2010).

Nitrogen (N) is generally considered to be the primary limiting nutrient during peak seasonal primary production in coastal waters (Hanisak 1983; Hurd, Nelson et al. 2004; Howarth and Marino 2006; Larned, Hamilton et al. 2011). Although N enrichment probably affects most New Zealand estuaries (Snelder, Larned et al. 2017), guidance on how to assess the extent of eutrophication, including indices and indicators that are useful for management, is limited. As a result, it has been difficult to:

- determine the current state of New Zealand's estuaries with regard to eutrophication;
- assess the effects of the land use intensification and change on estuaries;
- gauge the consequences for estuaries of nutrient limits for freshwater (e.g., the National Policy Statement for Freshwater Management, NPSFM (New Zealand Government 2014)); and
- set nutrient load limits to achieve estuarine objectives.

In response, regional council coastal scientists sought advice via the coastal Special Interest Group (cSIG), with funding through Envirolink Tools Grant (Contract No. C01X1420), on the development of a nationally consistent approach to the assessment of estuary eutrophication, including nutrient load thresholds. The purpose of that project, called the NZ Estuary Trophic Index (ETI), was to assist regional councils in determining the susceptibility of an estuary to eutrophication, assess its current trophic state, and assess how changes to nutrient load limits may alter its current state. The project did this by providing tools for determining estuary eco-morphological type, identifying the locations of estuaries along an ecological gradient from minimal to high eutrophication, and providing stressor-response tools (e.g., empirical relationships, nutrient models) that link the ecological expressions of eutrophication (measured using appropriate trophic state indicators) with N loads (e.g., macroalgal biomass/nitrogen load relationships).

In this report, we use these recently-developed tools to describe the susceptibility of New Zealand's estuaries to nutrient loading pressures, with the aim of improving our understanding of ecological health of New Zealand's estuaries in their current state. In interpreting these findings and to set them in context, it is useful to understand how far removed the current state is from their natural state, prior to arrival of humans. This understanding is an important part of the knowledge needed to establish load limits in upstream waters, in order to sustain ecological health of downstream receiving waters such as estuaries and other coastal ecosystems.

1.2 Scope

The Ministry for the Environment commissioned NIWA to provide information on how nutrient loads from freshwater affect nutrient concentrations and trophic condition in New Zealand's estuaries, specifically:

- maps of 'potential' total nitrogen (TN) concentrations (i.e., the concentration that would exist in the absence of biological processes that result in nutrient loss within estuaries) for all estuaries in NIWA's coastal database, considering loads from land and processes of freshwater flow and mixing with salt water that depend on physical processes in each estuary;
- maps of susceptibility to eutrophication as manifested by excess growth of macro-algae and phytoplankton for all these estuaries resulting from these N loads, using methods developed for the NZ Estuary Trophic Index (ETI);
- a comparison of N loading and susceptibility to eutrophication under current conditions with conditions before arrival of humans in New Zealand.

2 Methodology

2.1 Estuary typology

New Zealand has a large number and wide variety of estuaries. These water bodies differ from freshwater environments in that changes to state and impacts driven by contaminant loads from land are dependent on the interactive effects of freshwater discharge, tidal mixing of fresh and salt water, and coastal basin morphology (Pearl 2009). Various classification systems for these water bodies have been proposed. In this report, we are concerned mostly with implications of the physical characteristics of water bodies on eutrophic response to nutrient loadings. Consequently, the typology used here is primarily based on those physical properties.

We have adopted the New Zealand Estuary Trophic Index typology (Robertson, Stevens et al. 2016a), which consists of 4 estuary types specifically suited to the assessment of estuarine eutrophication susceptibility in New Zealand.

1. Shallow intertidal dominated estuaries (**SIDEs**).
2. Shallow, short residence time river and tidal river with adjoining lagoon estuaries (**SSRTREs**).
3. Deep, subtidal dominated, longer residence time estuaries (**DSDEs**).
4. **Coastal Lakes**, which are mostly closed the sea, but may be brackish due to wave overtopping, seepage, or infrequent openings.

Intermittently closed/open estuaries (ICOEs) are subtypes of SIDEs and SSRTREs (Zeldis, Plew et al. 2017; Plew, Zeldis et al. 2018a).[1] They may close to the sea, but their normal state is open, in contrast to coastal lakes which are usually or always closed. The classification of estuaries is based on data in the Coastal Explorer Database (Hume, Snelder et al. 2007) and the New Zealand Coastal Hydrosystems Classification (NZCHS) (Hume, Gerbeaux et al. 2016). Neither of these contain information as to which systems are ICOEs. We therefore assume that all systems, other than coastal lakes, are open to the sea. We note that some coastal lakes are not estuarine, but for the purpose of this report, we call all coastal hydrosystems "estuaries".

Other typologies in use in New Zealand include a geomorphic classification (Hume and Herdendorf 1988), and a hydrodynamic processes classification (Hume, Snelder et al. 2007). These have recently been superseded by the NZCHS (Hume, Gerbeaux et al. 2016). The NZCHS consists of 11 classes, each of which may include subclasses. Most estuaries have been assigned an ETI classification solely based on data contained in the Coastal Explorer database. The mapping between NZCHS classes and ETI classes is not always consistent, as in some cases ETI types may map to more than one NZCHS class (and vice versa). For example, the ETI classifies systems with no tidal prism as coastal lakes, which in the NZCHS may be classed as damp sand plain lakes, Waituna-type lagoons, Hāpua-type lagoons, or beach streams. However, the classification of an estuary does not affect the results of our analysis, but we note that local knowledge of estuaries may reveal that some estuaries would be better

[1] Hume, T., Gerbeaux, P., Hart, D., Kettles, H., Neale, D. (2016) A classification of New Zealand's coastal hydrosystems, CR 254: 120. http://www.mfe.govt.nz/publications/marine/classification-of-new-zealands-coastal-hydrosystems have concluded that the previously-used descriptor for intermittent systems (ICOLL: intermittently closed or open lakes and lagoons) developed for Australian systems is inappropriate in the New Zealand context.

described using a different type than that to which they have been assigned here. In Table 2-1, we provide the most common mapping between NZCHS classes and ETI types used in this study.

Table 2-1: Relationships between New Zealand Coastal Hydrosystem (NZCHS) Classes and Estuary Trophic Index (ETI) estuary types. ETI type is that which most commonly corresponds to each NZCHS class.

NZCHS class	ETI type
1. Damp sand plain lake	Coastal Lake
2. Waituna-type lagoon	Coastal Lake
3. Hāpua-type lagoon	SSRTRE
4. Beach stream	SSRTRE
5. Freshwater river mouth	SSRTRE
6. Tidal river mouth	SSRTRE
7. Tidal Lagoon	SIDE
8. Shallow drowned valley	SIDE
9. Deep drowned valley	DSDE
10. Fjord	DSDE
11. Coastal embayment	DSDE

2.2 Nutrient load modelling

Nutrient loads to estuaries were modelled using CLUES (Catchment Land Use and Environmental Sustainability) (Elliott, Semadeni-Davies et al. 2016). This GIS-based tool combines a suite of catchment models (OVERSEER, SPASMO and SPARROW) to predict nutrient loads based on land use, catchment characteristics and climate. Two land cover layers were used to create scenarios in CLUES.

1. Present day (2008) land use, as defined in the national Land Cover Database version 3.0 (LCDB3 [2], Landcare Research, http://www.lcdb.scinfo.org.nz), AgriBase Rural Properties database (AsureQuality, New Zealand, 2008 baseline year) and the Land Environments of New Zealand (LENZ, Leathwick 2002). This land cover is shown in Figure 2-1.

2. Pre-human land cover conditions, using land cover thought to have been present before human occupation of New Zealand. This used a potential vegetation pattern developed by Landcare Research (https://lris.scinfo.org.nz/layer/48289-potential-vegetation-of-new-zealand/) to identify which areas of New Zealand were covered by native forest, tussock, or other (Leathwick, McGlone et al. 2012). This layer was

[2] While a more recent version of the Land Cover Data Base (LCBD v4.1) is available that has land cover for 2012, this has not yet been incorporated into CLUES.

adapted from the work of Leathwick (2001) and Leathwick, Overton et al. (2003), and is shown in Figure 2-2. Note that Leathwick, McGlone et al. (2012) grouped tussock and scrub together. In CLUES, scrub has the same N export rates as forest, while that of tussocks is lower. We have modelled their combined scrub & tussock categories as tussock when applying the CLUES model because tussock likely dominated much of these areas, and overall biomass was lower than in forested areas making the use of a lower N export rate appropriate.

We also compare nutrient loads to estuaries with those calculated using a regression modelling approach by Snelder, Larned et al. (2017). They also estimated 'natural' loads by reducing the agriculture land-use intensity factor in their model to zero.

It is likely that the CLUES outputs using pre-human land cover and the natural loads from Snelder, Larned et al. (2017) both overestimate N loadings to estuaries before arrival of humans to New Zealand. This is primarily because neither model accounts for differences in atmospheric N deposition to land since the arrival of humans to New Zealand. Pre-industrial atmospheric N deposition in New Zealand has been estimated to be 3-20 times lower than present day (Holland, Dentener et al. 1999; Galloway, Dentener et al. 2004; Menge and Hedin 2009; Verburg, Elliott et al. 2016). The atmospheric N deposition for New Zealand's North Island may have increased to over 6 kg ha^{-1} yr^{-1}, while the South Island receives on average 2.35 kg ha^{-1} yr^{-1} (Holland, Dentener et al. 1999; Verburg, Elliott et al. 2016). On average only around 25% of anthropogenic N added to catchments reaches the marine system, because post-deposition losses (such as denitrification) remove it before it reaches the marine environment (Howarth, Billen et al. 1996; Boyer, Howarth et al. 2006). These post-industrial increases in atmospheric N deposition are likely to have had a considerable influence on N flux from forested catchments. CLUES has been calibrated to recent gaugings of riverine N loads, i.e., under present day atmospheric N deposition rates. The average catchment yield to estuaries under the CLUES pre-human land cover scenario was 3.27 kg ha^{-1} yr^{-1}. This compares favourably with measurements of TN export from native forest of 2.07 to 3.67 kg ha^{-1} yr^{-1} (Cooper and Thomsen 1988; Quinn and Stroud 2002). This means that our 'pre-human land cover' catchment yields use present day atmospheric N deposition rates. Therefore, the results of our 'pre-human land cover' scenario represent what loads to estuaries would be if land cover reverted to pre-human conditions, but with present day atmospheric N deposition.

To account for changes in atmospheric N deposition, we compared the CLUES 'pre-human land cover' scenario with measurements of N flux to oceans from pristine forested catchments worldwide (Howarth, Billen et al. 1996), which had with natural land cover and atmospheric deposition rates not influenced by developed catchments. Howarth, Billen et al. (1996) used a range of N flux rates from 0.76 to 2.3 kg ha^{-1} yr^{-1} for pristine catchments in temperate latitudes, but noted that N export across pristine catchments is variable and depends on a range of factors that include precipitation. CLUES includes a precipitation factor that results in greater N export from catchments with high rainfall, thus giving spatial resolution in catchment yields over the country. Therefore, we estimated 'pristine' conditions by scaling the output for each catchment from the 'pre-human land cover' scenario (described above) to give a mean national N-export of 1.5 kg ha^{-1} yr^{-1}; this being the mid-point of the range from Howarth, Billen et al. (1996), above. This approach accounts to some extent for historic N deposition rates in New Zealand, as the range of Howarth, Billen et al. (1996) includes catchments with low atmospheric N deposition.

The 1.5 kg ha^{-1} yr^{-1} average is also consistent with estimates that can be derived from New Zealand studies. Parfitt, Baisden et al. (2008) calculated N budgets for New Zealand in 1861. In 1861, anthropogenic sources accounted for at least 38% of the total N inputs to catchments (Parfitt, Baisden et al. 2008). Parfitt, Schipper et al. (2006) noted that the ratio of N exported to rivers to net anthropogenic N inputs in New Zealand was very similar to that of North Atlantic catchments, despite quite different agriculture and population densities. Howarth, Billen et al. (1996) derived a regression between North Atlantic catchment N inputs and riverine export. The same regression can be used to check our estimate of pristine loads in New Zealand. Reducing the 1861 value of total N inputs from Parfitt, Baisden et al. (2008) by 38% to remove anthropogenic sources, and then applying this regression gives an expected net catchment yield of 1.8 kg ha^{-1} yr^{-1}. Parfitt, Baisden et al. (2008) calculate atmospheric deposition rates in 1861 of 2.36 kg ha^{-1} yr^{-1}. Given that there was considerable human influence in New Zealand in 1861, it is likely that pre-human atmospheric N deposition rates, and consequently riverine N export, were lower still. Consequently, 1.5 kg ha^{-1} yr^{-1} is a justifiable estimate of the average N export to New Zealand estuaries under 'pristine' (i.e., prior to human influence) conditions.

We therefore have developed three scenarios that we use throughout this report as follows.

1. Current Land Cover: This incorporates present day land cover and atmospheric nitrogen deposition rates.

2. Pre-human Land Cover: This incorporates pre-human land cover and current atmospheric nitrogen deposition rates (it assesses the effects of land cover change only).

3. Pristine: This incorporates pre-human land cover and estimated pre-industrial atmospheric nitrogen deposition rates (it assesses the combined effects of land cover and atmospheric nitrogen changes).

The CLUES model does not account for wetlands; the total area of which has been reduced by 90% from pre-human times [3]. Wetland areas are defined as either Rivers, lakes, snow & ice or as Scrub in the current and pre-human land use layers (Figure 2-1 and Figure 2-2). Consequently, any denitrification services provided by wetlands are not accounted for in either the current, pre-human or pristine scenarios.

[3] https://data.mfe.govt.nz/table/52541-estimated-contemporary-and-pre-human-wetland-area-by-type-2008-estimate/data/

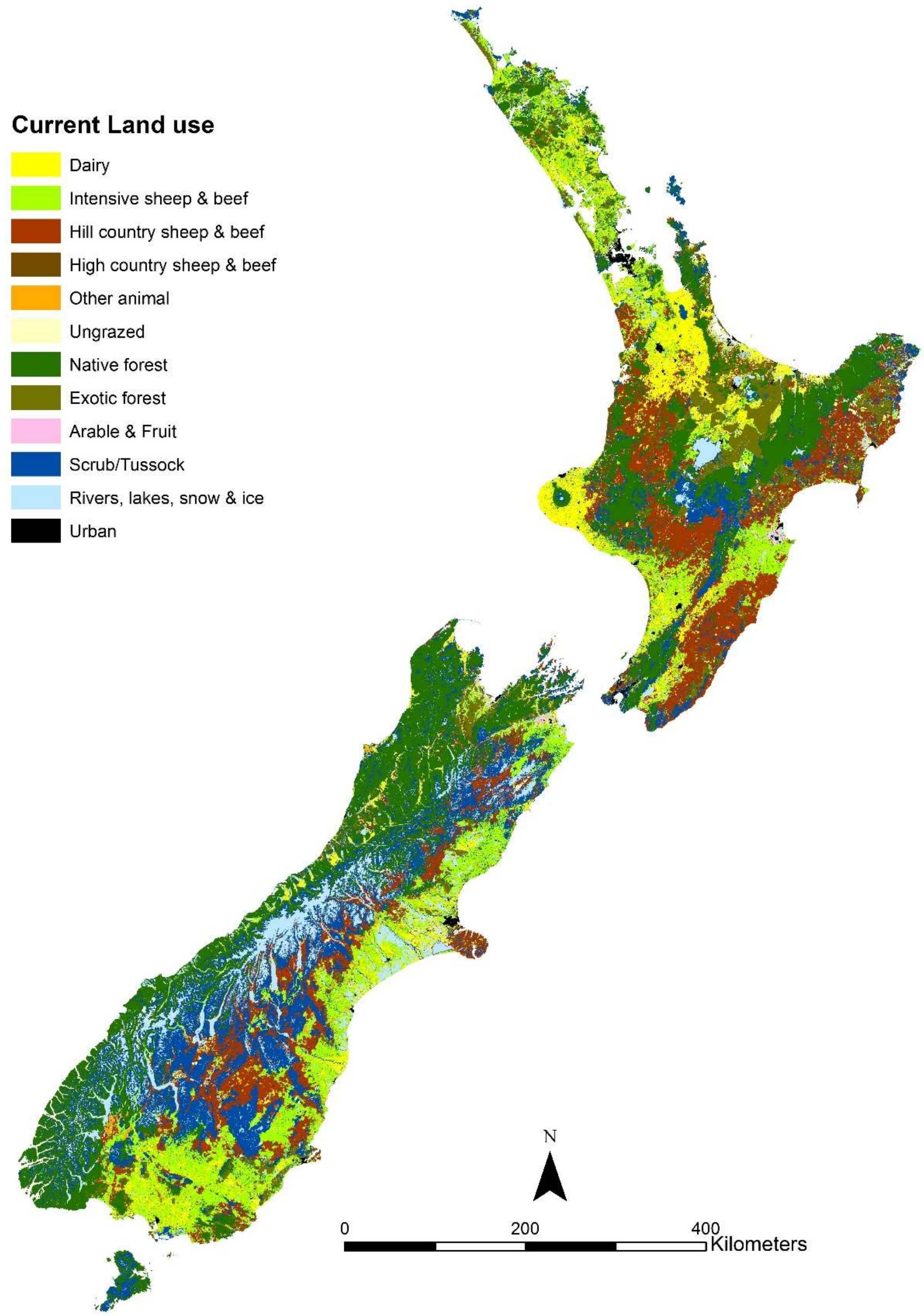

Figure 2-1: Map of the land use categories for the 'current land cover' scenario used in CLUES. The land coverage categories are derived from the national Land Cover Database version 3.0 (LCDB3, Landcare Research, http://www.lcdb.scinfo.org.nz), AgriBase Rural Properties database (AsureQuality, New Zealand, 2008 baseline year) and the Land Environments of New Zealand (LENZ, Leathwick 2002) for the baseline year 2008.

Figure 2-2: Map of the land use categories used for the 'pre-human land cover' and the 'pristine' scenarios. Adapted from the Potential Vegetation Pattern from Landcare Research (Leathwick, McGlone et al. 2012). Note that scrub and tussock are combined in the 'pre-human land cover' and are modelled using CLUES parameters developed for tussock.

2.3 Dilution modelling approach

Assessments of susceptibility to eutrophication are based on potential total nitrogen (TN) concentrations and flushing times of the estuaries. Potential TN concentrations are the time and volume-averaged concentrations in the estuary in the absence of non-conservative processes such as losses to denitrification or uptake of the N by organisms. Observed nutrient concentrations (such as measured in typical water quality sampling) within a water body may often be lower than potential concentrations due to these processes, especially during periods of high seasonal plant growth and nutrient depletion (Bricker, Ferreira et al. 2003). At such times, a high (potentially eutrophic) biomass of algae may take up a large proportion of nutrient from the water column such that observed (measured) nutrients may be in comparatively low concentrations. Such measures may therefore be misleading when assessing eutrophic state with respect to nutrient concentrations. Macroalgal cover has been found to link strongly with nutrient load in New Zealand (Robertson, Stevens et al. 2016a) and overseas (Fox, Stieve et al. 2008). Similarly, nutrient loads and residence time have been found to be better predictors of phytoplankton biomass than observed nutrient concentrations (National Research Council 2000; Ferreira, Wolff et al. 2005), particularly during nutrient limited phases of the annual cycle (Bricker, Ferreira et al. 2003). Potential concentrations thus represent the loading on the estuary, after dilution with seawater, and are expected to be more useful in predicting the trophic response of estuaries than measured within-estuary nutrient concentrations.

Potential concentrations in estuaries were calculated using a dilution modelling approach described by Plew, Zeldis et al. (2018a). This approach uses basic physiographic properties of estuaries such volume, tidal prism and freshwater inflow to determine the ratio of freshwater to seawater within estuaries. Physical parameters (tidal prism, volume, intertidal area) for estuaries were obtained from the Coastal Explorer database (Hume, Snelder et al. 2007), which contains data for over 400 New Zealand estuaries. The data within the database were collated from a variety of sources including bathymetry charts, aerial photographs, tidal models and various estuary studies. The data used in this study are given in Appendix A, Table A-1.

The dilution models used in the present investigation include a tidal prism model with a tuning factor that accounts for incomplete mixing and return flow into the estuary (Luketina 1998), and a two layer box model for systems with density stratification (Gillibrand, Inall et al. 2013).

The tuning factor in the tidal prism model would ideally be set using observed salinities, volume-averaged over the estuary at high tide (Plew, Dudley et al. 2017). However, this information is available for only a few estuaries in the database. Therefore, the tuning factor is set using the ratio of freshwater inflow to tidal prism using a predictor obtained from salinity data measured or modelled in 16 estuaries (Plew, Zeldis et al. 2018a). These estuaries were from both North and South Islands (Table 2-2). The majority (12) were ETI SIDES, while the others were DSDE and SSRTRE. There can be considerable variability in the value of the tuning factor between estuaries with similar freshwater input/tidal prism ratios, and this introduces a degree of uncertainty in calculation of nutrient concentrations within estuaries. However, within each estuary, the same dilution is used for all scenarios (i.e., current land cover, 'pre-human' land cover, pristine), and the relative changes in concentration will be consistent. An indication of the error in the dilution modelling approach is obtained by comparing predicted salinity ratio (in-estuary salinity/ocean salinity) to the observed ratio. The standard error is 12%. The error in the potential nutrient concentrations due to uncertainties in the mixing model will be similar.

Coastal lakes, which have no tidal prism and little or no inflow from the sea, are modelled as freshwater systems. This conservative approach ignores possible seawater inputs from wave overtopping, salt spray or percolation through gravel barriers, and results in high in-lake concentrations as no dilution by seawater is allowed for. However, coastal lakes generally have low salinity, and therefore low dilution of riverine nutrients by sea water compared to other estuarine systems.

Table 2-2: Estuary data used to set tuning factor in the tidal prism model (from Plew, Zeldis et al. 2018). NZCHS Type is the New Zealand Coastal Hydrosystem type (Hume, Gerbeaux et al. 2016), ETI is the NZ Estuary Trophic Index type, QT/P is the ratio of fresh water input (Q) over a tidal period (T) to the tidal prism (P), S/S_0 is the ratio of volume-averaged estuary salinity at high tide to ocean salinity, and b the tuning factor. Estuaries for which volume averaged salinities were obtained from hydrodynamic models are denoted with 'model' following the estuary name.

Estuary	NZCHS Type	ETI type	Lat (°S)	Lon (°N)	QT/P	S/S_o	b
Te Puna /Kerikeri Inlet	8	SIDE	35.204	174.069	0.000481	0.73	0.987
Opua Inlet System	9	SIDE	35.244	174.099	0.001128	0.826	0.946
Whangarei Harbour	8	SIDE	35.848	174.513	0.001732	0.771	0.994
Whangarei Harbour (model)	8	SIDE	35.848	174.513	0.002516	0.95	0.952
Kaipara Harbour	8	SIDE	36.418	174.164	0.003535	0.948	0.935
Waitemata Harbour	8	SIDE	36.839	174.818	0.001765	0.871	0.988
Manukau Harbour	8	SIDE	37.047	174.527	0.000892	0.912	0.991
Waihou (model)	6A	SSRTRE	37.17	175.542	0.042924	0.315	0.98
Tauranga Harbour System	8	SIDE	37.638	176.156	0.007031	0.858	0.957
Pelorus Sound	9	DSDE	40.945	174.086	0.001257	0.957	0.972
Queen Charlotte Sound	9	DSDE	41.09	174.38	0.000928	0.994	0.843
Porirua Harbour	8	SIDE	41.094	174.863	0.016949	0.846	0.906
Avon-Heathcote	7A	SIDE	43.564	172.749	0.02183	0.813	0.904
Avon-Heathcote (model)	7A	SIDE	43.564	172.749	0.02183	0.828	0.894
Okains Bay Estuary	7A	SIDE	43.694	173.055	0.030341	0.831	0.849
Le Bons Bay Estuary	7A	SIDE	43.746	173.095	0.15284	0.777	0.424
Kakanui (model)	6B	SSRTRE	45.187	170.898	0.514917	0.436	0.464
Kakanui (model)	6B	SSRTRE	45.187	170.898	0.221814	0.457	0.79
New River Estuary	8	SIDE	46.507	168.272	0.037336	0.712	0.906
New River Estuary (model)	8	SIDE	46.507	168.272	0.037336	0.77	0.873

The two-layer box model calculates the volume, thickness, salinity and temperature of each layer. It is forced with wind stress, river discharge, surface heat flux, tide, and boundary conditions of oceanic salinity and temperature profiles. The model allows for entrainment of water into the upper layer via the estuarine circulation process. The model is run for a 28-day period to obtain a steady state solution for salinity, from which an estuary-averaged dilution factor is calculated. Wind forcing for the model was obtained from the nearest of 18 meteorological stations across New Zealand using hourly wind speed and direction from the year 2008. To efficiently incorporate results from the two-layer box mode, the steady state results of simulations run across a range of freshwater inflows for all New Zealand estuaries contained in the New Zealand Coastal Explorer database were stored and used to create a regression between inflow and dilution for each estuary. Further details of this process are described by Plew, Zeldis et al. (2018a).

The dilution modelling approach also allows calculation of a flushing time, which is defined as the time required for the cumulative freshwater inflow to equal the amount of freshwater originally in the water body (Dyer 1973; Monsen, Cloern et al. 2002).

Dilution modelling results are obtained for 399 estuaries. A further 44 estuaries from the Coastal Explorer database are excluded because either they are located outside of areas where CLUES has been applied (e.g., Chatham Islands, Stewart Island), or in some cases have no identifiable terminal reach entering the estuary in the REC2.

2.4 Macroalgal susceptibility

Susceptibility to nuisance macroalgae blooms is determined using bandings developed from a comparison of potential TN concentrations with observations of macroalgae from 22 estuaries (Robertson, Stevens et al. 2016b; Zeldis, Whitehead et al. 2017).

Our macroalgae bandings are based on thresholds from the Opportunistic Macroalgal Blooming Tool (OBMT) (Water Framework Directive - United Kingdom Advisory Group 2014), which have received extensive review and are considered appropriate for New Zealand estuaries. Macroalgal levels are assessed using Ecological Quality Rating (EQR), which is a combined metric developed by the European Water Framework Directive based on both biomass and spatial measures. EQR is calculated from observations of % cover of available intertidal habitat, affected area with > 5% macroalgae cover, average biomass, and % cover with algae > 3 cm deep (Robertson, Stevens et al. 2016b). EQR scores range from 0 (severely impacted) to 1 (no impact). While the OMBT has 5 bandings for EQR, we combine the lowest two categories and use 4 bandings (A-D). A description of the expected ecological condition corresponding to each banding is given in Table 2-3.

Table 2-3: Description of expected ecological conditions corresponding to macroalgal estuary bandings. The bandings relate potential total nitrogen concentrations - calculated from annual loads and mean annual flow - to summer macroalgae response. Adapted from ETI tool 2 (Robertson, Stevens et al. 2016b) and Plew, Zeldis et al. (2018b).

Band	A Minimal eutrophication	B Moderate eutrophication	C High eutrophication	D Very high eutrophication
	TN_{est} < 80 mg/m³ Ecological communities (e.g., bird, fish, seagrass, and macroinvertebrates) are healthy and resilient. Algal cover <5% and low biomass (<50 g/m² wet weight) of opportunistic macroalgal blooms and with no growth of algae in the underlying sediment. Sediment quality high	80 ≤ TN_{est} < 200 mg/m³ Ecological communities (e.g., bird, fish, seagrass, and macroinvertebrates) are slightly impacted by additional macroalgal growth arising from nutrients levels that are elevated. Limited macroalgal cover (5–20%) and low biomass (50–200 g/m² wet weight) of opportunistic macroalgal blooms and with no growth of algae in the underlying sediment. Sediment quality transitional	200 ≤ TN_{est} < 320 mg/m³ Ecological communities (e.g., bird, fish, seagrass, and macroinvertebrates) are moderately to strongly impacted by macroalgae. Persistent, high % macroalgal cover (25–50%) and/or biomass (>200–1000 g/m² wet weight), often with entrainment in sediment. Sediment quality degraded	TN_{est} ≥ 320 mg/m³ Ecological communities (e.g., bird, fish, seagrass, and macroinvertebrates) are strongly impacted by macroalgae. Persistent very high % macroalgal cover (>75%) and/or biomass (>1000 g/m² wet weight), with entrainment in sediment. Sediment quality degraded with sulphidic conditions near the sediment surface

We have developed potential TN bandings corresponding to EQR bands by fitting a linear regression between predicted potential TN and observed EQR (Figure 2-3), then using this regression to calculate potential TN concentrations corresponding to EQR thresholds. We used annual TN loads and annual mean flows to calculate potential TN concentrations. EQR observations are from peak growth (summer) periods. Our bandings therefore relate annual loads and flows to summer macroalgae response. These thresholds are reported in Table 2-4.

We note that in summer when peak macroalgae biomass typically occurs, N loads and freshwater inflows, and therefore estuary potential TN concentrations, are likely lower than annual mean values. Differences between estuaries in ratios of summer/annual loads may account for some of the spread in Figure 2-3. If summer potential TN concentrations were used, it is likely that this relationship would shift to the left in Figure 2-3 and the thresholds between bands would be lower. It is also possible that the fit of the regression improves. However, CLUES provide annual loads and does not yet provide seasonal resolution. Therefore, we develop our susceptibility bandings for potential TN concentrations calculated from annual loads and mean flows.

Because estuarine macroalgae growth is inhibited by low salinity conditions (Martins, Oliveira et al. 1999), we apply a susceptibility band of A if the estuary salinity (calculated from the dilution modelling) is less than 5 ppt, irrespective of potential nutrient concentrations.

Table 2-4: Thresholds for macroalgae susceptibility. Potential total nitrogen (TN) concentrations are based on annual loads and annual mean flow.

Macroalgae susceptibility band	Ecological Quality Rating	Potential TN concentration (mg/m³)
A	1.0 > EQR ≥ 0.8	≤ 80
B	0.8 > EQR ≥ 0.6	80 < TN ≤ 200
C	0.6 > EQR ≥ 0.4	200 < TN ≤ 320
D	EQR < 0.4	TN > 320

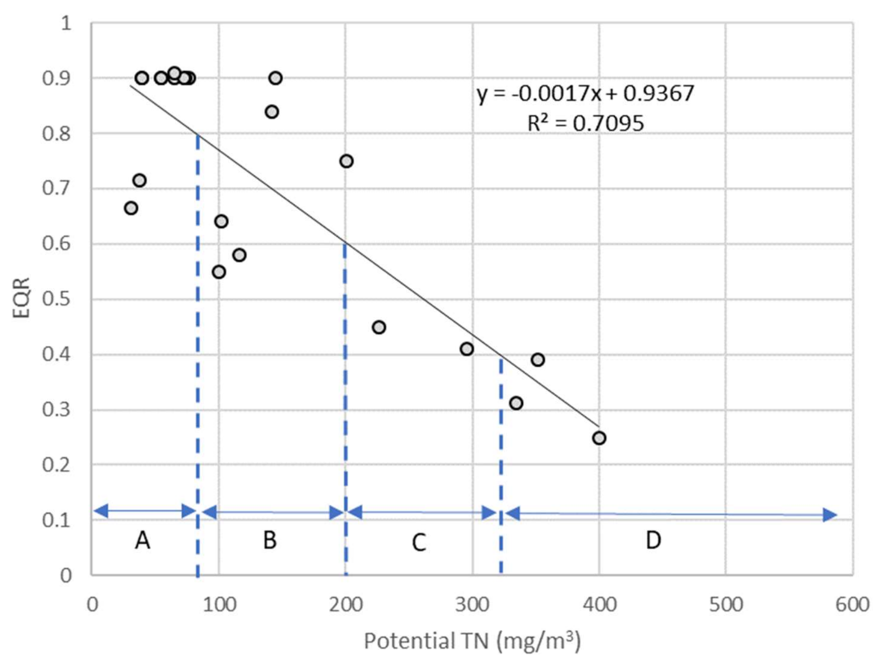

Figure 2-3: Observations of macroalgae Ecological Quality Rating (EQR) plotted against calculated potential total nitrogen (TN) concentrations for 23 New Zealand Estuaries. Proposed bandings for potential TN concentrations are shown, corresponding to EQR bandings in Table 2-4. Data from Robertson, Stevens et al. (2016b) and Plew, Zeldis et al. (2018a).

2.5 Phytoplankton susceptibility

Susceptibility to phytoplankton (suspended algae) blooms is assessed using a growth model (Plew et al. in prep) where phytoplankton growth is assumed to be limited only by nitrogen. We have focused on N loads because, as in other countries, N is almost always the limiting nutrient in New Zealand estuaries and coastal waters (Valiela, McClelland et al. 1997; National Research Council 2000; Barr and Rees 2003). Managing phosphorus loads may be an issue for coastal lakes, and other approaches that link algae to areal phosphorus loading, depth and residence time may be more appropriate for those systems (OECD 1982). The inputs to the model are the potential TN concentration and estuary flushing time (obtained from the dilution model), and the output is phytoplankton biomass as chl-*a* (chlorophyll-*a*). Three parameters are required in the model. These are the specific growth rate, a half saturation coefficient which describes the effect of N limitation on growth, and a conversion factor between the ratio of chl-*a* to the tissue N content of phytoplankton. These values have been set based on literature (Table 2-5).

Table 2-5: Parameters used in the estuary phytoplankton growth model.

Parameter	Description	Value	Source
k	Specific growth rate	0.3 d^{-1}	(Vant and Budd 1993; Gibbs and Vant 1997)
N_s	Half saturation coefficient for TN	45 mg m^{-3}	Eppley, Rogers et al. (1969) provide values for nitrate, and we assume nitrate is ~80% of TN.
α	Ratio of chl-*a* to phytoplankton tissue nitrogen concentration	8.8 µg N/µg chl-*a*	(Cloern, Grenz et al. 1995)

The growth model for phytoplankton reduces to

$$C = \frac{1}{\alpha}\left(N_p - \frac{N_s}{kT_F - 1}\right) \qquad \text{for} \qquad T_F > \frac{N_p + N_s}{kN_p}$$

else

$$C = 0$$

where N_p is the potential TN concentration in the estuary (from the dilution model), T_F the estuary flushing time, and C the chl-*a* concentration in the estuary. The condition $T_F > \frac{N_p+N_s}{kN_p}$ indicates that there is a minimum flushing time below which phytoplankton will be flushed from the estuary faster than they grow, and therefore phytoplankton concentrations will be negligible. This minimum flushing time is determined mostly by the specific growth rate, but also increases at low potential TN concentrations as growth rates becomes nitrogen limited.

Susceptibility bandings for phytoplankton blooms used here are those proposed in the ETI (Robertson, Stevens et al. 2016b). The ETI bandings for phytoplankton are interim values largely based on response thresholds from Basque estuaries (Revilla, Franco et al. 2010) due to the limited data available for New Zealand. ETI bandings for chl-*a* observations are for the 90^{th} percentile based on monthly measurements. We use the same banding thresholds for susceptibility but use chl-*a* concentrations predicted by the model using potential TN concentrations derived from mean annual flows and annual N loads to the estuary (Table 2-6). The susceptibility bandings for oligo/meso/polyhaline estuaries are shown as a function of flushing time and potential TN concentration in Figure 2-4. The expected ecological condition of the estuary corresponding to each band is described in Table 2-7.

Table 2-6: Phytoplankton susceptibility bands based on ranges of chlorophyll-*a* in high (>30 ppt) and other (<30 ppt) salinity ranges. The bandings were developed for the 90th percentile of monthly observations but applied to the model using mean annual flows and annual N loads. Oligohaline 0.5-5ppt salinity, Mesohaline >5-18ppt, Polyhaline >18-30 ppt, Euhaline > 30 ppt. From Robertson, Stevens et al. (2016b).

Band	Euhaline estuaries (> 30 ppt)	Oligo/Meso/Polyhaline estuaries (< 30 ppt)
A	< 3 µg/l	< 5 µg/l
B	3-8 µg/l	5-10 µg/l
C	> 8-12 µg/l	> 10-16 µg/l
D	> 12 µg/l	> 16 µg/l

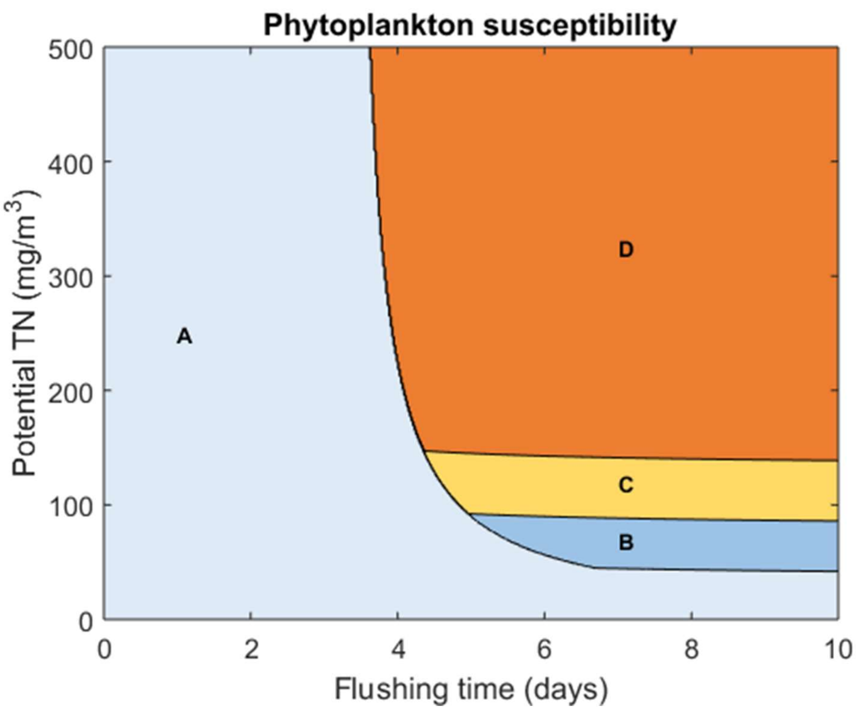

Figure 2-4: Phytoplankton susceptibility bandings as a function of flushing time and potential TN concentration in the estuary. Bandings shown for estuaries with salinity < 30 ppt.

Table 2-7: Description of expected ecological conditions corresponding to phytoplankton estuary bandings. Adapted from ETI tool 2 (Robertson, Stevens et al. 2016b) and Plew, Zeldis et al. (2018b).

Band	A Minimal eutrophication	B Moderate eutrophication	C High eutrophication	D Very high eutrophication
Euhaline estuaries	chl-*a* < 3 µg/l	3 ≤ chl-*a* < 8 µg/l	8 ≤ chl-*a* < 12 µg/l	chl-*a* ≥ 12 µg/l
Oligo/Meso/ Polyhaline estuaries	chl-*a* < 5 µg/l	5 ≤ chl-*a* < 10 µg/l	10 ≤ chl-*a* < 16 µg/l	chl-*a* ≥ 16 µg/l
	Ecological communities are healthy and resilient	Ecological communities are slightly impacted by additional phytoplankton growth arising from nutrients levels that are elevated	Ecological communities are moderately impacted by phytoplankton biomass elevated well above natural conditions. Reduced water clarity likely to affect habitat available for native macrophytes	Excessive algal growth making ecological communities at high risk of undergoing a regime shift to a persistent, degraded state without macrophyte/seagras s cover

2.6 Overall susceptibility banding

Primary symptoms of estuary eutrophication are high biomass of macroalgae or phytoplankton. However, these may not necessarily result in secondary symptoms of eutrophication. For example, high phytoplankton concentrations are unlikely to result in low oxygen levels or significant light attenuation if an estuary is shallow and well mixed. A high susceptibility to macroalgae blooms might not result in eutrophic conditions if there are little suitable shallow or intertidal areas available for the macroalgae to grow. We therefore assess the overall susceptibility of an estuary using estuary characteristics to determine whether macroalgae or phytoplankton (or either) are of concern.

Most estuaries (91%) classified as SIDEs in the ETI database have large (>40%) intertidal areas, suitable for macroalgae growth. They generally have short flushing times and thus are not prone to phytoplankton blooms. However, larger systems may have flushing times long enough for phytoplankton blooms to occur but, being shallow, are normally vertically well-mixed and do not develop low oxygen concentrations from phytoplankton respiration. For these systems, the susceptibility to eutrophication is determined from the macroalgae susceptibility banding.

DSDEs are generally large estuaries, fjords, sounds or embayments. The intertidal portion of DSDEs is small (typically < 5%), so even if macroalgae blooms occur, they are confined to a small portion of the estuary. However, DSDEs are deep, commonly develop a thermal and/or salinity driven stratification, and have long flushing times. Phytoplankton blooms are therefore the primary symptom of eutrophication for DSDEs.

Half (50%) of estuaries classified as SSRTREs in the ETI database have a low proportion of intertidal area (i.e., < 5% of the estuary is intertidal). These estuaries are unlikely to develop wide-spread macroalgae blooms. However, a further 39% of SSRTREs have an intermediate proportion of intertidal area (5-40%), so can develop nuisance levels of macroalgae. Most SSRTREs have short flushing times, but larger systems or systems that intermittently close can develop phytoplankton blooms. Consequently, SSRTREs may be susceptible to both phytoplankton and macroalgae.

There is some overlap of estuary size and intertidal area between ETI classes. Consequently, we base our overall assessment of susceptibility on % intertidal area (Table 2-8). The overall susceptibility of estuaries with >40% intertidal areas is determined by the susceptibility to macroalgae. The susceptibility for estuaries with <5% intertidal area is determined from the phytoplankton susceptibility. For estuaries with intermediate intertidal area (5-40%), we consider both macroalgal and phytoplankton susceptibility, and use the highest (greatest) of these as the overall susceptibility.

Table 2-8: Overall susceptibility to eutrophication is determined from macroalgal or phytoplankton based on % intertidal area.

Intertidal area	Susceptibility
>40%	Macroalgae
5-40%	Highest of macroalgae or phytoplankton susceptibility
<5%	Phytoplankton

3 Results

3.1 Comparison of N loads to estuaries from CLUES and Snelder et al. (2017)

The CLUES-based and Snelder, Larned et al. (2017) estimates of N loads under current land cover are strongly correlated ($R^2 = 0.88$, $P < 0.001$, Figure 3-1), but CLUES gives estuary loads that are on average (i.e., averaged across estuaries) 21% lower than those from Snelder, Larned et al. (2017). However, the total load to estuaries from CLUES is only 7% lower than from Snelder, Larned et al. (2017) (Table 3-1). The difference between these two values (21% vs 7%) is likely due to better agreement between the estimates for estuaries with high loads, while differences between the two estimates are greater for estuaries with small loads. Both approaches are calibrated to observations (gaugings) of nutrient loads in rivers, which are more commonly collected in large rivers. Both approaches are likely better calibrated for estuaries receiving high loads, and increasing scatter at lower loads (Figure 3-1) reflects differences in the methodologies.

Table 3-1: Total TN loads to estuaries in NIWA's Coastal Explorer database. Note that loads to estuaries not included in the database, or directly to the ocean, have been excluded.

Scenario	CLUES (T/yr)	Snelder et al. (2017) (T/yr)
Current land cover	132,377	141,740
'Pre-human land cover' (CLUES) and 'natural' (Snelder et al. 2017)	69,185	55,153
'Pristine' (pre-human land cover adjusted for reduced atmospheric N deposition)	31,755	-

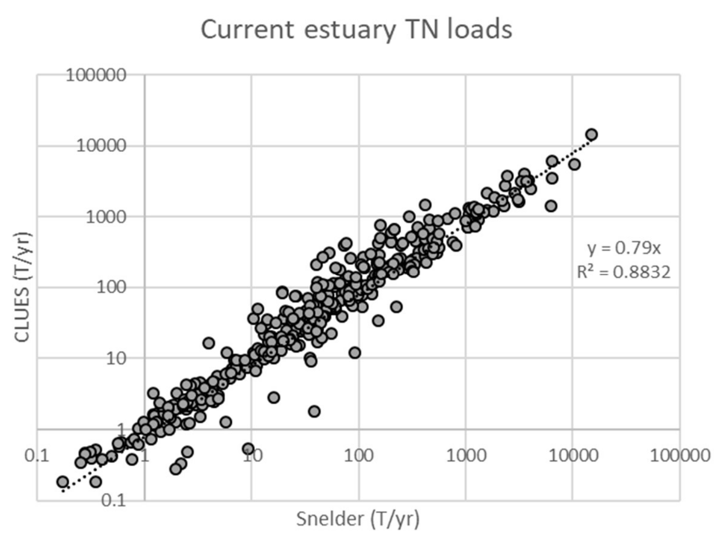

Figure 3-1: Comparison of annual total nitrogen (TN) loads to estuaries predicted by CLUES and Snelder, Larned et al. (2017). Linear regression with zero intercept, $P < 0.0001$. The regression coefficient (y) shows that for an N load reported for a given estuary in Snelder, Larned et al. (2017), CLUES predicts an N load 0.79 times as great. The R^2 value gives the fit of this relationship.

We also compare the 'natural' scenario from Snelder, Larned et al. (2017) with the 'pre-human land cover' scenario from CLUES. These show a closer agreement, with CLUES loads on average 4% lower than Snelder, Larned et al. (2017) values (Figure 3-2). However, there is a bigger difference between total loads, with the CLUES 'pre-human land cover' total N load to estuaries being 25% larger than those from Snelder, Larned et al. (2017) (Table 3-1).

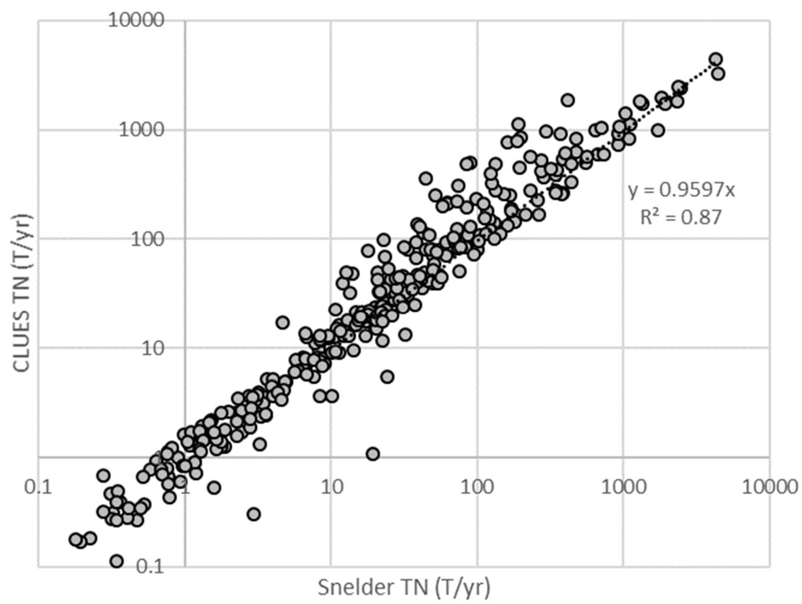

Figure 3-2: Comparison of annual total nitrogen (TN) loads to estuaries predicted by CLUES for the 'pre-human land cover' scenario, and the 'natural' land use scenario from (Snelder, Larned et al. 2017). The regression coefficient (y) shows that for an N load reported for a given estuary in Snelder, Larned et al. (2017), CLUES predicts an N load 0.9597 times as great. The R^2 value gives the fit of this relationship.

There is generally good consistency between results from the two models. This is encouraging given the very different methods used in calculating nutrient loads (see section 2.2, above). For example, while 'natural' condition N loads were calculated by Snelder, Larned et al. (2017) by reducing the proportions of catchments occupied by intensive agricultural land cover to zero (effectively reducing intensity but not changing land cover), the CLUES 'pre-human land cover' estimate used in this study reverted all land covers in the catchment to their 'pre-human land cover' state. From here-on, we base our assessment of estuary eutrophication using output from the CLUES model. The major advantage of the CLUES model is the ease with which different land-use scenarios can be created and assessed.

3.2 Comparison of CLUES scenarios

Loads to estuaries are compared for the CLUES scenarios of 'pre-human land cover' and current land use (Figure 3-3). Summed across estuaries, current TN loads are 91% greater than those calculated for the 'pre-human land cover' scenario (Table 3-1). The slope of the regression indicates an average increase of 108%. The larger average increase (in comparison to the total increase in TN load) suggests that estuaries receiving a smaller 'pre-human land cover' load experienced a greater relative increase in TN load under current conditions. This increase is similar to Snelder, Larned et al. (2017) who calculated that anthropogenic influence has caused a 74% increase in N export to the ocean. The higher increase in TN loads predicted in our study is likely due to Snelder, Larned et al. (2017) calculating total export of N to the ocean while we consider only export to estuaries in NIWA's Coastal Explorer Database, and differences in study methods as described above.

Total current TN load to estuaries predicted using CLUES is 320% higher than that calculated using the 'pristine' scenario (Table 3-1). This figure is considerably higher than the increase that we attribute to change in land cover using the 'pre-human land cover' scenario, or the figure from Snelder, Larned et al. (2017). This is because N loads under the 'pristine' scenario account for differences in atmospheric N deposition between pre-industrial and present day New Zealand. The average increase of N load to estuaries is slightly higher at 356% (Figure 3-4), which is due to the model predicting higher increase of loads to small estuaries than larger estuaries.

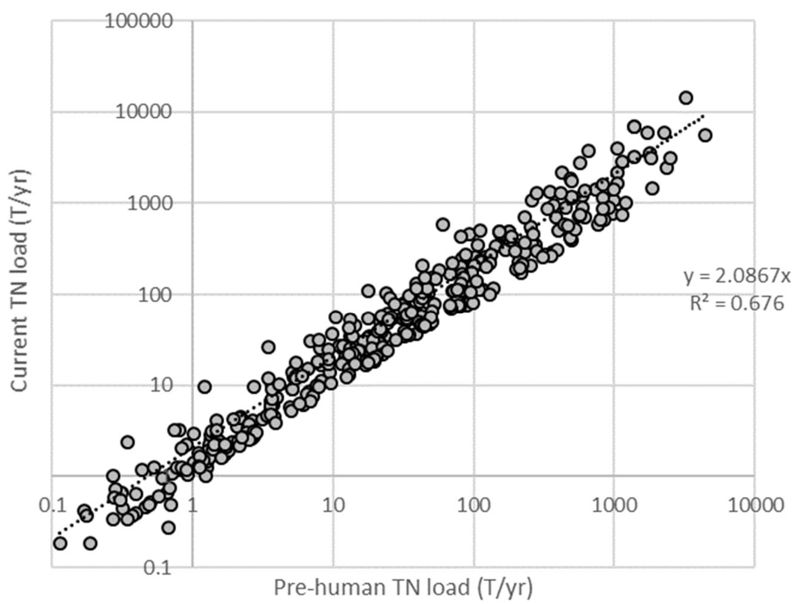

Figure 3-3: Comparison of current annual TN loads to estuaries with estimated 'pre-human land cover' TN loads. The 'pre-human land cover' TN loads are calculated from CLUES using a potential vegetation land cover layer (see Figure 2-2).

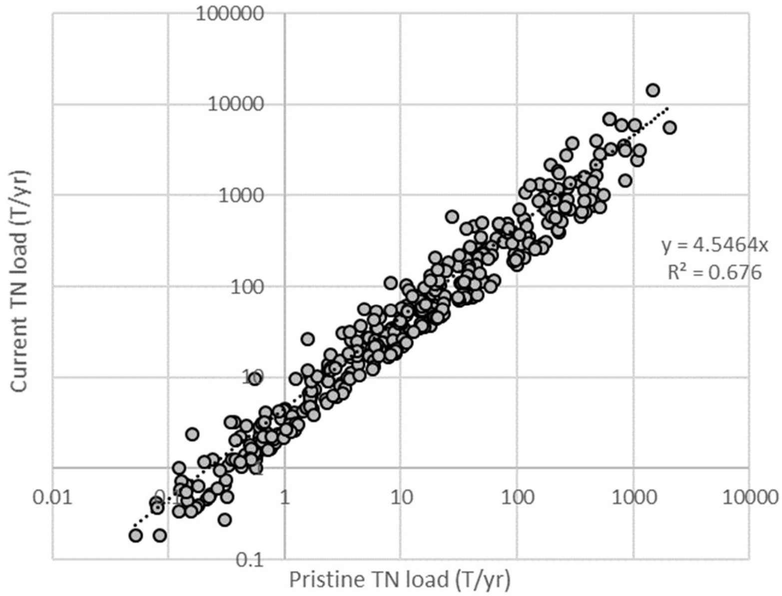

Figure 3-4: Comparison of current annual TN loads to estuaries with estimated 'pristine' loads. Pristine loads have been estimated by scaling catchment yields from the 'pre-human land cover' scenario to a mean value of 1.5 kg ha^{-1} yr^{-1} TN.

3.3 Spatial patterns of N load increases

Figure 3-5 shows spatial patterns of N load increases in New Zealand estuaries. Load increases are greatest around the central and southern North Island, and the eastern South Island. Load increases are the least along the West Coast of the South Island, reflecting comparatively little change in land cover and land use intensity in this area. Regional patterns of TN load increase seen here are similar to the results of Snelder, Larned et al. (2017), who calculated increases as being the greatest in the Manawatu-Wanganui, Southland, Canterbury, Otago, Taranaki and Hawkes Bay regions.

There are differences between the 'Pre-human land cover' and 'Pristine' comparisons which indicate that in some regions, such as Fiordland and parts of the Marlborough Sounds area, increases in loads from pristine to current may be largely attributable to increased atmospheric deposition. In these regions, current loads have changed little from the pre-human loads (Figure 3-5). However, over most of the country, the increases in load are driven by land cover changes.

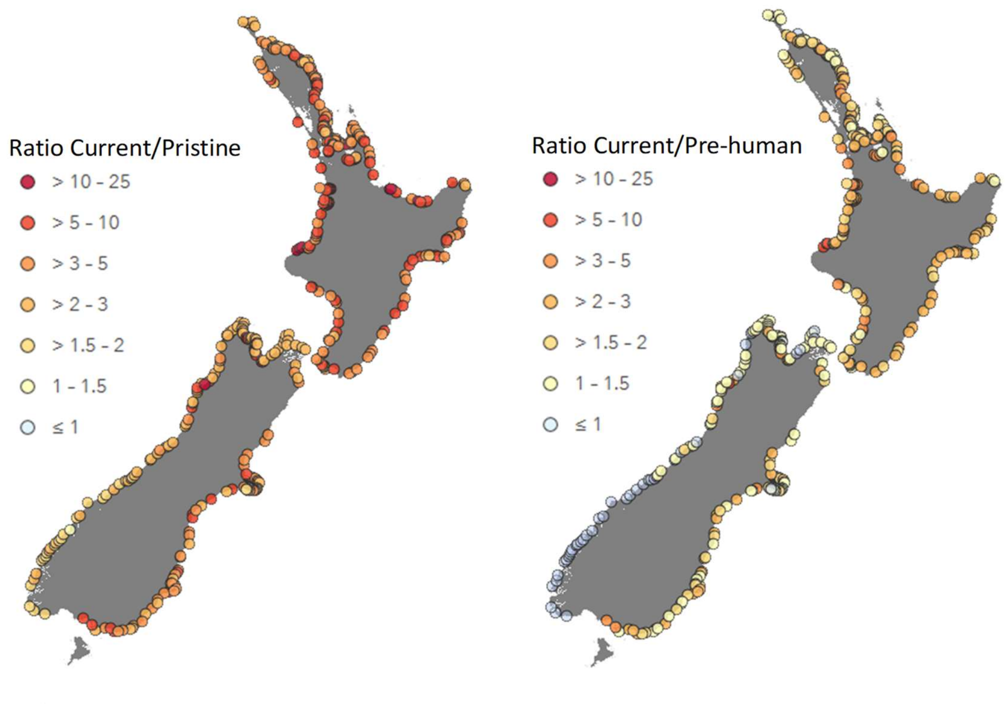

Figure 3-5: Ratio of current N load to estuaries to the N load from the 'pre-human land cover' and 'pristine' scenarios. Values > 1 indicate current TN is greater than 'pre-human land cover' or 'pristine' TN.

3.4 Maps of estuary potential TN concentrations

3.4.1 Results for each scenario

Potential TN concentrations in estuaries for current land use are shown in Figure 3-6. These concentrations are calculated using the dilution models described in section 2.2 to determine the amount of mixing between ocean and river water in the estuaries. The concentrations are consequently determined by both catchment N loads and estuary dilution characteristics.

Regional patterns in current concentrations are apparent. Estuaries along the western coast of the South Island generally have low concentrations, partly because current land use is less intensive in comparison to the east coast (see Figure 3-5, above), and because many of these estuaries are DSDEs (e.g., fjords) with high dilution. Similarly, the coastal embayments around Banks Peninsula, the Marlborough Sounds and Northland also have high dilution that reduces potential N concentrations.

Under the 'pre-human land cover' scenario, estuary potential TN concentrations are reduced, particularly along the east coast of the north and south islands. However, these regions still have higher concentrations than the west coast. This is largely due to differences in river flows, with west coast estuaries receiving higher flows for equivalent catchment area than east coast estuaries. The higher flows result in lower nutrient concentrations in the freshwater inflow to west coast estuaries.

Under the 'pristine' scenario, estuary concentrations are generally low everywhere other than in some coastal lakes on the east coast of the South Island. These results highlight the effect of low dilution and export of freshwater loads in creating high potential nutrient concentrations in coastal lakes, even under very low loading from land.

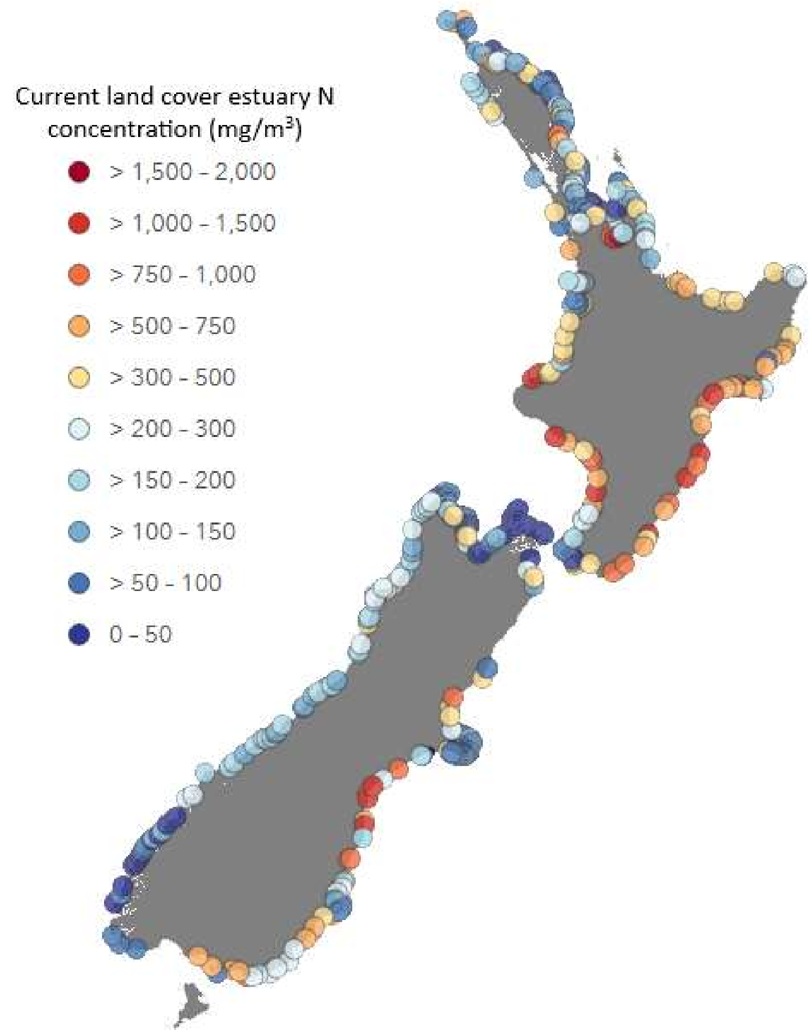

Figure 3-6: Current potential total nitrogen (TN) concentrations in New Zealand estuaries. Loads calculated from CLUES, and estuary concentrations from dilution modelling.

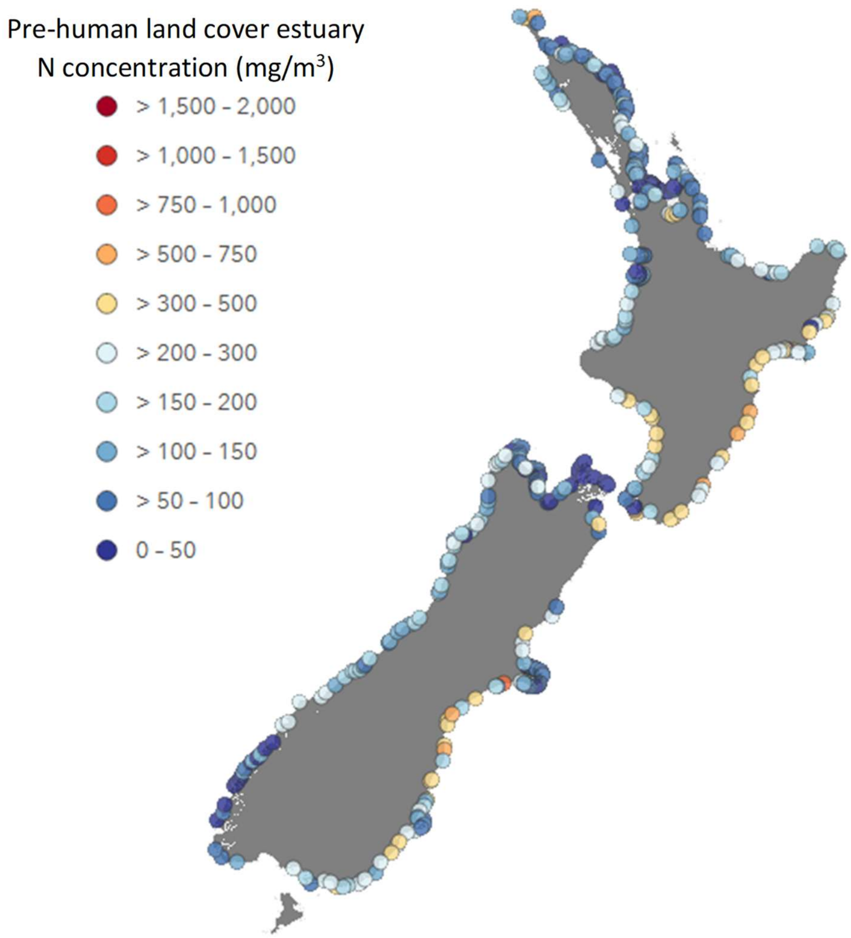

Figure 3-7: 'Pre-human land cover': total nitrogen (TN) concentrations in New Zealand estuaries. Loads calculated from CLUES using potential land cover taken from Leathwick, McGlone et al. (2012), and estuary concentrations from dilution modelling.

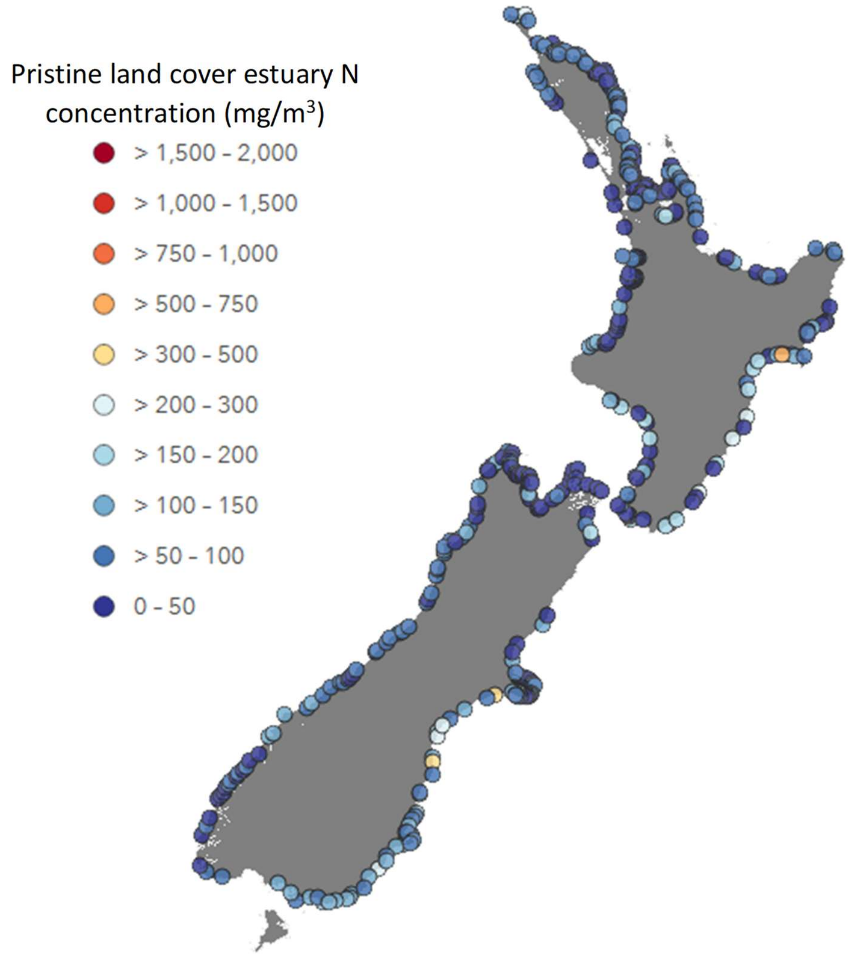

Figure 3-8: 'Pristine' land conditions: total nitrogen (TN) concentrations in New Zealand estuaries. Pristine concentrations in estuaries are estimated by scaling CLUES pre-human land cover loads to a mean yield of 1.5 kg ha^{-1} yr^{-1} TN yield across New Zealand, based on pristine catchments worldwide (Howarth, Billen et al. 1996), and applying estuary-specific dilution modelling.

3.4.2 Comparison between scenarios

The load increases seen in Figure 3-5 have caused disproportionate increases in potential nutrient concentrations in estuaries with poor dilution, as seen in Figures 3-9 and 3-10. Increases have been greatest in SSRTRES and coastal lakes, and less (but still substantial) in SIDES and least in DSDEs. Dilution is related to the fraction of freshwater in the estuary, with higher freshwater fractions indicating lower dilution (Table 3-2). As noted previously, coastal lakes are assumed to have zero salinity, which ignores any input of seawater from wave overtopping, salt spray, percolation through gravel barriers, or inflow from the ocean if the barrier is breached for a period. Consequently, potential nutrient concentrations in coastal lakes under the modelled scenarios represent typical 'closed' conditions when dilution by ocean water is low.

Table 3-2: Average freshwater fraction for each estuary type. The freshwater fraction indicates the amount of dilution in an estuary. Estuaries with a low fresh water fraction are more diluted by oceanic water, and would show a smaller increase in concentration for a given load increase.

ETI estuary type	Average freshwater fraction
DSDE	6.9%
SIDE	20%
SSRTRE	78%
Coastal Lake	100%

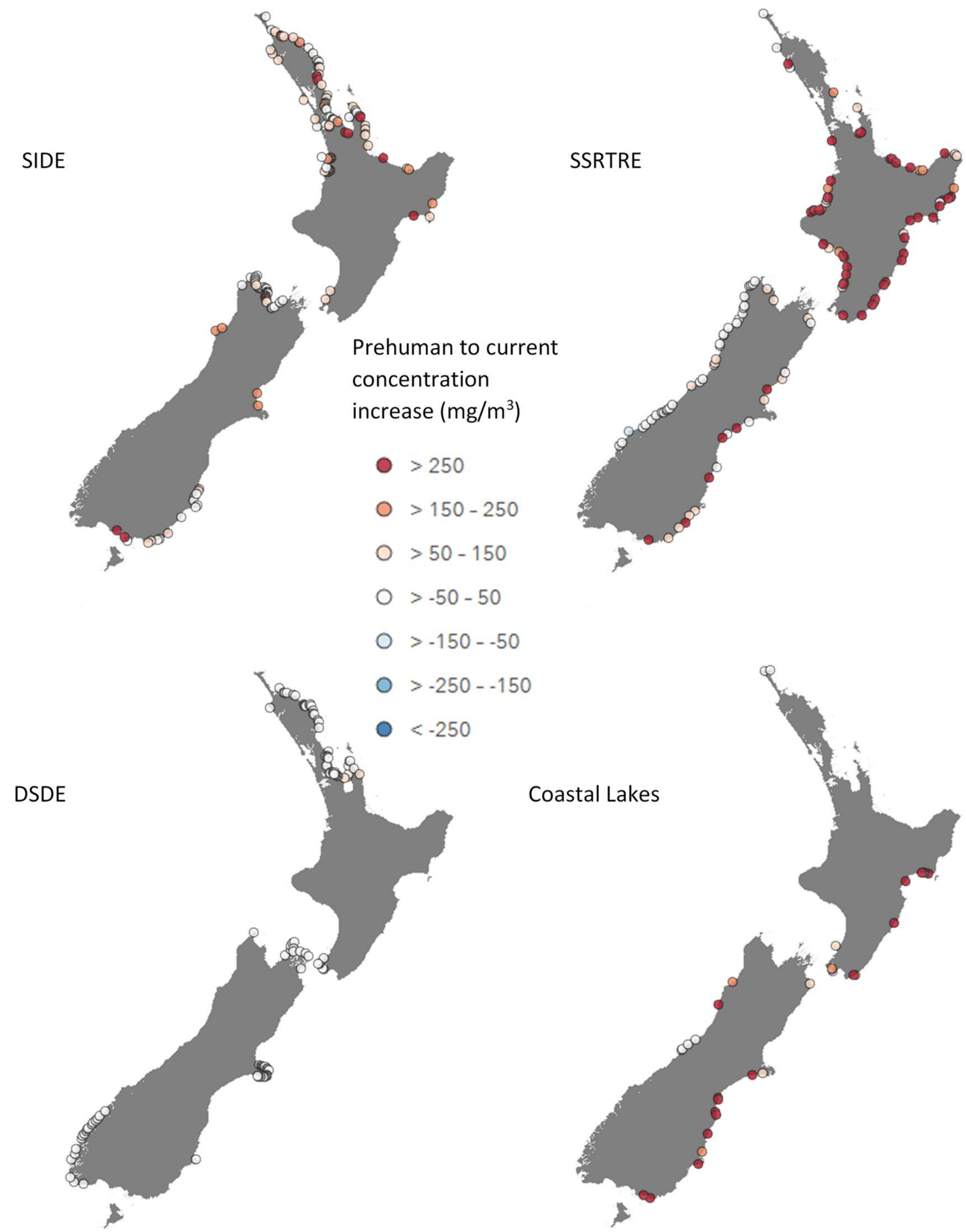

Figure 3-9: Increase in estuary N concentration from 'pre-human land cover' to 'current land cover' scenarios. Shown for each ETI estuary type.

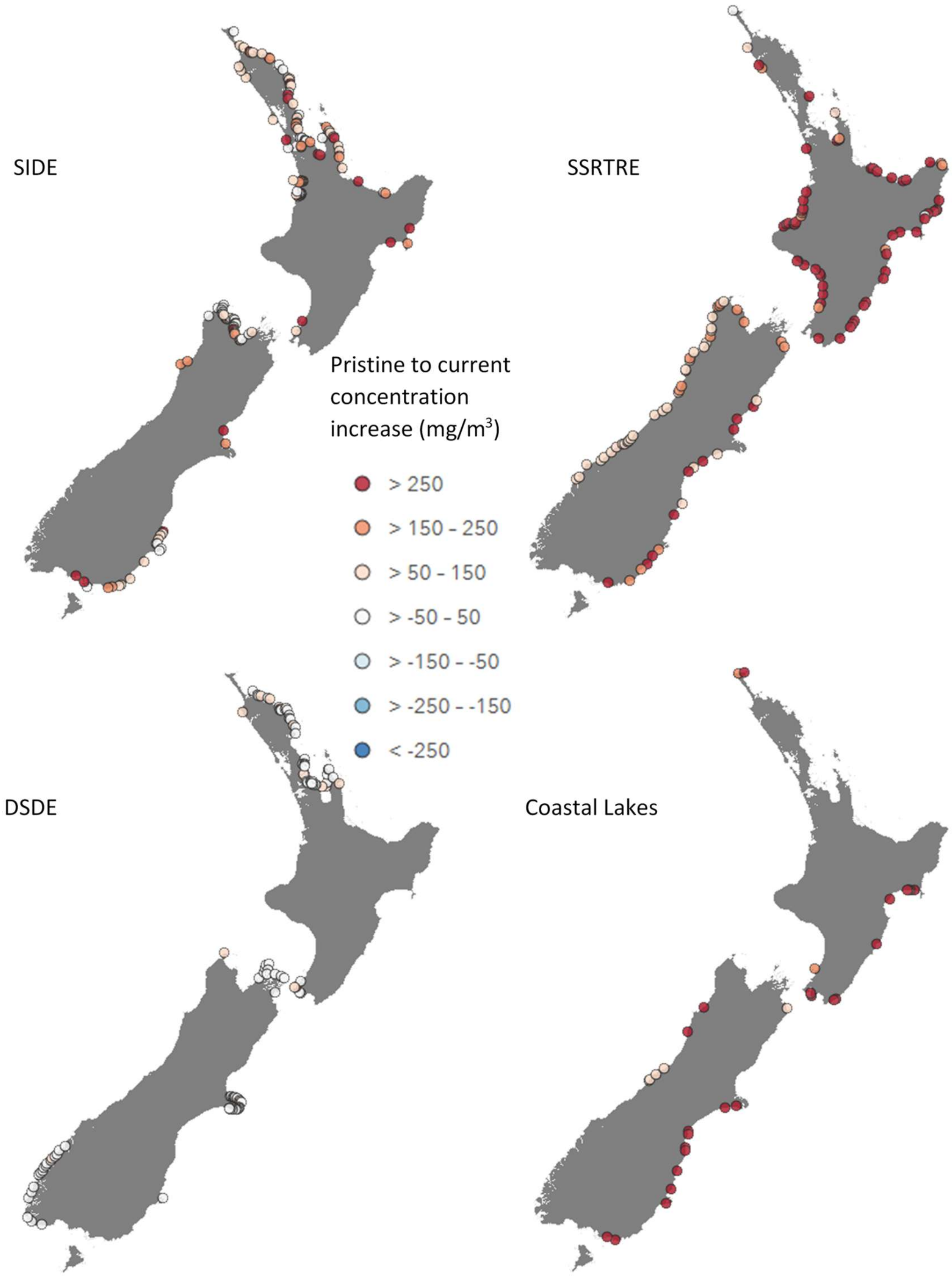

Figure 3-10: Increase in estuary N concentration from 'pristine' to 'current land cover' scenarios. Shown for each ETI estuary type.

3.5 Maps of estuarine susceptibility to eutrophication

Maps of the predicted susceptibility of estuaries to eutrophication for the present day, pre-human land cover and pristine scenarios are given in Figures 3-11, 3-12 and 3-13, below. Figure 3-14 gives counts of estuaries fitting the ETI eutrophication susceptibility classes under current conditions, and the same two historic scenarios.

Changes in estuary eutrophication susceptibility bandings between the three scenarios are influenced by estuary type. Eutrophication bands A and B indicate a low to moderate susceptibility, while C and D indicate high or very high susceptibility.

Shallow intertidal dominated estuaries (SIDEs) show the greatest shift in the proportion of high to very high susceptibility when loads are increased from the 'pristine' and 'pre-human land cover' scenarios to current scenario. Under the 'pristine' and 'pre-human land cover' scenarios, 0% and 11% of SIDEs are classified as C or D susceptibility. This increases to 42% under the current land use scenario. This substantial increase in the proportion of high risk estuaries is partially due to location – many SIDEs are in areas that have seen high increases in loading such as the eastern coasts of the North and South Islands, but also because SIDEs have a moderate dilution (Table 3-2). SIDEs have large intertidal areas, and consequently are prone to macroalgae blooms.

Shallow, short residence time river and tidal river with adjoining lagoon estuaries (SSRTRE) are the second most common type of estuary in the Coastal Explorer database. Fewer SSRTRE show an increase in susceptibility from A/B to C/D as loading was increased from pristine (1.7%) or 'pre-human land cover' scenarios (18%) to current land use (24%). This is despite their lower dilution than SIDEs (Table 3-2), which results in greater increases in estuary N concentration as inflow concentrations increase. The reasons for this are two-fold. Firstly, many SSRTRE are in regions that show small increases, or even decreases, in load (Figure 3-5). Secondly, many SSRTRE have little intertidal area, and those estuaries consequently have low susceptibility to macroalgae blooms because of lack of suitable habitat. Because SSRTRE estuaries generally have high freshwater throughput, they also have short residence times which inhibits phytoplankton growth. Consequently, through a combination of low intertidal area and short residence times, many SSRTRE are insensitive even to high nutrient loads.

The number of deep, subtidal dominated estuaries (DSDEs) classified as C or D susceptibility increased from 1% under the pristine scenario to 13% under the pre-human land cover scenarios, and to 31% under current land use conditions. This change reflects regional differences in loading change (Figure 3-5) relative to the locations of DSDE estuaries, and high dilution of freshwater nutrient loads by marine water (Figure 3-9 and 3-10). Like SSRTREs, the typically low intertidal area of DSDEs renders them unlikely to exhibit macroalgal blooms. However, because many DSDEs have low freshwater throughput, they also have long residence times, so that phytoplankton populations are retained within the estuary. Increases in eutrophication susceptibility of DSDEs under current N loads reflect current conditions more conducive to excessive phytoplankton production.

The number of coastal lakes classified as C or D susceptibility increased from 45% under the pristine scenario to 55% under the pre-human land cover scenarios, and to 58% under current land use conditions. Counterintuitively, the relatively small increase seen in coastal lakes reflects the sensitivity of these water bodies to nutrient loads from land, both in terms of their low dilution by ocean water, and their long retention times. Many of the coastal lakes in the NIWA database fit within the D band for eutrophication susceptibility even under the pristine scenario. While these systems showed little change in banding between historic and current conditions it should not be interpreted that these coastal lakes are resistant to change in nutrient loads. Instead, we suggest that this indicates many coastal lakes have always been susceptible to eutrophication, and continue to be sensitive to nutrient load increases. Some small systems classified as coastal lakes in the ETI typology have a very short flushing time that would indicate phytoplankton would be flushed from estuary faster than they can grow. Being fresh water systems, they are also not likely to support macroalgae growth. Similar to SSRTREs, coastal lakes with very short flushing times (3 days or less) are likely to be insensitive to nutrient loads, and retain an A banding for susceptibility under all three scenarios.

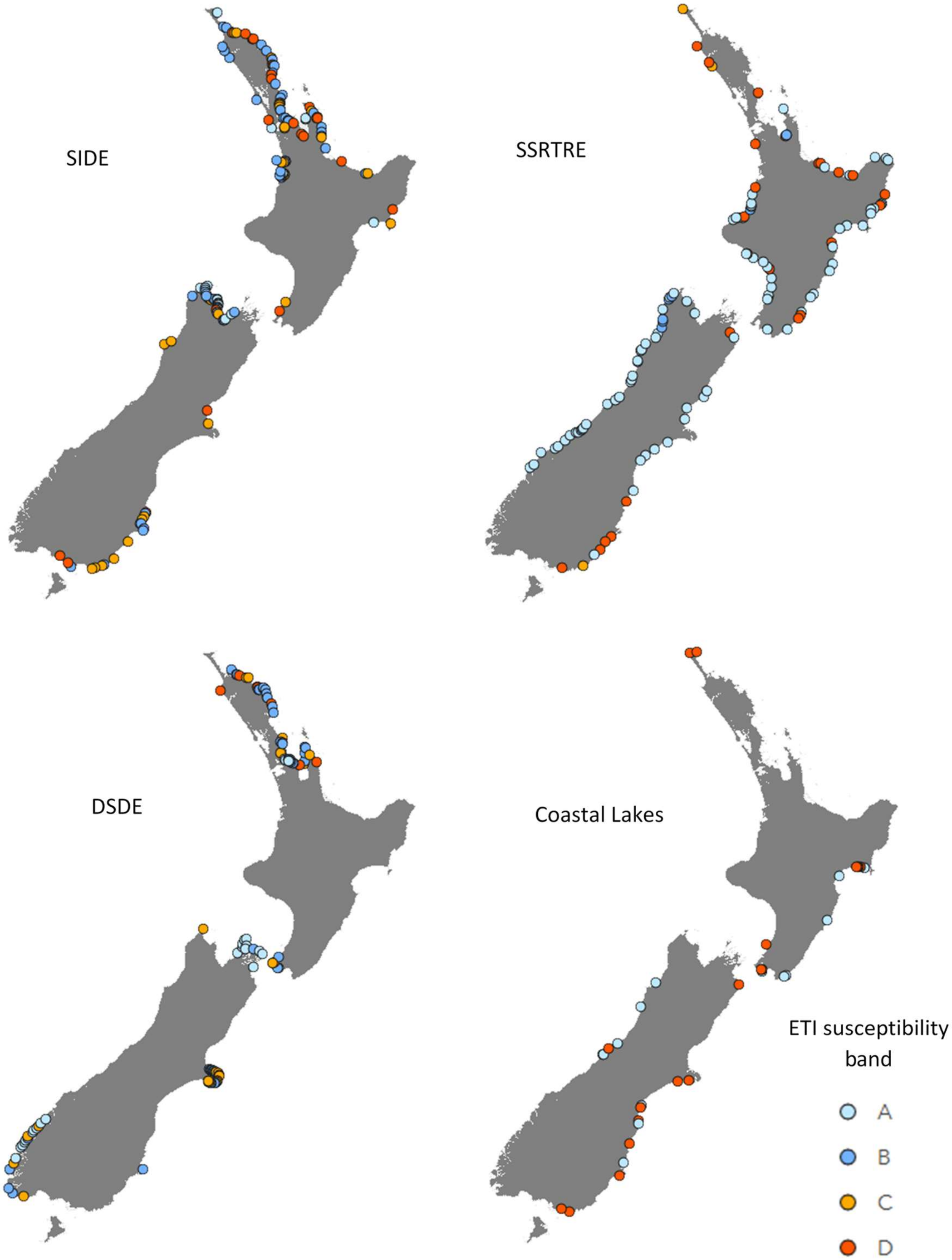

Figure 3-11: Eutrophication susceptibilities of New Zealand estuaries for the 'current land cover' scenario. A = low susceptibility, B = moderate susceptibility, C = high susceptibility, D = very high susceptibility. See Tables 2-3 and 2-7 for descriptions of ecological conditions expected for ETI susceptibility bandings.

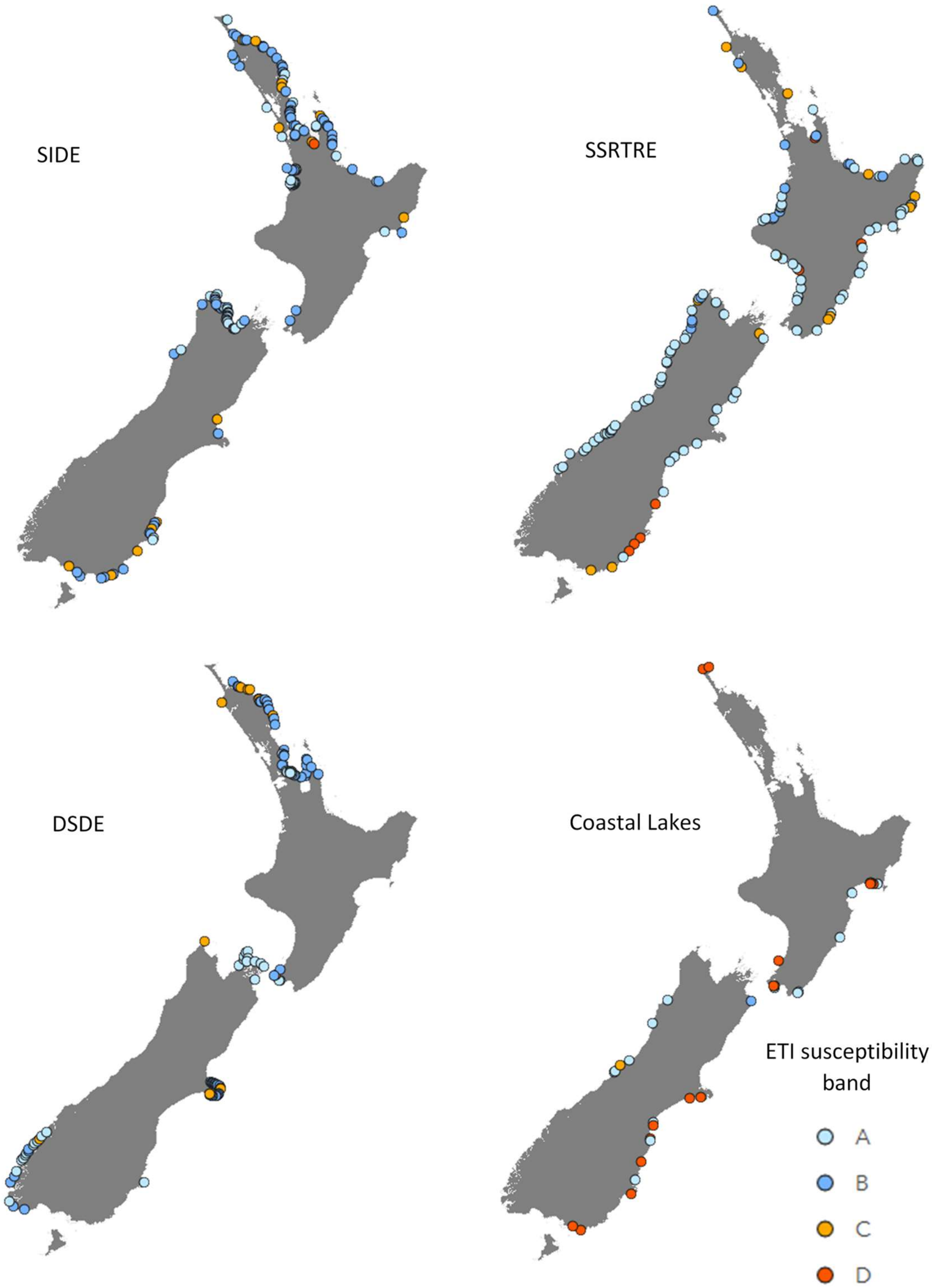

Figure 3-12: Eutrophication susceptibilities of New Zealand estuaries for the 'pre-human land cover' scenario. A = low susceptibility, B = moderate susceptibility, C = high susceptibility, D = very high susceptibility. See Tables 2-3 and 2-7 for descriptions of ecological conditions expected for ETI susceptibility bandings.

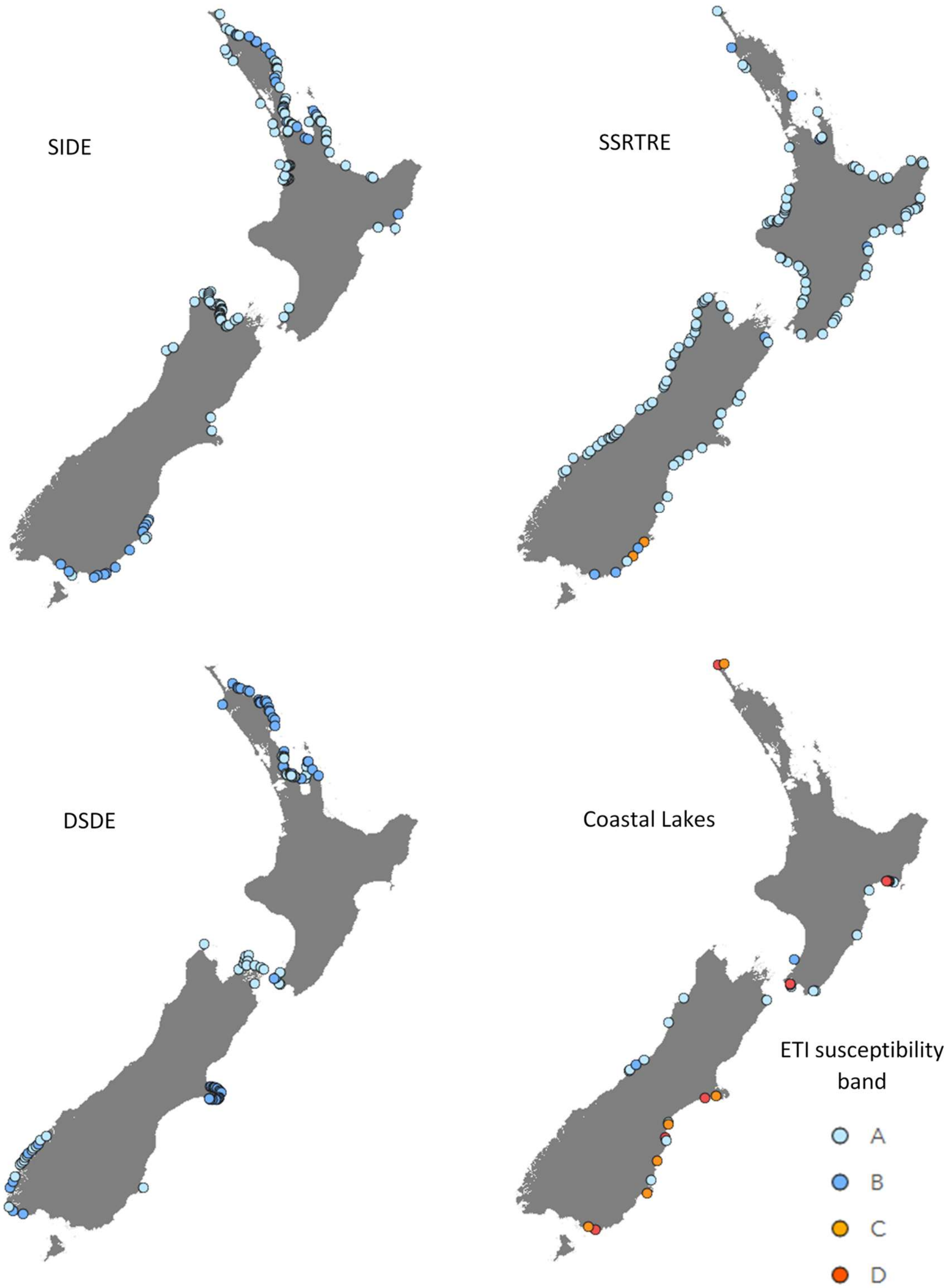

Figure 3-13: Eutrophication susceptibility bandings for New Zealand estuaries under the 'pristine' scenario. A = low susceptibility, B = moderate susceptibility, C = high susceptibility, D = very high susceptibility. See Tables 2-3 and 2-7 for descriptions of ecological conditions expected for ETI susceptibility bandings.

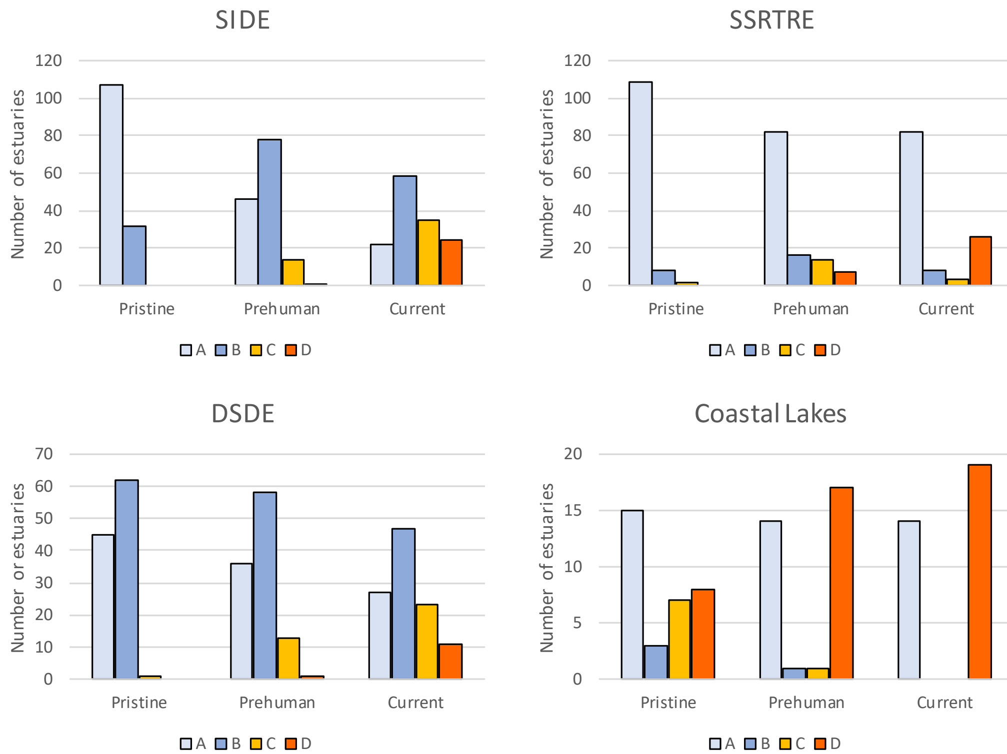

Figure 3-14: Eutrophication susceptibility of New Zealand estuaries predicted under the 'pristine', 'pre-human land cover' and 'current land cover' scenarios. Susceptibility bands plotted by counts of estuary type. A = low susceptibility, B = moderate susceptibility, C = high susceptibility, D = very high susceptibility. See Tables 2-3 and 2-7 for descriptions of ecological conditions expected for ETI susceptibility bandings.

4 Summary

4.1 Key results and implications

Summed across estuaries, estimated current N loads to estuaries from land are 91% greater than those calculated for the 'pre-human land cover' scenario. This increase is similar to Snelder, Larned et al. (2017) who estimated that anthropogenic influence has caused a 74% increase in N export to the ocean.

Current N loads from land are 320% greater than those calculated for the 'pristine' scenario. This increase is considerably higher than for the 'pre-human land cover' scenario, or the figure from Snelder, Larned et al. (2017) because N loads under the 'pristine' scenario account for differences in atmospheric N deposition between pre-industrial and present day New Zealand.

Increases in N load to estuaries vary spatially around the country, with the greatest increases around the central and southern North Island, and the eastern South Island. Increased N loads caused the largest increase in potential N concentrations in estuaries where estuarine water is not well diluted by ocean water. Concentration increases were greatest in SSRTRE and Coastal Lake estuary classes, and to a lesser degree the SIDE estuary class.

Many more estuaries are now susceptible to eutrophication due to anthropogenic increases in N loads to freshwater. Under current N loading conditions (based on 2008 land use), 35% of New Zealand estuaries fit within C or D (high or very high) ETI bands of eutrophication susceptibility. In the 'pre-human land cover' scenario, 17% of estuaries fit the C or D class of eutrophication susceptibility. In the 'pristine' scenario, 4.5% of estuaries fit the C or D class of eutrophication susceptibility.

Estuaries with the highest sensitivity to increases in freshwater nutrient loads have low dilution, and high proportions of intertidal area or long flushing times. For example, shallow, intertidal-dominated estuaries (SIDE class) had the greatest increase in C and D bandings, rising from 0% and 11% under 'pristine' and 'pre-human land cover' scenarios to 42% under current conditions.

Our results indicate that substantial increases in TN concentrations have occurred in New Zealand's estuaries after human settlement. These N increases are likely to cause considerable ecological change (Vitousek, Aber et al. 1997; Howarth and Marino 2006). This is concerning because estuarine species with low tolerance to eutrophication have historically provided valuable ecosystem services, e.g., important macroinvertebrate communities (Robertson, Gardner et al. 2015; Robertson, Savage et al. 2016) and nursery grounds for inshore fisheries, and shellfish fisheries (Morrison, Lowe et al. 2009; Morrison, Jones et al. 2014).

Even under pristine loading conditions, some systems, particularly coastal lakes, were identified as having high susceptibility to eutrophication. Some coastal lakes may be naturally eutrophic (Lepistö, Kauppila et al. 2006; Kitto 2010), and it would be incorrect to assume that all estuaries were oligotrophic in their natural state. Coastal lakes are essentially freshwater systems that originally sustained much lower N concentrations (Figure 3-9, 3-10) than currently, but nevertheless originally had high N concentrations relative to condition bands A-D. This suggests that these freshwater systems may be evolved to support freshwater or brackish macrophyte communities which are maintained in a healthy state under essentially riverine nutrient concentrations (Kitto 2010; Cosgrove 2012; Schallenberg 2018). Burns and Bryers (2000) suggest that New Zealand lakes transition between mesotrophic and eutrophic states at TN concentrations of ~ 300 mg m^{-3} (and also provide trigger levels for phosphorus). This is higher than the C/D threshold of ~150 mg m^{-3} from Figure 2-4.

However, coastal lakes, being at times brackish, may require different thresholds to inland lakes. An example case could be that of Te Waihora/Lake Ellesmere, which historically supported a healthy macrophyte-based community, but which in recent decades has received much-elevated nutrient loads and has 'flipped' (possibly semi-permanently) to a high turbidity, plankton-dominated state. Studies in Denmark and Florida (Sagrario, Jeppesen et al. 2005; Jeppesen, Søndergaard et al. 2007) have found that phytoplankton replaces macrophyte dominated communities at TN concentrations above 1000-1200 mg m^{-3}. Examination of Appendix A shows that six out of 33 New Zealand coastal lakes have crossed such a threshold. Hence, our banding system which is geared toward assessing susceptibility to marine macroalgae and phytoplankton, may be inappropriate for coastal lakes. In summary, the anthropogenic increase in N loads has increased the risk of eutrophication in many estuaries (SIDEs, SSRTREs, and DSDEs), and may have exacerbated conditions in naturally productive systems (coastal lakes).

Our predictions of changes in estuarine potential N concentration and eutrophication susceptibility across estuary types have several uses in the development of strategies to manage nutrients loads from freshwater. They prepare the groundwork for extrapolation upstream, in terms of consideration of what water quality limits would be necessary to protect estuarine receiving environment health. They identify regions in New Zealand, and types of estuaries, where more detailed investigations should be targeted. And the outputs regarding potential nitrogen, flushing and intertidal areas across estuary types, can be further used within Tool 3 of the ETI (Zeldis, Storey et al. 2017) to examine possible ramifications for other estuary components (e.g., macrobenthos, seagrass).

4.2 Caveats and limitations

We stress that a high susceptibility does not necessarily indicate that an estuary is currently eutrophic or was eutrophic prior to human settlement. A high susceptibility indicates that estuarine nutrient concentrations and flushing times provide suitable conditions for eutrophication to occur. However, there may be other factors that mean algal blooms do not occur, or do not lead to deleterious effects on ecosystem health.

Our results indicate how the susceptibility of estuaries in their present form has been altered by changes in load, but do not consider how susceptibility may have been altered by other factors that are not accounted for in our models, such as changes in estuary geometry and freshwater inflows. Many estuaries have changed dramatically in their shape and volume due to infilling from sediment deposition, rising sea levels, tectonic movement, or in some cases direct anthropogenic modification such as land 'reclamation', building of causeways, or physical control of openings. Similarly, river flows are highly likely to have changed both due to changes in land cover, but also due to differences in climate between pre-human land cover, pristine and present-day conditions.

The effect of wetlands has not been included in our analysis. Denitrification in wetlands can remove significant quantities of nitrogen, although denitrification rates are variable and influenced by vegetation present, climate, fraction of open water, hydraulic and nutrient loading (Alldred and Baines 2016; Land, Granéli et al. 2016), and may also differ between natural and constructed wetlands (Uuemaa, Palliser et al. 2018). Typical nitrogen removal efficiencies are in the range 30-45% (Land, Granéli et al. 2016) although higher efficiencies have been observed in small wetlands (Uuemaa, Palliser et al. 2018). Total wetland area has reduced by 90% (from 24,710 km^2 to 2,490 km^2) from pre-human to present day (2008)[4]. By neglecting wetlands, the nitrogen load may be overestimated for some estuaries. The reduction in nitrogen loads to estuaries due to wetlands would likely be greater for the pre-human case when wetlands were more extensive. Consequently, the increase in nitrogen loads to estuaries between pre-human and current (2008) conditions may be greater than reported here.

Also missing from our analysis are other inputs of nitrogen to estuaries such as from marine biota (sea lions, fur seals) and birds, which can be a major source of nutrients in otherwise pristine environments (Schallenberg 2018). In pre-human conditions when populations of marine mammals and birds were larger (MacDiarmid, Abraham et al. 2016), this marine subsidy may have been a major source of nutrients, particularly to poorly flushed systems such as coastal lakes.

We have focused on N loads because, as in other countries, N is almost always the limiting nutrient in New Zealand estuaries and coastal waters (Valiela, McClelland et al. 1997; National Research Council 2000; Barr and Rees 2003). Managing phosphorus loads may be an issue for coastal lakes, and other approaches that link algae to areal phosphorus loading, depth and residence time may be appropriate for those systems (OECD 1982).

The dilution modelling approach results in a time- and space-averaged concentration for an estuary and does not provide any spatial or temporal resolution. It provides an indication of the overall susceptibility of an estuary but does not resolve where in an estuary eutrophication may occur. This approach is also not able to identify if there are systems where there may be eutrophic conditions in small, localised areas where nutrients are concentrated (such as near point sources), but elsewhere estuary condition is good. Spatial resolution can be added either by applying compartmentalised tidal prism models (Plew and Dudley 2018), or more complex 2D or 3D hydrodynamic models. Neither approach is suitable for a nation-wide screening of estuaries, but they are useful for modelling individual estuaries where more detailed assessments are required. While it is possible to apply seasonal loads and flows in the dilution models to obtain some degree of temporal resolution, CLUES does not currently have the capability of providing these inputs. Our prediction of macroalgae response is based on annual loads and annual mean flows, and observations of macroalgae from summer (when peak biomass occurs). Thus, our susceptibility prediction is tuned to give predictions of summer response from annual load and flows, and makes its predictions for the season when maximum primary-producer growth is expected.

The predictions for macroalgae susceptibility are calibrated with observations (see section 2.4). The regression-based approach we used distinguished between estuaries with A/B bandings and those with C/D bandings, but did not clearly distinguish between the A and B bands (see Figure 2-3). We consider the threshold between B and C bands to be the most important for indicating when eutrophic conditions are likely to develop (Table 2-3 and Table 2-7). Estuaries with A or B bands can be considered healthy, thus it less important to separate A from B.

The phytoplankton susceptibilities have been determined using an analytical model to predict chlorophyll-*a* concentrations. This model has not been validated, and the thresholds between bands, as proposed in the New Zealand ETI (Robertson, Stevens et al. 2016b), are interim values based on overseas literature. There is currently a lack of sufficient observations in New Zealand, across a range of eutrophic conditions, to refine these thresholds and validate our model.

[4] https://data.mfe.govt.nz/table/52541-estimated-contemporary-and-pre-human-wetland-area-by-type-2008-estimate/data/

We are aware, through other detailed studies of individual estuaries, that Coastal Explorer data contain some inaccuracies. Relevant to this study, the Coastal Explorer values for estuary volumes and tidal prisms are sometimes estimates, and errors in these values may affect our dilution calculations and potential TN concentrations. Some data have been corrected in the on-line ETI Tools, and those values have been used here (see also Appendix A). In addition, the dilution models used in this study were tuned using limited data, and better estimates of susceptibility of an estuary can be obtained using site-specific data (Plew, Dudley et al. 2017; Plew and Dudley 2018). Thus, the results for individual estuaries should be refined where accurate assessments are required. There are also many, mostly small, estuaries not included in the Coastal Explorer database and consequently not included in this study. A revised estuary database, with input from Regional Councils, would prove valuable for further assessments of the state of New Zealand's estuaries.

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6 References

Alldred, M., Baines, S.B. (2016) Effects of wetland plants on denitrification rates: a meta-analysis. *Ecological Applications*, 26(3): 676-685. doi:10.1890/14-1525

Barr, N.G., Rees, T.A.V. (2003) Nitrogen status and metabolism in the green seaweed Enteromorpha intestinalis: an examination of three natural populations. *Marine Ecology Progress Series*, 249: 133-144. http://www.int-res.com/abstracts/meps/v249/p133-144/

Boyer, E.W., Howarth, R.W., Galloway, J.N., Dentener, F.J., Green, P.A., Vörösmarty, C.J. (2006) Riverine nitrogen export from the continents to the coasts. *Global Biogeochemical Cycles*, 20(1).

Bricker, S.B., Ferreira, J.G., Simas, T. (2003) An integrated methodology for assessment of estuarine trophic status. *Ecological Modelling*, 169(1): 39-60. http://dx.doi.org/10.1016/S0304-3800(03)00199-6

Burns, N., Bryers, G. (2000) Protocol for monitoring trophic levels of New Zealand lakes and reservoirs: 137.

Cloern, J.E., Grenz, C., Vidergar-Lucas, L. (1995) An empirical model of the phytoplankton chlorophyll : carbon ratio-the conversion factor between productivity and growth rate. *Limnology and Oceanography*, 40(7): 1313-1321. 10.4319/lo.1995.40.7.1313

Cooper, A.B., Thomsen, C.E. (1988) Nitrogen and phosphorus in streamwaters from adjacent pasture, pine, and native forest catchments. *New Zealand Journal of Marine and Freshwater Research*, 22(2): 279-291.

Cosgrove, S. (2012) Anthropogenic impacts on Waituna Lagoon: reconstructing the environmental history. University of Otago.

Dyer, K.R. (1973) *Estuaries: A Physical Introduction*. John Wiley and Sons, London, U.K.,

Elliott, A.H., Semadeni-Davies, A.F., Shankar, U., Zeldis, J.R., Wheeler, D.M., Plew, D.R., Rys, G.J., Harris, S.R. (2016) A national-scale GIS-based system for modelling impacts of land use on water quality. *Environmental Modelling & Software*, 86: 131-144. http://dx.doi.org/10.1016/j.envsoft.2016.09.011

Eppley, R.W., Rogers, J.N., McCarthy, J.J. (1969) Half-saturation constants for uptake of nitrate and ammomium by marine phytoplankton. *Limnology and Oceanography*, 14(6): 912-920. 10.4319/lo.1969.14.6.0912

Ferreira, J.G., Wolff, W.J., Simas, T.C., Bricker, S.B. (2005) Does biodiversity of estuarine phytoplankton depend on hydrology? *Ecological Modelling*, 187(4): 513-523. http://dx.doi.org/10.1016/j.ecolmodel.2005.03.013

Fowler, D., Coyle, M., Skiba, U., Sutton, M.A., Cape, J.N., Reis, S., Sheppard, L.J., Jenkins, A., Grizzetti, B., Galloway, J.N. (2013) The global nitrogen cycle in the twenty-first century. *Phil. Trans. R. Soc. B*, 368(1621): 20130164. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3682748/pdf/rstb20130164.pdf

Fox, S.E., Stieve, E., Valiela, I., Hauxwell, J., McClelland, J. (2008) Macrophyte Abundance in Waquoit Bay: Effects of Land-Derived Nitrogen Loads on Seasonal and Multi-Year Biomass Patterns. *Estuaries and Coasts*, 31(3): 532-541. 10.1007/s12237-008-9039-6

Galloway, J.N., Dentener, F.J., Capone, D.G., Boyer, E.W., Howarth, R.W., Seitzinger, S.P., Asner, G.P., Cleveland, C., Green, P., Holland, E. (2004) Nitrogen cycles: past, present, and future. *Biogeochemistry*, 70(2): 153-226. https://link.springer.com/content/pdf/10.1007%2Fs10533-004-0370-0.pdf

Gibbs, M.M., Vant, W.N. (1997) Seasonal changes in factors controlling phytoplankton growth in Beatrix Bay, New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 31(2): 237-248. 10.1080/00288330.1997.9516761

Gillibrand, P.A., Inall, M.E., Portilla, E., Tett, P. (2013) A box model of the seasonal exchange and mixing in regions of restricted exchange: application to two contrasting Scottish inlets. *Environmental Modelling & Software*, 43: 144-159.

Hanisak, M. (1983) The nitrogen relationships of marine macroalgae.

Holland, E.A., Dentener, F.J., Braswell, B.H., Sulzman, J.M. (1999) Contemporary and pre-industrial global reactive nitrogen budgets. *Biogeochemistry*, 46(1-3): 7-43.

Howard-Williams, C., Davies-Colley, R., Rutherford, K., Wilcock, R. (2010) Diffuse pollution and freshwater degradation: New Zealand perspectives. *Issues and Solutions to Diffuse Pollution, OECD, Paris*: 126-140.

Howarth, R.W., Billen, G., Swaney, D., Townsend, A., Jaworski, N., Lajtha, K., Downing, J.A., Elmgren, R., Caraco, N., Jordan, T. (1996) Regional nitrogen budgets and riverine N & P fluxes for the drainages to the North Atlantic Ocean: Natural and human influences. *Nitrogen cycling in the North Atlantic Ocean and its watersheds*. Springer: 75-139.

Howarth, R.W., Marino, R. (2006) Nitrogen as the limiting nutrient for eutrophication in coastal marine ecosystems: evolving views over three decades. *Limnology and Oceanography*, 51(1part2): 364-376.

Hume, T., Gerbeaux, P., Hart, D., Kettles, H., Neale, D. (2016) A classification of New Zealand's coastal hydrosystems, CR 254: 120. http://www.mfe.govt.nz/publications/marine/classification-of-new-zealands-coastal-hydrosystems

Hume, T.M., Herdendorf, C.E. (1988) A geomorphic classification of estuaries and its application to coastal resource management—A New Zealand example. *Ocean and Shoreline Management*, 11(3): 249-274. http://dx.doi.org/10.1016/0951-8312(88)90022-7

Hume, T.M., Snelder, T., Weatherhead, M., Liefting, R. (2007) A controlling factor approach to estuary classification. *Ocean & Coastal Management*, 50(11–12): 905-929. http://dx.doi.org/10.1016/j.ocecoaman.2007.05.009

Hurd, C.L., Nelson, W.A., Falshaw, R., Neill, K.F. (2004) History, current status and future of marine macroalgal research in New Zealand: Taxonomy, ecology, physiology and human uses. *Phycological Research*, 52(2): 80-106.

Jeppesen, E., Søndergaard, M., Meerhoff, M., Lauridsen, T.L., Jensen, J.P. (2007) Shallow lake restoration by nutrient load reduction - some recent findings and challenges ahead. *Hydrobiologia*, 584(1): 239-252.

Kitto, S.G. (2010) The Environmental History of Te Waihora-Lake Ellesmere: A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Environmental Science in the University of Canterbury. University of Canterbury.

Land, M., Granéli, W., Grimvall, A., Hoffmann, C.C., Mitsch, W.J., Tonderski, K.S., Verhoeven, J.T.A. (2016) How effective are created or restored freshwater wetlands for nitrogen and phosphorus removal? A systematic review. *Environmental Evidence*, 5(1): 9. 10.1186/s13750-016-0060-0

Larned, S., Hamilton, D., Zeldis, J., Howard-Williams, C. (2011) Nutrient-limitation in New Zealand rivers. lakes and estuaries: 19.

Leathwick, J. (2001) New Zealand's potential forest pattern as predicted from current species-environment relationships. *New Zealand Journal of Botany*, 39(3): 447-464.

Leathwick, J., McGlone, M., Walker, S. (2012) New Zealand's potential vegetation pattern. Landcare Research. https://lris.scinfo.org.nz/layer/48289-potential-vegetation-of-new-zealand/

Leathwick, J., Overton, J., McLeod, M. (2003) An environmental domain classification of New Zealand and its use as a tool for biodiversity management. *Conservation Biology*, 17(6): 1612-1623.

Leathwick, J.R. (2002) Land Environments of New Zealand: a Technical Guide.

Lepistö, L., Kauppila, P., Rapala, J., Pekkarinen, M., Sammalkorpi, I., Villa, L. (2006) Estimation of reference conditions for phytoplankton in a naturally eutrophic shallow lake. *Hydrobiologia*, 568(1): 55-66. 10.1007/s10750-006-0032-4

Luketina, D. (1998) Simple tidal prism models revisited *Estuarine, Coastal and Shelf Science*, 46(1): 77–84.

MacDiarmid, A., Abraham, E., Baker, C., Carroll, E., Chagué-Goff, C., Cleaver, P., Francis, M., Goff, J., Horn, P., Jackson, J. (2016) Taking Stock–the changes to New Zealand marine ecosystems since first human settlement: synthesis of major findings, and policy and management implications. *New Zealand Aquatic Environment and Biodiversity Report*(170).

Martins, I., Oliveira, J.M., Flindt, M.R., Marques, J.C. (1999) The effect of salinity on the growth rate of the macroalgae Enteromorpha intestinalis (Chlorophyta) in the Mondego estuary (west Portugal). *Acta Oecologica*, 20(4): 259-265.

Menge, D.N., Hedin, L.O. (2009) Nitrogen fixation in different biogeochemical niches along a 120 000-year chronosequence in New Zealand. *Ecology*, 90(8): 2190-2201.

Ministry for the Environment (2007) Environment New Zealand 2007.

Monsen, N.E., Cloern, J.E., Lucas, L.V. (2002) A comment on the use of flushing time, residence time, and age as transport time scales. *Limnology and Oceanography*, 47(5): 1545-1553. 10.4319/lo.2002.47.5.1545

Morand, P., Briand, X. (1996) Excessive growth of macroalgae: a symptom of environmental disturbance. *Botanica marina*, 39(1-6): 491-516.

Morrison, M., Jones, E.G., Consalvey, M., Berkenbusch, K. (2014) *Linking marine fisheries species to biogenic habitats in New Zealand: a review and synthesis of knowledge*. Ministry for Primary Industries.

Morrison, M.A., Lowe, M., Parsons, D., Usmar, N., McLeod, I. (2009) A review of land-based effects on coastal fisheries and supporting biodiversity in New Zealand. *New Zealand aquatic environment and biodiversity Report*, 37: 100.

National Research Council (2000) Clean coastal waters: Understanding and reducting the effects of nutrient polution. National Academy Press, Washington, DC: 405.

New Zealand Government (2014) National Policy Statement for Freshwater Management 2014. http://www.mfe.govt.nz/publications/fresh-water/national-policy-statement-freshwatermanagement-2014

OECD (Organisation for Economic Cooperation and Development) (1982) Eutrophication of waters. Monitoring, assessment and control: 154.

Parfitt, R., Schipper, L., Baisden, W., Elliott, A. (2006) Nitrogen inputs and outputs for New Zealand in 2001 at national and regional scales. *Biogeochemistry*, 80(1): 71-88.

Parfitt, R.L., Baisden, W.T., Schipper, L.A., Mackay, A.D. (2008) Nitrogen inputs and outputs for New Zealand at national and regional scales: Past, present and future scenarios. *Journal of the Royal Society of New Zealand*, 38(2): 71-87. 10.1080/03014220809510547

Pearl, H. (2009) Controlling eutrophication along the freshwater-marine continuum: dual nutrient (N and P) reductions are essential. *Estuaries and Coasts*, 32: 593-601.

Plew, D., Dudley, B. (2018) Eutrophication susceptibility of Shag River Estuary. *NIWA Client Report*, 2018133CH: 24.

Plew, D., Dudley, B., Bind, J. (2017) Canterbury region estuary eutrophication susceptibility assessment. *NIWA Client Report*, 2017154CH: 26. https://api.ecan.govt.nz/TrimPublicAPI/documents/download/3208268

Plew, D.R., Zeldis, J.R., Shankar, U., Elliott, A.H. (2018a) Using simple dilution models to predict New Zealand estuarine water quality. *Estuaries and Coasts*, 41(6): 1643-1659. 10.1007/s12237-018-0387-6

Plew, D.R., Zeldis, J.R., Shankar, U., Elliott, A.H. (2018b) Using Simple Dilution Models to Predict New Zealand Estuarine Water Quality. *Estuaries and coasts*. 10.1007/s12237-018-0387-6

Quinn, J.M., Stroud, M.J. (2002) Water quality and sediment and nutrient export from New Zealand hill-land catchments of contrasting land use. *New Zealand Journal of Marine and Freshwater Research*, 36(2): 409-429.

Revilla, M., Franco, J., Garmendia, M., Borja, Á. (2010) A new method for phytoplankton quality assessment in the Basque estuaries (northern Spain), within the European Water Framework Directive. *Revista de Investigación Marina*, 17(7): 149-164.

Robertson, B.M., Stevens, L., Robertson, B., Zeldis, J., Green, M., Madarasz-Smith, A., Plew, D., Storey, R., Hume, T., Oliver, M. (2016a) NZ Estuary Trophic Index Screening Tool 1. Determining eutrophication susceptibility using physical and nutrient load data. *Prepared for Environlink Tools Project: Estuarine Trophic Index*: 47. http://envirolink.govt.nz/assets/Envirolink-reports/R10-120NZ20Estuary20trophic20index20Screening20Tool20120-20Determining20eutrophication20susceptibility20using20physical20and20nutrient20load20data.PDF

Robertson, B.M., Stevens, L., Robertson, B., Zeldis, J., Green, M., Madarasz-Smith, A., Plew, D., Storey, R., Oliver, M. (2016b) NZ Estuary Trophic Index Screen Tool 2. Determining Monitoring Indicators and Assessing Estuary Trophic State. *Prepared for Environlink Tools Project: Estuarine Trophic Index*: 68.

Robertson, B.P., Gardner, J.P.A., Savage, C. (2015) Macrobenthic–mud relations strengthen the foundation for benthic index development: A case study from shallow, temperate New Zealand estuaries. *Ecological Indicators*, 58: 161-174. http://dx.doi.org/10.1016/j.ecolind.2015.05.039

Robertson, B.P., Savage, C., Gardner, J.P.A., Robertson, B.M., Stevens, L.M. (2016) Optimising a widely-used coastal health index through quantitative ecological group classifications and associated thresholds. *Ecological Indicators*, 69: 595-605. https://doi.org/10.1016/j.ecolind.2016.04.003

Sagrario, M.A.G., Jeppesen, E., Gomà, J., Søndergaard, M., Jensen, J.P., Lauridsen, T., Landkildehus, F. (2005) Does high nitrogen loading prevent clear-water conditions in shallow lakes at moderately high phosphorus concentrations? *Freshwater Biology*, 50(1): 27-41. 10.1111/j.1365-2427.2004.01290.x

Schallenberg, M. (2018) Determining the reference conditions for New Zealand lakes. *Science for Conservation, Department of Conservation*: in press.

Snelder, T.H., Larned, S.T., McDowell, R.W. (2017) Anthropogenic increases of catchment nitrogen and phosphorus loads in New Zealand. *New Zealand Journal of Marine and Freshwater Research*: 1-26. 10.1080/00288330.2017.1393758

Uuemaa, E., Palliser, C.C., Hughes, A.O., Tanner, C.C. (2018) Effectiveness of a Natural Headwater Wetland for Reducing Agricultural Nitrogen Loads. *Water*, 10(3): 287.

Valiela, I., McClelland, J., Hauxwell, J., Behr, P.J., Hersh, D., Foreman, K. (1997) Macroalgal blooms in shallow estuaries: Controls and ecophysiological and ecosystem consequences. *Limnology and Oceanography*, 42(5part2): 1105-1118. 10.4319/lo.1997.42.5_part_2.1105

Vant, W.N., Budd, R.G. (1993) Phytoplankton photosynthesis and growth in contrasting regions of Manukau Harbour, New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 27(3): 295-307. 10.1080/00288330.1993.9516570

Verburg, P., Elliott, S., Schallenberg, M., McBride, C. (2016) Nutrient budgets in lakes. In: D. Hamilton, K. Collier, C. Howard-Williams & J. Quinn (Eds). *Lake Restoration Handbook*. Springer.

Vitousek, P.M., Aber, J.D., Howarth, R.W., Likens, G.E., Matson, P.A., Schindler, D.W., Schlesinger, W.H., Tilman, D.G. (1997) Human alteration of the global nitrogen cycle: sources and consequences. *Ecological Applications*, 7(3): 737-750.

Water Framework Directive - United Kingdom Advisory Group (2014) UKTAG Transitional and Coastal Water Assessment Method Macroalgae Opportunistic Macroalgal Blooming Tool: 24. http://www.wfduk.org/resources%20/transitional-and-coastal-waters-opportunistic-macroalgae

Zeldis, J., Plew, D., Whitehead, A., Madarasz-Smith, A., Oliver, M., Stevens, L., Robertson, B., Burge, O., Dudley, B. (2017) The New Zealand Estuary Trophic Index (ETI) Tools: Tool 1 - Determining Eutrophication Susceptibility using Physical and Nutrient Load Data. Ministry of Business, Innovation and Employment Envirolink Tools: C01X1420. https://shiny.niwa.co.nz/Estuaries-Screening-Tool-1/

Zeldis, J., Storey, R., Plew, D., Whitehead, A., Madarasz-Smith, A., Oliver, M., Stevens, L., Robertson, B., Dudley, B. (2017) The New Zealand Estuary Trophic Index (ETI) Tools: Tool 3 - Assessing Estuary Trophic State using a Bayesian Belief Network Ministry of Business, Innovation and Employment Envirolink Tools Contract: C01X1420. https://shiny.niwa.co.nz/Estuaries-Screening-Tool-3/

Zeldis, J., Whitehead, A., Plew, D., Madarasz-Smith, A., Oliver, M., Stevens, L., Robertson, B., Storey, R., Burge, O., Dudley, B. (2017) The New Zealand Estuary Trophic Index (ETI) Tools: Tool 2 - Assessing Estuary Trophic State using Measured Trophic Indicators. Ministry of Business, Innovation and Employment Envirolink Tools: C01X1420. https://shiny.niwa.co.nz/Estuaries-Screening-Tool-2/

Appendix A Table of estuary results

Table A-1: Summary of estuary data and results. Estuary data were derived from the Coastal Explorer database, and information available through ETI tool 1 https://shiny.niwa.co.nz/Estuaries-Screening-Tool-1/.

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Tapotupotu Bay	NRC	7B	SSRTRE	-34.435	172.715	557185	797044	1	1341	0.20	8.0	18	1.231	2.683	2.723	61	102	103	3.4	7.9	8.0	A	B	B	A	B	C	A	B	C
Waitahora Stream	NRC	7B	C.LAKE	-34.456	172.795	0	206506	0	615	0.09	25.8	100	0.575	1.252	1.262	197	429	433	21.6	48.0	48.4	A	A	A	D	D	D	D	D	D
Parengarenga Harbour System	NRC	8	SIDE	-34.529	173.016	74683095	109524603	82	19596	2.87	13.7	3	35.361	77.040	94.581	53	67	73	4.3	6.0	6.7	A	A	A	B	B	B	A	A	A
Houhora Harbour	NRC	8	SIDE	-34.836	173.174	14648771	19560356	87	11633	1.62	10.9	8	18.197	39.645	59.998	62	95	126	4.8	8.5	12.0	A	B	B	B	C	D	A	B	B
Rangaunu Harbour	NRC	8	SIDE	-34.875	173.272	122167882	248188694	78	55150	11.47	17.0	7	115.589	251.834	559.314	57	83	141	5.3	8.2	14.7	A	B	B	B	C	D	A	B	B
Matai Bay	NRC	11	DSDE	-34.823	173.422	4217028	20270627	7	324	0.05	47.5	1	0.752	1.638	1.637	43	49	49	4.5	5.2	5.2	A	A	A	B	B	B	B	B	B
Awapoko River	NRC	6B	SIDE	-34.968	173.431	928354	1581009	47	9551	2.08	3.1	35	20.551	44.774	98.893	135	264	551	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Taipa River	NRC	7A	SIDE	-34.982	173.475	2234740	3706197	52	12618	3.85	3.6	33	21.927	47.772	104.319	87	156	307	0.0	0.0	0.0	B	B	C	A	A	A	B	B	C
Mangonui Harbour	NRC	8	SIDE	-34.978	173.518	11218376	11929984	68	25644	7.37	4.4	24	44.665	97.312	189.116	77	130	223	0.0	0.0	9.6	A	B	C	A	A	C	A	B	C
Takerau Bay	NRC	11	DSDE	-34.926	173.546	456821	1490234	1	101	0.02	29.8	4	0.212	0.463	0.462	50	64	64	5.1	6.6	6.6	A	A	A	B	B	B	B	B	B
Taemaro Bay	NRC	11	DSDE	-34.930	173.584	1345496	3726052	3	432	0.10	24.1	6	0.773	1.684	1.733	52	68	68	5.0	6.9	7.0	A	A	A	B	B	B	B	B	B
Waimahana Bay	NRC	11	DSDE	-34.943	173.627	401044	1193351	8	729	0.17	15.5	19	1.175	2.561	2.749	74	124	130	7.0	12.6	13.4	A	B	B	B	C	D	B	C	D
Whangaihe Bay	NRC	11	DSDE	-34.984	173.818	389449	983997	3	207	0.06	19.4	10	0.425	0.927	1.047	58	85	91	5.5	8.6	9.3	A	B	B	B	C	C	B	C	C
Mahinepua Bay	NRC	11	DSDE	-35.001	173.869	947726	1596911	3	655	0.17	12.1	11	1.217	2.652	4.087	59	89	119	4.8	8.2	11.6	A	B	B	B	C	C	B	C	C
Takou River	NRC	7A	SIDE	-35.102	173.950	811887	1064981	57	7214	2.04	2.2	36	11.034	24.039	104.397	86	158	605	0.0	0.0	0.0	B	B	D	A	A	A	B	B	D
Tahoranui River	NRC	7A	SIDE	-35.118	173.967	429703	621026	25	2697	0.75	3.1	33	4.541	9.893	37.119	88	162	537	0.0	0.0	0.0	B	B	D	A	A	A	B	B	D
Tapuaetahi Creek	NRC	7A	SIDE	-35.118	173.982	425482	485568	84	1185	0.31	4.5	25	2.384	5.195	12.224	88	159	336	0.0	2.9	22.9	B	B	D	A	A	D	B	B	D
Te Puna /Kerikeri Inlet System	NRC	9	DSDE	-35.186	174.112	64786580	175541487	11	24430	7.92	21.6	8	42.680	92.986	464.814	49	66	192	4.7	6.6	20.8	A	A	B	B	B	D	B	B	D
Opua Inlet System	NRC	9	DSDE	-35.219	174.130	90004189	201871822	20	92633	23.16	14.5	14	170.507	371.484	954.476	66	106	220	6.0	10.5	23.5	A	B	C	B	C	D	B	C	D
Paroa Bay	NRC	11	DSDE	-35.244	174.146	2755026	4652984	27	359	0.09	16.0	3	0.792	1.726	2.144	45	54	58	3.8	4.8	5.2	A	A	A	B	B	B	B	B	B
Manawaora Bay	NRC	11	DSDE	-35.247	174.176	12159634	38744602	7	1044	0.27	30.8	2	1.819	3.963	7.242	42	47	54	4.2	4.7	5.5	A	A	A	B	B	B	B	B	B
Parekura Bay	NRC	11	SIDE	-35.241	174.213	5605251	14893034	37	2165	0.57	22.0	7	3.111	6.779	8.597	49	63	71	4.6	6.3	7.1	A	A	A	B	B	B	B	B	B
Oke Bay	NRC	11	DSDE	-35.224	174.272	1279573	6541153	1	73	0.02	50.2	1	0.085	0.185	0.185	40	42	42	4.2	4.4	4.4	A	A	A	B	B	B	B	B	B
Deep Water Cove	NRC	11	DSDE	-35.198	174.292	2453313	28637035	0	254	0.07	112	2	0.305	0.665	0.666	41	45	45	4.5	5.0	5.0	A	A	A	B	B	B	B	B	B
Whangamumu Harbour	NRC	11	DSDE	-35.242	174.329	4711274	41029541	1	138	0.04	86.9	1	0.228	0.498	0.526	40	42	42	4.4	4.5	4.6	A	A	A	B	B	B	B	B	B
Bland Bay	NRC	11	DSDE	-35.342	174.374	6415453	16993476	3	293	0.08	26.1	1	0.462	1.008	1.437	41	43	45	3.9	4.2	4.4	A	A	A	B	B	B	B	B	B
Whangaruru Harbour	NRC	9	SIDE	-35.360	174.346	19897380	44236086	26	6659	1.98	18.4	7	10.677	23.261	34.576	49	63	76	4.4	6.1	7.5	A	A	A	B	B	B	B	B	B
Helena Bay	NRC	11	DSDE	-35.423	174.387	5262636	12202396	3	2639	0.92	16.9	11	3.745	8.159	16.737	49	66	99	4.4	6.3	10.0	A	A	B	B	B	C	B	B	C
Mimiwhangata Bay	NRC	11	DSDE	-35.429	174.405	7386532	22294769	3	249	0.08	29.9	1	0.369	0.803	3.243	41	42	51	4.0	4.2	5.2	A	A	A	B	B	B	B	B	B
Whananaki Inlet	NRC	7A	SIDE	-35.523	174.470	2514250	3550490	75	5366	1.51	6.2	23	9.187	20.015	35.753	74	126	201	2.4	8.3	16.8	A	B	C	A	B	D	A	B	C
Whangaroa Harbour	NRC	9	SIDE	-34.995	173.774	41307851	109346708	32	24385	7.91	18.8	12	51.478	112.154	218.278	59	87	137	5.6	8.8	14.5	A	B	B	B	C	D	B	C	D

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Ngunguru River	NRC	7A	SIDE	-35.636	174.518	7228451	11875487	55	7988	2.24	9.9	16	14.268	31.085	54.003	65	103	155	4.7	9.1	15.0	A	B	B	A	B	D	A	B	B
Matapouri Bay System (MBS)	NRC	7A	SIDE	-35.558	174.518	1223426	1580950	61	1406	0.47	7.1	18	2.363	5.148	9.040	61	95	143	2.4	6.2	11.7	A	B	B	A	B	C	A	B	B
Matapouri Bay MBS	NRC	11	DSDE	-35.562	174.511	725674	2077939	19	1406	0.47	12.0	23	2.363	5.148	9.040	67	111	173	5.7	10.7	17.6	A	B	B	B	C	D	B	C	D
Matapouri Estuary MBS	NRC	7A	SIDE	-35.565	174.511	497713	517153	96	570	0.18	5.9	18	0.946	2.062	3.576	62	96	143	0.2	4.2	9.5	A	B	B	A	A	C	A	B	B
Tutukaka Harbour	NRC	9	DSDE	-35.617	174.543	1902412	4884170	4	377	0.10	23.3	4	0.603	1.313	2.206	45	54	66	4.2	5.3	6.6	A	A	A	B	B	B	B	B	B
Horahora River	NRC	7A	SIDE	-35.669	174.516	1862424	2309703	70	8573	2.08	3.7	29	14.603	31.817	81.433	91	166	383	0.0	0.0	0.0	B	B	D	A	A	A	B	B	D
Pataua River	NRC	7A	SIDE	-35.705	174.531	3152066	3584537	85	5043	1.07	6.6	17	8.370	18.237	35.045	73	123	207	3.1	8.7	18.3	A	B	C	A	B	D	A	B	C
Taiharuru River	NRC	7A	SIDE	-35.704	174.556	3949736	4425331	87	1301	0.26	9.9	5	2.360	5.142	13.780	50	67	120	3.1	5.0	11.1	A	A	B	B	B	C	A	A	B
Awahoa Bay	NRC	11	DSDE	-35.747	174.558	869832	1359689	10	63	0.01	15.4	1	0.078	0.170	0.417	39	42	50	3.0	3.4	4.2	A	A	A	B	B	B	B	B	B
Whangarei Harbour System	NRC	8	SIDE	-35.848	174.513	148225378	457556265	58	26787	5.28	29.0	3	47.070	102.551	259.778	44	53	80	4.3	5.4	8.5	A	A	B	B	B	C	A	A	B
Ruakaka River	NRC	7A	SIDE	-35.905	174.473	1250387	2070573	50	8993	1.58	4.5	30	17.929	39.063	130.426	132	259	806	0.7	15.1	77.3	B	C	D	A	C	D	B	C	D
Waipu River	NRC	7A	SIDE	-35.993	174.489	2499800	4339888	41	22087	4.68	3.6	33	38.186	83.197	251.583	109	211	590	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Mangawhai Harbour	NRC	7A	SIDE	-36.089	174.609	6562592	9718917	67	6572	1.02	11.2	10	10.886	23.717	50.029	65	105	188	5.2	9.8	19.2	A	B	B	B	C	D	A	B	B
Pakiri River	ARC	7A	SSRTRE	-36.241	174.732	155329	213063	35	3434	0.79	1.3	42	5.833	12.708	24.221	117	233	427	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Omaha Cove	ARC	11	DSDE	-36.293	174.821	624012	2256953	0	352	0.07	29.2	8	0.594	1.295	1.926	50	75	98	5.1	7.9	10.4	A	A	B	B	B	C	B	B	C
Whangateau Harbour	ARC	7A	SIDE	-36.329	174.793	9491105	11663589	85	3734	0.82	10.4	6	7.535	16.417	27.199	48	70	96	3.1	5.6	8.6	A	A	B	B	B	C	A	A	B
Millon Bay	ARC	11	DSDE	-36.400	174.764	1714237	1953712	62	493	0.10	10.2	4	1.013	2.208	4.554	44	61	95	2.6	4.5	8.4	A	A	B	A	B	C	A	A	B
Matakana River	ARC	8	SIDE	-36.403	174.743	6532060	8325191	76	4855	1.15	9.3	11	9.857	21.476	49.904	58	93	180	3.7	7.8	17.6	A	B	B	B	B	D	A	B	B
Mahurangi Harbour System	ARC	8	SIDE	-36.512	174.732	44892812	67261470	51	9954	3.05	13.2	5	19.469	42.416	101.984	39	52	84	2.7	4.1	7.8	A	A	B	A	B	B	A	A	B
Te Muri-O-Tarariki	ARC	7A	SIDE	-36.517	174.722	325629	325814	100	489	0.10	5.9	16	0.983	2.142	4.431	74	132	246	1.9	8.5	21.5	A	B	C	A	B	D	A	B	C
Puhoi River	ARC	7A	SIDE	-36.533	174.725	2697410	3693641	71	5304	1.17	7.1	19	9.993	21.772	38.370	77	139	226	4.2	11.2	21.1	A	B	C	A	C	D	A	B	C
Waiwera River	ARC	7A	SIDE	-36.548	174.717	1659432	2364498	64	3593	0.78	7.1	20	6.936	15.111	27.809	81	148	252	4.7	12.3	24.1	B	B	C	A	C	D	B	B	C
Orewa River	ARC	7A	SIDE	-36.595	174.709	1758642	1899475	89	2546	0.52	6.6	16	5.099	11.109	26.923	74	131	281	3.2	9.7	26.8	A	B	C	A	B	D	A	B	C
Okoromai Bay	ARC	11	DSDE	-36.621	174.812	2310461	2832822	27	190	0.03	12.1	1	0.359	0.782	1.166	34	39	43	1.9	2.4	3.0	A	A	A	A	A	A	A	A	A
Hobbs Bay (Gulf Harbour)	ARC	11	DSDE	-36.632	174.784	601267	1075639	0	447	0.07	14.4	8	0.688	1.499	2.446	53	83	117	4.5	7.9	11.8	A	B	B	B	B	C	B	B	C
Weiti River	ARC	6B	SIDE	-36.655	174.758	4937928	7032306	63	2783	0.52	11.7	8	5.375	11.711	26.924	52	81	150	3.9	7.1	15.0	A	B	B	B	B	D	A	B	B
Okura River	ARC	7A	SIDE	-36.657	174.752	2089152	2370942	79	2099	0.32	8.6	10	3.772	8.218	11.095	64	108	137	4.1	9.1	12.3	A	B	B	B	C	D	A	B	B
Waitemata Harbour System	ARC	8	SIDE	-36.836	174.824	177003695	341571865	36	39111	7.74	17.8	3	59.101	128.764	256.879	37	47	65	3.0	4.1	6.2	A	A	A	B	B	B	B	B	B
Tamaki River	ARC	8	SIDE	-36.842	174.887	37427602	49163825	40	8675	1.18	12.4	3	10.524	22.929	53.012	36	45	66	2.2	3.2	5.6	A	A	A	A	B	B	A	B	B
Whitford Embayment System (WES)	ARC	8	SIDE	-36.890	174.967	18516635	25549889	82	5334	0.75	12.8	3	8.701	18.958	28.626	41	55	68	2.8	4.4	5.9	A	A	A	A	B	B	A	A	A
Mangemangeroa Estuary WES	ARC	8	SIDE	-36.913	174.956	963637	1005437	87	674	0.09	8.7	7	1.133	2.469	3.416	54	86	109	3.0	6.6	9.2	A	B	B	B	B	C	A	B	B
Turanga Creek WES	ARC	8	SIDE	-36.915	174.962	2670640	3626616	74	2614	0.37	10.5	9	4.346	9.469	13.695	61	102	135	4.6	9.2	13.0	A	B	B	B	C	D	A	B	B
Waikopua Creek WES	ARC	8	SIDE	-36.904	174.981	2463504	2464243	100	1216	0.17	8.8	5	1.708	3.721	6.180	45	65	89	2.0	4.2	6.9	A	A	B	A	B	B	A	A	B
Wairoa River	ARC	8	SIDE	-36.938	175.096	5774004	8679788	42	27317	5.10	5.2	26	43.606	95.005	190.829	93	178	336	1.6	11.2	29.1	B	B	D	A	C	D	B	B	D
Firth of Thames System	EW/ARC	9	DSDE	-36.891	175.303	1924525011	6865962947	15	378239	90.37	32.7	4	632.150	1377.268	6882.549	36	46	118	3.5	4.6	12.8	A	A	B	B	B	D	B	B	D
Miranda Stream	EW	7A	SIDE	-37.187	175.337	126642	130134	95	1437	0.20	2.4	32	2.493	5.432	17.726	143	289	898	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Waitakaruru River	EW	6A	SIDE	-37.217	175.394	1092075	1442025	64	16594	2.93	2.1	36	39.908	86.948	273.637	175	359	1093	0.0	0.0	0.0	B	D	D	A	A	A	B	D	D
Piako River	EW	6A	SSRTRE	-37.191	175.493	4900022	7426156	26	148199	21.86	1.6	41	263.323	573.703	2772.465	172	356	1658	0.0	0.0	0.0	B	D	D	A	A	A	B	D	D
Waihou River	EW	6A	SSRTRE	-37.157	175.535	31594215	59347458	7	198287	58.82	3.9	33	302.372	658.779	3748.132	72	136	689	0.0	0.0	46.9	A	B	D	A	A	D	A	B	D
Kauranga River	EW	6A	SSRTRE	-37.151	175.538	612254	842741	55	13298	6.43	0.8	52	23.369	50.913	66.471	29	144	183	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Kirita Bay	EW	11	DSDE	-36.873	175.409	928268	1065676	9	425	0.13	8.9	9	0.685	1.494	4.119	42	60	120	1.7	3.8	10.6	A	A	B	A	B	C	A	B	C
Manaia Harbour	EW	8	SIDE	-36.842	175.424	11080679	20538114	76	5914	2.31	12.8	12	10.012	21.813	28.523	43	63	74	3.0	5.3	6.7	A	A	A	B	B	B	A	A	A
Te Kouma Harbour	EW	8	SIDE	-36.828	175.426	5915819	10226151	46	427	0.13	16.7	2	0.889	1.936	4.209	33	37	48	2.4	3.0	4.1	A	A	A	A	A	B	A	A	A
Coromandel Harbour	EW	8	DSDE	-36.798	175.431	62796785	139671893	21	6955	2.67	20.6	3	15.232	33.186	51.316	35	42	49	2.9	3.8	4.6	A	A	A	A	B	B	A	B	B
Colville Bay	EW	8	DSDE	-36.620	175.425	11660466	13665726	5	4205	1.23	9.6	7	8.178	17.818	33.933	44	63	94	2.3	4.4	8.0	A	A	B	A	B	B	A	B	B
Waiaro Estuary	EW	7A	SSRTRE	-36.591	175.417	236567	328276	0	1150	0.33	3.6	31	1.652	3.600	5.465	71	129	184	0.0	0.0	0.0	A	B	B	A	A	A	A	A	A
Stony Bay	EW	11	DSDE	-36.496	175.434	2498637	9982717	1	1614	0.49	28.3	12	2.282	4.973	5.693	46	67	72	4.5	6.9	7.6	A	A	A	B	B	B	B	B	B
Port Charles	EW	11	DSDE	-36.506	175.459	10050641	46090872	2	3105	0.88	38.9	6	5.710	12.440	17.202	43	59	70	4.4	6.2	7.5	A	A	A	B	B	B	B	B	B
Waikawau Estuary	EW	7A	SIDE	-36.593	175.534	242475	254465	95	2767	0.79	1.4	38	5.583	12.163	20.517	104	204	331	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Kennedy Bay System (KBS)	EW	11	DSDE	-36.675	175.579	8586637	29286184	15	5202	1.61	24.4	12	9.326	20.319	25.353	48	73	85	4.7	7.5	8.8	A	A	B	B	B	C	B	B	C
Kennedy Bay Estuary KBS	EW	7A	SIDE	-36.674	175.603	545200	593615	91	5202	1.61	1.6	37	9.326	20.319	25.353	87	168	204	0.0	0.0	0.0	B	B	C	A	A	A	B	B	C
Whangapoua Harbour	EW	7A	SIDE	-36.718	175.645	14902971	17164235	80	10122	3.43	7.7	13	21.267	46.334	85.525	52	83	132	2.1	5.6	11.1	A	B	B	A	B	C	A	B	B
Mercury Bay System (MBS)	EW	11	SIDE	-36.808	175.756	50508655	164248550	36	44399	20.86	17.2	19	85.370	185.997	431.404	48	77	148	4.3	7.6	15.6	A	A	B	A	B	D	A	B	D
Whitianga Harbour MBS	EW	7A	SIDE	-36.812	175.734	17110627	23675974	72	42442	20.21	4.0	29	82.223	179.140	400.749	58	103	204	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Purangi River	EW	7A	SIDE	-36.827	175.752	1167979	1229451	95	1956	0.64	4.8	22	3.147	6.857	30.655	57	97	352	0.0	0.0	28.5	A	B	D	A	A	D	A	B	D
Tairua Harbour	EW	7A	SIDE	-37.009	175.886	7702351	7749027	51	27956	14.96	2.0	34	50.541	110.114	237.566	55	97	188	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Wharekawa Harbour	EW	7A	SIDE	-37.118	175.894	1888011	2164594	86	9002	4.02	2.1	34	15.368	33.483	60.712	59	109	182	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Whangamata Harbour	EW	7A	SIDE	-37.213	175.897	4552366	6488899	78	4874	2.12	7.1	20	7.531	16.407	30.744	44	70	113	0.5	3.5	8.4	A	A	B	A	A	C	A	A	B
Otahu River	EW	7A	SIDE	-37.237	175.897	1138659	1516965	60	7160	3.45	1.9	37	11.181	24.359	61.237	55	100	226	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Tauranga Harbour System	EBOP	8	SIDE	-37.475	175.998	211514717	425300509	77	122234	36.40	14.7	11	158.530	345.390	1333.115	35	53	146	2.5	4.5	15.1	A	A	B	A	B	D	A	A	B
Maketu River	EBOP	6A	SSRTRE	-37.756	176.429	2638842	3548243	58	122892	44.75	0.6	62	117.889	256.844	1090.648	28	123	492	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Waihi Estuary	EBOP	7A	SSRTRE	-37.754	176.484	3213142	4353159	57	33807	11.88	1.7	39	50.477	109.975	509.339	67	129	546	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Whakatane River	EBOP	6B	SSRTRE	-37.939	177.007	2169092	6359039	31	178157	63.93	0.9	81	228.662	498.188	1131.151	26	205	459	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Ohiwa Harbour	EBOP	9	SIDE	-37.984	177.152	26561008	44190150	84	16288	5.30	11.7	12	19.630	42.768	209.450	32	48	169	1.5	3.5	17.2	A	A	B	A	B	D	A	A	B
Waiotahi River	EBOP	7A	SIDE	-37.990	177.206	1114065	1744343	68	14660	5.48	1.5	42	19.160	41.743	113.218	58	112	285	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Waioeka River	EBOP	7A	SSRTRE	-37.984	177.304	1481683	3093189	14	120369	56.27	0.6	100	176.710	384.998	697.091	100	217	393	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waiaua River	EBOP	7A	SSRTRE	-37.978	177.387	215979	289650	59	10884	4.44	0.5	68	14.079	30.674	77.390	21	155	383	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Whangaparaoa River	EBOP	6B	SSRTRE	-37.572	177.990	261264	418937	0	18152	13.78	0.4	100	36.724	80.011	191.396	84	184	440	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Wharekahika River	GDC	6D	SSRTRE	-37.576	178.297	66886	99537	34	16157	12.31	0.1	100	32.575	70.972	109.239	84	183	281	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Karakatuwhero River	GDC	3C	SSRTRE	-37.618	178.346	40895	66045	0	8403	7.31	0.1	100	19.465	42.409	58.201	84	184	253	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Uawa River (Tolaga Bay)	GDC	6B	SSRTRE	-38.374	178.314	1475920	3216449	23	55860	14.11	1.3	50	87.928	191.568	326.513	22	225	378	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Pakarae River	GDC	6B	SSRTRE	-38.562	178.253	381278	645017	0	24437	5.12	0.8	57	38.620	84.143	182.108	20	303	648	0.0	0.0	0.0	A	C	D	A	A	A	A	A	A
Waiomoko River	GDC	6B	SSRTRE	-38.584	178.226	170479	288697	0	7199	1.37	1.2	48	10.190	22.201	58.199	18	254	651	0.0	0.0	0.0	A	C	D	A	A	A	A	A	A

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m³)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m³/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m³)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Pouawa River	GDC	6B	SSRTRE	-38.617	178.190	81407	135668	8	4254	0.67	1.1	48	6.070	13.225	25.935	18	308	596	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Turanganui River	GDC	6B	SSRTRE	-38.676	178.022	869183	895593	0	32355	4.39	1.0	42	39.577	86.226	176.563	130	272	546	0.0	0.0	0.0	B	C	D	A	A	A	A	A	A
Waipaoa River	GDC	6B	SSRTRE	-38.716	177.945	1529244	4675430	2	218313	39.92	0.1	4	271.200	590.864	1229.427	25	35	57	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Wherowhero Lagoon	GDC	7A	SIDE	-38.748	177.952	655772	1052427	23	2478	0.18	10.1	15	2.512	5.473	12.785	80	158	350	6.5	15.4	37.2	A	B	D	B	C	D	B	C	D
Maraetaha River	GDC	6A	SSRTRE	-38.792	177.937	82547	139987	1	7841	1.88	0.6	71	11.982	26.104	54.215	17	319	658	0.0	0.0	0.0	A	C	D	A	A	A	A	A	A
Maungawhio Lagoon	GDC	7A	SIDE	-39.072	177.908	829969	1034215	79	7384	2.46	1.8	37	11.259	24.530	48.457	64	127	242	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Nuhaka River	HBRC	4C	SSRTRE	-39.072	177.749	169469	283513	0	20640	7.60	0.4	100	31.269	68.127	168.447	130	284	703	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Tahaenui River	HBRC	4D	C.LAKE	-39.068	177.679	0	77718	0	5689	1.84	0.5	100	8.161	17.781	54.073	140	306	930	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Whakaki Lagoon	HBRC	2A	C.LAKE	-39.065	177.573	0	4749001	0	3332	0.75	72.8	100	1.677	3.654	10.144	70	153	426	7.8	17.2	48.2	A	A	A	B	D	D	B	D	D
Te Paeroa Lagoon	HBRC	2A	C.LAKE	-39.055	177.518	0	604566	0	90	0.02	368.9	100	0.315	0.686	0.738	526	1147	1234	59.8	130	140	A	A	A	D	D	D	D	D	D
Wairau Lagoon	HBRC	2A	C.LAKE	-39.056	177.500	0	185129	1	154	0.03	66.4	100	0.124	0.271	0.337	122	266	331	13.6	29.9	37.4	A	A	A	C	D	D	C	D	D
Ohuia Lagoon	HBRC	2A	C.LAKE	-39.067	177.474	0	551787	0	2824	0.56	11.4	100	3.722	8.110	25.320	211	459	1432	21.8	50.0	161	A	A	A	D	D	D	D	D	D
Wairoa River	HBRC	8	SIDE	-39.070	177.423	3409409	9734902	16	367359	125.10	0.9	100	480.551	1046.979	2191.545	122	265	556	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waihua River	HBRC	3D	SSRTRE	-39.096	177.297	137315	230207	0	16164	3.42	0.6	75	18.396	40.080	93.920	16	281	654	0.0	0.0	0.0	A	C	D	A	A	A	A	A	A
Waikari River	HBRC	6C	SSRTRE	-39.172	177.099	202449	339576	0	32697	6.30	0.6	100	36.958	80.521	203.461	186	406	1025	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Aropaoanui River	HBRC	4C	C.LAKE	-39.286	177.005	0	63082	0	16831	3.77	0.2	100	19.852	43.251	115.639	167	364	974	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Ahuriri Estuary	HBRC	7A	SSRTRE	-39.476	176.896	3853629	6347333	9	13801	1.00	10.6	14	16.422	35.778	63.486	87	175	302	7.5	17.6	32.0	B	B	C	B	D	D	B	D	D
Ngaruroro River	HBRC	6B	SSRTRE	-39.568	176.936	1048044	2485690	0	336903	63.41	0.5	100	338.910	738.383	1407.965	169	369	704	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Mangakuri River	HBRC	6B	SSRTRE	-39.949	176.935	37602	64771	0	10495	1.81	0.4	100	14.713	32.055	69.356	257	561	1213	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Pourerere Stream	HBRC	4C	SSRTRE	-40.103	176.879	27797	47624	3	3714	0.54	0.7	66	4.209	9.169	24.586	14	362	964	0.0	0.0	0.0	A	D	D	A	A	A	A	A	A
Porangahau River	HBRC	7A	C.LAKE	-40.261	176.706	0	1667332	26	85544	9.88	2.0	100	77.828	169.565	438.796	250	544	1408	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Akitio River	MWRC	6B	SSRTRE	-40.612	176.429	354498	614967	0	58970	11.46	0.6	100	66.377	144.615	334.497	184	400	925	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Owahanga River	MWRC	6B	SSRTRE	-40.690	176.358	801529	1391322	0	40813	8.28	1.0	52	55.168	120.195	260.229	19	244	521	0.0	0.0	0.0	A	C	D	A	A	A	A	A	A
Whareama River	GWRC	6A	SSRTRE	-41.019	176.120	158714	276805	0	53246	8.41	0.4	100	61.071	133.056	276.278	230	502	1042	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Motuwaireka Stream	GWRC	4C	SSRTRE	-41.087	176.087	66593	112132	15	3319	0.61	1.1	50	4.224	9.203	17.438	16	246	459	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Patanui Stream	GWRC	6D	SSRTRE	-41.160	176.030	35312	60854	7	3500	0.67	0.7	66	4.239	9.236	19.137	16	293	601	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Pahaoa River	GWRC	6C	SSRTRE	-41.404	175.727	210195	370772	0	65066	12.65	0.3	100	76.371	166.390	306.712	191	417	769	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Oterei River	GWRC	6C	C.LAKE	-41.490	175.583	0	71782	0	6534	1.35	0.6	100	7.065	15.393	23.780	166	362	559	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Awhea River	GWRC	6C	C.LAKE	-41.510	175.529	0	56818	0	15194	3.39	0.2	100	18.984	41.361	83.607	178	387	783	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Lake Onoke/Turanganui River	GWRC	2A	SSRTRE	-41.413	175.136	7736470	20721539	2	343409	123.85	1.2	61	519.685	1132.240	2832.866	29	184	449	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Wainuiomata River	GWRC	3C	C.LAKE	-41.427	174.875	0	40514	0	13382	3.96	0.1	100	22.881	49.852	56.029	183	399	448	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Lake Kohangatera	GWRC	2B	C.LAKE	-41.379	174.857	0	212559	0	2096	0.38	6.5	100	2.985	6.503	8.047	249	543	672	22.9	56.3	71.0	A	A	A	D	D	D	D	D	D
Lake Kohangapiripiri	GWRC	2B	C.LAKE	-41.370	174.848	0	107970	2	387	0.07	18.5	100	0.330	0.719	1.080	155	337	507	16.5	37.2	56.5	A	A	A	D	D	D	D	D	D
Wellington Harbour	GWRC	9	DSDE	-41.354	174.834	88321085	1369490185	0	71351	28.83	6.1	1	127.126	276.969	346.107	19	21	22	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Lyall Bay	GWRC	11	DSDE	-41.348	174.800	2472115	19926805	0	380	0.06	77.6	2	0.418	0.911	2.247	22	27	42	2.3	2.9	4.5	A	A	A	A	A	B	A	A	B
Te Ikaamaru Bay	GWRC	11	DSDE	-41.236	174.662	415484	4743860	0	550	0.09	79.2	12	0.579	1.262	1.484	41	73	83	4.5	8.0	9.2	A	A	B	B	C	C	B	C	C
Ohariu Bay	GWRC	11	DSDE	-41.214	174.704	290759	1424578	0	7985	1.16	5.6	40	10.097	21.999	39.333	120	249	437	6.3	20.9	42.3	B	C	D	B	D	D	B	D	D

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Titahi Bay	GWRC	11	DSDE	-41.104	174.822	385084	1264686	0	105	0.01	31.7	2	0.144	0.313	0.654	27	38	62	2.4	3.7	6.4	A	A	A	A	B	B	A	B	B
Okupe Lagoon	GWRC	1	C.LAKE	-40.829	174.962	0	78777	0	112	0.02	45.1	100	0.052	0.114	0.183	82	178	287	8.9	19.8	32.2	A	A	A	B	D	D	B	D	D
Te Awarua-o-Porirua Harbour	GWRC	8	SIDE	-41.077	174.831	7413661	9678790	11	17205	2.60	7.4	17	21.799	47.493	81.193	60	114	185	2.7	8.8	16.9	A	B	B	A	B	D	A	B	D
Waikanae River	GWRC	6B	SIDE	-40.862	174.994	451237	618297	50	15345	4.67	0.8	52	23.930	52.137	79.017	19	191	285	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Waikawa Stream	GWRC	4D	SSRTRE	-40.695	175.131	170327	221858	54	7933	2.07	0.7	55	11.653	25.388	91.198	18	220	771	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Ohau River	MWRC	4D	SSRTRE	-40.664	175.142	601043	883621	0	18822	7.84	0.7	56	32.174	70.098	221.418	18	166	510	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Manawatu River	MWRC	6B	SSRTRE	-40.482	175.207	4869597	9050692	2	587649	133.22	0.6	78	797.317	1737.117	5991.202	31	327	1119	0.0	0.0	0.0	A	D	D	A	A	A	A	A	A
Rangitikei River	MWRC	6B	SSRTRE	-40.303	175.212	931087	1690595	4	392919	72.36	0.3	100	382.870	834.160	1620.377	168	366	710	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Turakina River	MWRC	6B	SSRTRE	-40.087	175.135	903827	1189344	34	96155	7.99	0.8	49	83.400	181.703	390.608	24	363	770	0.0	0.0	0.0	A	D	D	A	A	A	A	D	D
Whangaehu River	MWRC	6B	SSRTRE	-40.042	175.096	1109554	1978770	0	199151	41.59	0.6	100	226.604	493.703	1179.636	173	376	899	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Wanganui River	TRC	6C	SSRTRE	-39.954	174.981	8439492	9667230	0	713573	227.23	0.4	78	825.703	1798.962	3492.812	34	199	382	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Waitotara River	TRC	6A	SSRTRE	-39.856	174.681	284040	387553	0	116194	22.17	0.2	100	119.021	259.311	363.774	170	371	520	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Whenuakura River	TRC	6B	SSRTRE	-39.786	174.506	309675	383403	47	46644	9.22	0.4	82	51.548	112.308	236.008	19	318	665	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Patea River	TRC	6B	SSRTRE	-39.779	174.485	573063	1047793	32	104940	29.62	0.4	100	128.467	279.892	1280.652	138	300	1371	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waiwakaiho River	TRC	6B	SSRTRE	-39.032	174.101	246678	319589	17	13633	10.16	0.4	100	37.176	80.995	435.577	116	253	1359	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waiongana Stream	TRC	6B	SSRTRE	-38.984	174.185	234809	309331	5	16580	7.47	0.5	100	27.539	60.000	579.645	117	255	2459	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waitara River	TRC	6B	SSRTRE	-38.978	174.225	1293504	2131199	0	113936	57.15	0.4	100	196.221	427.508	2158.854	109	237	1198	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Onaero River	TRC	6B	SSRTRE	-38.982	174.363	67645	86479	24	8842	3.32	0.3	100	12.645	27.549	79.318	121	263	758	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Urenui River	TRC	6B	SSRTRE	-38.979	174.388	343238	453746	0	13358	5.93	0.6	63	19.969	43.507	92.927	21	154	320	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Mimi River	TRC	6B	SSRTRE	-38.955	174.418	369321	459278	39	13392	5.52	0.6	59	19.668	42.851	105.800	22	154	368	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Tongaporutu River	TRC	6B	SSRTRE	-38.816	174.572	1203331	1870689	25	27216	12.35	0.9	52	38.799	84.531	131.297	23	122	184	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Mohakatino River	TRC	6B	SSRTRE	-38.736	174.597	216433	355439	2	12654	5.35	0.6	74	18.585	40.492	50.035	22	184	226	0.0	0.0	0.0	A	B	C	A	A	A	A	A	A
Mokau River	EW/TRC	6B	SSRTRE	-38.707	174.602	3343698	5511303	0	144670	55.28	0.7	62	222.596	484.971	1855.152	27	180	666	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Awakino River	EW	6B	SSRTRE	-38.666	174.610	997461	1646005	0	38339	20.15	0.6	68	83.218	181.308	451.444	24	200	487	0.0	0.0	0.0	A	B	D	A	A	A	A	A	A
Waikawau River	EW	4C	SSRTRE	-38.480	174.615	99715	132581	0	8179	3.99	0.4	100	15.334	33.409	55.440	122	266	441	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Marakopa River	EW	6B	SSRTRE	-38.309	174.699	1837757	2973975	14	36451	16.49	1.0	49	71.063	154.824	461.215	26	158	449	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Waiharakeke Stream	EW	8	SIDE	-38.130	174.814	9782841	10520315	93	6272	2.42	7.0	14	11.814	25.740	55.720	42	68	123	0.2	3.1	9.4	A	A	B	A	A	C	A	A	B
Kaitawa Inlet KHS	EW	8	SIDE	-38.102	174.850	841197	849694	100	173	0.06	8.9	5	0.342	0.744	3.207	33	45	115	0.7	2.0	10.0	A	A	B	A	A	C	A	A	B
Rakaunui Inlet KHS	EW	8	SIDE	-38.101	174.862	3142104	3595496	87	3740	1.43	5.8	20	6.603	14.385	45.923	49	83	222	0.0	2.5	18.3	A	B	C	A	A	D	A	B	C
Awaroa River KHS	EW	8	SIDE	-38.082	174.895	4016263	4953457	81	10973	5.05	3.4	30	20.757	45.224	118.987	56	102	240	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Oparau River KHS	EW	8	SIDE	-38.067	174.887	2793279	3271584	85	12402	5.65	2.3	34	22.023	47.981	149.655	58	108	301	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Mangaora Inlet KHS	EW	8	SIDE	-38.059	174.856	830374	830706	100	980	0.31	5.5	18	1.636	3.563	6.669	50	85	142	0.0	1.9	8.4	A	B	B	A	A	C	A	B	B
Te Wharu Bay KHS	EW	8	SIDE	-38.061	174.835	2767234	2767511	100	412	0.13	9.2	4	0.464	1.011	2.928	28	33	50	0.3	0.8	2.8	A	A	A	A	A	A	A	A	A
Kawhia Inlet KHS	EW	8	SIDE	-38.086	174.778	102127938	148874545	69	45322	18.91	10.5	11	81.761	178.133	493.971	37	56	116	1.8	3.9	10.8	A	A	B	A	B	C	A	A	B
Kawhia Harbour System (KHS)	EW	8	SIDE	-38.089	174.745	126295622	162209696	74	45322	18.91	9.8	10	81.761	178.133	493.971	35	51	103	1.3	3.1	9.1	A	A	B	A	B	C	A	A	B
Aotea Harbour System	EW	8	SIDE	-38.018	174.783	59186968	100566459	74	16198	5.48	14.3	7	24.202	52.729	150.575	32	43	81	2.1	3.4	7.7	A	A	B	A	B	B	A	A	B

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Opotoru River RHS	EW	8	SIDE	-37.801	174.866	3078635	3670285	84	5538	1.41	6.0	20	6.106	13.304	53.127	48	80	259	0.0	2.8	23.1	A	B	C	A	A	D	A	B	C
Waitetuna Creek RHS	EW	8	SIDE	-37.793	174.924	9057971	11445503	79	17328	5.62	5.4	23	25.988	56.619	185.621	54	94	261	0.0	2.5	21.5	A	B	C	A	A	D	A	B	C
Kerikeri/Waingaro Arm	EW	8	SIDE	-37.790	174.909	26377784	34716747	76	16678	4.37	9.7	11	23.074	50.272	156.195	41	62	143	2.0	4.4	13.6	A	A	B	A	B	D	A	A	B
Ponganui/Paihere Creeks	EW	8	SIDE	-37.789	174.874	1434284	1439611	100	885	0.22	7.6	10	1.241	2.704	9.547	41	62	161	0.7	3.1	14.3	A	A	B	A	B	D	A	A	B
Raglan Inlet RHS	EW	8	SIDE	-37.801	174.842	20986083	45141069	46	50536	14.24	8.8	24	69.567	151.565	486.162	57	100	278	3.3	8.2	28.5	A	B	C	A	B	D	A	B	C
Raglan Harbour System (RHS)	EW	8	SIDE	-37.806	174.812	27652903	40076671	69	50536	14.24	6.9	21	69.567	151.565	486.162	53	91	249	1.2	5.6	23.5	A	B	C	A	B	D	A	B	C
Waikato River	EW	6B	SSRTRE	-37.374	174.684	49891290	116992603	8	1447309	355.48	1.8	46	1491.131	3248.732	14497.72	40	148	610	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Manukau Harbour System (MHS)	ARC	8	SIDE	-37.072	174.503	710146881	2215803524	62	81877	14.33	30.3	2	105.387	229.607	705.504	31	36	54	2.9	3.4	5.5	A	A	A	A	B	B	A	A	A
Waitakere River (Bethells Beach)	ARC	4C	SIDE	-36.894	174.430	51824	55604	89	6648	1.57	0.3	82	7.009	15.272	24.265	29	259	409	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Kaipara Harbour System	NRC/ARC	8	SIDE	-36.454	174.088	1615117448	3992734683	42	573964	125.97	21.3	6	1036.164	2257.494	5935.779	44	62	116	4.1	6.1	12.3	A	A	B	B	B	D	A	A	B
Waipoua River	NRC	6B	SSRTRE	-35.676	173.468	322823	428204	22	11237	3.62	0.7	53	19.383	42.230	47.599	37	213	238	0.0	0.0	0.0	A	C	C	A	A	A	A	C	C
Waimaukau River	NRC	6B	SSRTRE	-35.599	173.404	521306	678376	32	13309	4.02	0.9	47	21.329	46.469	116.351	37	192	451	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Hokianga Harbour System	NRC	8	SIDE	-35.541	173.350	216172096	482972423	49	154045	41.87	15.8	12	285.427	621.861	1373.215	57	87	155	5.1	8.5	16.2	A	B	B	B	C	D	A	B	B
Whangapae Harbour System	NRC	8	SIDE	-35.383	173.204	17954810	24626719	67	29203	8.73	6.7	21	60.009	130.742	218.411	73	126	191	3.2	9.2	16.7	A	B	B	A	B	D	A	B	B
Herekino Harbour	NRC	8	SIDE	-35.297	173.148	7646102	8424765	84	8853	1.93	7.1	14	15.360	33.464	59.133	66	108	168	3.0	7.8	14.6	A	B	B	B	B	D	A	B	B
Waiatua Stream	NRC	4C	DSDE	-35.286	173.137	104253	142421	5	613	0.08	5.1	25	0.824	1.795	1.927	106	201	213	2.2	12.9	14.4	B	C	C	A	C	D	B	C	D
Tanutanu Stream	NRC	4C	SSRTRE	-35.235	173.083	452892	622605	1	1581	0.22	6.8	20	2.297	5.005	5.213	96	177	183	6.0	15.2	15.9	B	B	B	B	C	D	B	C	D
Pahurehure Inlet MHS	ARC	8	SIDE	-37.053	174.858	29153366	45795422	64	32630	6.21	10.8	13	48.770	106.255	353.069	57	94	253	4.2	8.4	26.5	A	B	C	B	C	D	A	B	C
Lucas Creek WHS	ARC	8	SIDE	-37.772	174.661	2321528	2672417	87	3325	0.58	7.5	14	5.362	11.682	17.893	63	111	159	3.0	8.6	14.0	A	B	B	A	B	D	A	B	B
Waitangi Stream	NRC	4C	C.LAKE	-34.428	172.962	0	58779	0	1097	0.15	4.4	100	1.247	2.718	2.741	255	556	561	12.9	47.2	47.7	A	A	A	C	D	D	C	D	D
Maketu Estuary	EBOP	7A	SIDE	-37.754	176.454	2639051	3548524	58	2398	0.81	8.1	16	4.796	10.449	56.707	50	85	374	2.1	6.1	38.9	A	B	D	A	B	D	A	B	D
Waitahanui Stream	EBOP	4	SSRTRE	-37.829	176.598	50020	79478	0	11900	4.35	0.2	100	15.853	34.540	96.460	116	252	703	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Otaki River	GWRC	6C	SSRTRE	-40.763	175.100	325037	487150	0	35764	30.97	0.2	100	106.195	231.367	290.894	109	237	298	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Ohau Bay	GWRC	11	DSDE	-41.237	174.651	212251	2038928	0	304	0.05	65.0	13	0.278	0.606	0.942	39	68	97	4.2	7.4	10.7	A	A	B	B	B	C	B	B	C
Mercury Bay MBS	EW	11	DSDE	-36.808	175.756	32298500	161474432	3	44332	20.83	21.0	23	85.212	185.651	430.787	53	89	176	5.0	9.1	19.0	A	B	B	B	B	D	B	B	D
Firth of Thames	EW/ARC	9	DSDE	-36.891	175.303	1891415910	16000000000	15	378239	90.37	77.5	4	632.150	1377.268	6882.549	36	46	119	3.9	5.0	13.3	A	A	B	B	B	D	B	B	D
Puhinui Creek MHS	ARC	8	SIDE	-37.031	174.852	904391	904934	100	2554	0.39	5.2	19	3.041	6.626	15.218	71	128	264	0.0	5.5	20.9	A	B	C	A	B	D	A	B	C
North Cove	ARC	11	DSDE	-36.412	174.823	1089925	1561974	37	119	0.02	14.0	2	0.181	0.394	0.395	35	40	40	2.4	3.0	3.0	A	A	A	A	A	A	A	A	A
Bon Accord Harbour	ARC	11	DSDE	-36.424	174.813	5424129	12417347	19	871	0.13	22.0	2	1.214	2.645	2.644	36	43	43	3.2	4.0	4.0	A	A	A	B	B	B	B	B	B
South Cove Harbour	ARC	11	DSDE	-36.444	174.826	511869	614853	31	115	0.02	11.3	3	0.224	0.488	0.488	41	54	54	2.5	4.0	4.0	A	A	A	A	B	B	A	B	B
Gardiner Gap	ARC	11	DSDE	-36.767	174.889	637554	1069541	60	132	0.03	15.5	3	0.131	0.285	0.725	34	40	57	2.4	3.1	5.1	A	A	A	A	B	B	A	A	A
Islington Bay	ARC	11	DSDE	-36.797	174.904	4754895	7859547	7	173	0.04	16.5	1	0.172	0.375	0.375	30	32	32	2.2	2.3	2.3	A	A	A	A	A	A	A	A	A
Matiatia Bay	ARC	11	DSDE	-36.781	174.983	988824	1743905	3	104	0.02	17.3	1	0.127	0.276	0.583	33	37	45	2.5	3.0	3.9	A	A	A	A	A	B	A	A	B
Owhanake Bay	ARC	11	DSDE	-36.769	174.991	746236	1417337	2	58	0.01	18.8	1	0.081	0.177	0.375	32	36	43	2.6	3.0	3.8	A	A	A	A	A	B	A	A	B
Oneroa Bay	ARC	11	DSDE	-36.775	175.021	4000498	12801343	1	90	0.01	32.2	0	0.147	0.320	0.452	31	32	33	2.9	3.0	3.1	A	A	A	A	B	B	A	B	B
Mawhitipana Bay	ARC	11	DSDE	-36.776	175.042	914388	2301964	9	110	0.02	24.5	2	0.180	0.392	0.638	35	41	48	3.1	3.8	4.6	A	A	A	B	B	B	B	B	B

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													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Te Matuku Bay	ARC	11	DSDE	-36.850	175.132	4350612	5733543	76	1135	0.17	12.3	3	1.450	3.159	4.280	37	47	54	2.3	3.4	4.2	A	A	A	A	B	B	A	A	A
Awaawaroa Bay	ARC	11	DSDE	-36.846	175.104	7014047	10223362	29	1307	0.19	13.9	2	1.662	3.621	5.996	35	42	51	2.4	3.2	4.2	A	A	A	A	B	B	A	B	B
Rocky Bay	ARC	11	DSDE	-36.831	175.055	3000404	4104300	30	409	0.06	13.3	2	0.605	1.318	1.579	35	41	43	2.2	2.9	3.2	A	A	A	A	A	B	A	A	B
Putiki Bay	ARC	11	DSDE	-36.818	175.025	7777440	9953530	35	1007	0.15	12.4	2	1.557	3.392	4.630	35	41	45	2.1	2.8	3.2	A	A	A	A	A	B	A	A	B
Huruhi Bay	ARC	11	DSDE	-36.814	175.004	12139148	26462932	12	224	0.03	22.0	0	0.355	0.774	1.270	30	31	33	2.5	2.7	2.8	A	A	A	A	A	A	A	A	A
Port Underwood	MDC	9	DSDE	-41.349	174.109	30943063	294283650	1	2780	0.98	90.1	3	3.316	7.224	7.510	21	25	25	2.2	2.6	2.6	A	A	A	A	A	A	A	A	A
Wairau River	MDC	6B	SSRTRE	-41.501	174.062	18842997	44539663	20	58515	6.06	14.0	16	51.756	112.762	226.812	61	114	212	5.4	11.3	22.5	A	B	C	B	C	D	B	C	D
Awatere River	MDC	3B	SSRTRE	-41.606	174.167	110648	187275	12	158979	23.12	0.1	100	128.380	279.702	299.660	176	384	411	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Lake Grassmere	MDC	2A	C.LAKE	-41.712	174.188	0	13675802	0	6295	0.40	397.3	100	0.501	1.091	1.783	40	87	142	4.5	9.8	16.1	A	A	A	A	B	D	A	B	D
Waiau River	ECAN	3B	SSRTRE	-42.771	173.380	696703	1175582	0	333260	114.38	0.1	100	424.703	925.301	1155.648	118	257	320	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Hurunui River	ECAN	3B	SSRTRE	-42.906	173.292	270542	449093	0	266996	73.53	0.1	100	274.735	598.566	893.458	118	258	385	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waipara River	ECAN	3C	SSRTRE	-43.155	172.798	194307	305806	3	74060	5.58	0.5	80	46.246	100.757	209.309	37	465	960	0.0	0.0	0.0	A	D	D	A	A	A	A	A	A
Ashley River	ECAN	3D	SIDE	-43.271	172.727	1613564	2272805	78	129506	20.00	0.7	55	120.213	261.909	458.070	41	244	415	0.0	0.0	0.0	A	C	D	A	A	A	A	C	D
Waimakariri River	ECAN	6B	SSRTRE	-43.392	172.715	3733531	6746439	45	359020	144.14	0.5	100	485.775	1058.359	1666.250	107	233	367	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Avon-Heathcote River	ECAN	7A	SIDE	-43.559	172.759	8942222	13948201	66	29949	1.56	11.4	11	18.085	39.403	117.381	73	121	295	6.2	11.6	31.4	A	B	C	B	C	D	A	B	C
Lyttelton Harbour	ECAN	9	DSDE	-43.597	172.817	70438845	242920351	16	9512	0.82	34.1	1	8.853	19.287	31.685	40	44	49	4.0	4.5	5.0	A	A	A	B	B	B	B	B	B
Port Levy	ECAN	11	DSDE	-43.606	172.840	14590656	60344379	2	5373	0.48	39.1	3	5.931	12.922	15.891	47	59	64	4.8	6.2	6.8	A	A	A	B	B	B	B	B	B
Blind/Big Bay	ECAN	11	DSDE	-43.613	172.886	1926326	10379143	1	608	0.05	51.8	2	0.549	1.196	1.501	44	52	57	4.6	5.6	6.1	A	A	A	B	B	B	B	B	B
Little Pigeon Bay	ECAN	11	DSDE	-43.622	172.907	851828	3979252	0	396	0.02	44.7	2	0.321	0.700	0.491	46	58	51	4.8	6.1	5.4	A	A	A	B	B	B	B	B	B
Pigeon Bay	ECAN	11	DSDE	-43.625	172.922	15989724	84010556	0	5289	0.65	48.8	3	6.602	14.385	20.657	46	58	68	4.9	6.3	7.4	A	A	A	B	B	B	B	B	B
Scrubby Bay	ECAN	11	DSDE	-43.634	172.951	532413	1996237	4	294	0.03	34.3	4	0.307	0.669	0.278	50	67	48	5.1	7.0	4.9	A	A	A	B	B	B	B	B	B
Menzies Bay	ECAN	11	DSDE	-43.635	172.970	1812483	8854248	1	825	0.08	45.1	4	0.702	1.529	2.454	45	57	69	4.7	6.0	7.5	A	A	A	B	B	B	B	B	B
Decanter Bay	ECAN	11	DSDE	-43.649	173.002	1475602	5642346	0	745	0.08	34.6	4	0.687	1.497	2.224	46	60	72	4.7	6.3	7.7	A	A	A	B	B	B	B	B	B
Little Akaloa Bay	ECAN	11	DSDE	-43.651	173.012	3233941	11800533	4	1662	0.16	33.3	4	1.681	3.662	7.167	48	63	90	4.9	6.6	9.7	A	A	B	B	B	C	B	B	C
Okains Bay	ECAN	11	DSDE	-43.680	173.081	6419886	18315425	2	3279	0.50	24.6	6	3.574	7.786	18.033	47	63	100	4.6	6.3	10.6	A	A	B	B	B	C	B	B	C
Lavericks Bay	ECAN	11	DSDE	-43.718	173.110	746580	2719883	11	1003	0.15	25.6	12	1.164	2.536	3.700	62	97	127	6.2	10.3	13.7	A	B	B	B	C	D	B	C	D
Le Bons Bay	ECAN	11	DSDE	-43.734	173.122	3938326	14287266	6	2654	0.43	29.5	8	3.500	7.625	9.955	53	76	90	5.4	8.0	9.5	A	A	B	B	C	C	B	C	C
Otanerito Bay	ECAN	11	DSDE	-43.852	173.067	1149306	4377324	0	1095	0.21	27.3	11	1.115	2.430	3.034	52	74	85	5.2	7.7	8.9	A	A	B	B	B	C	B	B	C
Sleepy Bay	ECAN	11	DSDE	-43.854	173.060	311499	1171835	3	235	0.05	28.7	10	0.266	0.580	0.610	51	72	74	5.2	7.6	7.8	A	A	A	B	B	B	B	B	B
Stony Bay	ECAN	11	DSDE	-43.860	173.049	490309	1856834	2	754	0.15	23.0	16	0.785	1.710	2.116	58	89	103	5.7	9.3	10.8	A	B	B	B	B	C	B	B	C
Flea Bay	ECAN	11	DSDE	-43.880	173.020	1205445	6617243	1	859	0.17	42.2	10	0.872	1.900	2.405	49	67	76	5.1	7.2	8.2	A	A	A	B	B	C	B	B	C
Damons Bay	ECAN	11	DSDE	-43.889	172.992	1227804	10108813	0	362	0.07	73.6	5	0.382	0.832	1.270	43	52	61	4.7	5.7	6.7	A	A	A	B	B	B	B	B	B
Akaroa Harbour	ECAN	9	DSDE	-43.894	172.959	75076211	455980646	3	11505	2.29	57.7	3	16.478	35.901	62.766	43	49	59	4.5	5.3	6.3	A	A	A	B	B	B	B	B	B
Island Bay	ECAN	11	DSDE	-43.895	172.866	357393	1842196	0	439	0.08	34.4	13	0.519	1.131	1.666	60	91	119	6.3	9.8	12.9	A	B	B	B	B	D	B	B	D
Long Bay	ECAN	11	DSDE	-43.893	172.855	1480823	5739598	0	596	0.12	33.5	6	0.640	1.394	1.969	47	59	68	4.8	6.1	7.2	A	A	A	B	B	B	B	B	B
Horseshoe Bay	ECAN	11	DSDE	-43.882	172.226	1961739	11022650	0	712	0.14	49.3	5	0.803	1.749	2.118	79	91	95	8.6	9.9	10.4	A	B	B	C	C	C	C	C	C
Peraki Bay	ECAN	11	DSDE	-43.879	172.809	2088307	8392199	1	1760	0.36	29.5	11	1.738	3.788	4.479	52	71	78	5.2	7.5	8.2	A	A	A	B	B	C	B	B	C

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Te Oka Bay	ECAN	11	DSDE	-43.864	172.773	1346473	4347854	2	825	0.18	25.3	9	0.968	2.109	2.491	51	70	76	5.1	7.1	7.8	A	A	A	B	B	B	B	B	B
Tumbledown Bay	ECAN	11	DSDE	-43.860	172.766	298381	804808	6	462	0.09	16.1	16	0.569	1.240	1.016	64	101	89	6.0	10.2	8.8	A	B	B	B	C	C	B	C	C
Lake Forsyth (Te Roto o Wairewa)	ECAN	2B	C.LAKE	-43.829	172.710	0	5512392	1	11351	1.97	32.3	100	6.299	13.723	22.296	101	220	358	10.9	24.5	40.1	A	A	A	C	D	D	C	D	D
Lake Ellesmere (Te Waihora)	ECAN	2A	C.LAKE	-43.859	172.375	0	179138756	10	260018	19.00	109	100	227.733	496.162	1745.297	380	828	2913	43.0	93.9	331	A	A	A	D	D	D	D	D	D
Rakaia River	ECAN	3A	SSRTRE	-43.902	172.211	1072729	1670605	2	293275	175.55	0.1	100	456.563	994.715	1094.221	82	180	198	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Ashburton River	ECAN	3B	SSRTRE	-44.054	171.808	73445	114401	3	159696	32.63	0.0	100	152.701	332.691	871.906	148	323	847	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Rangitata River	ECAN	3B	SSRTRE	-44.184	171.521	137630	215935	1	181105	108.85	0.0	100	284.143	619.064	701.271	83	180	204	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Opihi River	ECAN	3C	SSRTRE	-44.281	171.355	278647	437747	1	237268	26.28	0.2	100	208.072	453.328	885.996	251	547	1069	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Washdyke Lagoon	ECAN	2A	C.LAKE	-44.369	171.264	0	230269	0	18170	1.13	2.4	100	6.117	13.328	34.434	172	374	966	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Saltwater Creek	ECAN	4D	C.LAKE	-44.427	171.257	0	109594	0	4774	0.26	4.9	100	1.681	3.662	9.053	207	452	1117	12.9	40.7	116	A	A	A	C	D	D	C	D	D
Wainono Lagoon	ECAN	2A	C.LAKE	-44.713	171.171	0	3792088	5	13725	0.56	79.0	100	2.514	5.477	12.006	143	313	685	16.1	35.3	77.6	A	A	A	D	D	D	D	D	D
Waihao River	ECAN	4D	C.LAKE	-44.774	171.174	0	358476	0	64849	4.28	1.0	100	42.510	92.616	168.768	315	686	1250	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waitaki River	ECAN	3A	SSRTRE	-44.943	171.148	932411	1499963	3	1195472	410.37	0.0	100	1091.437	2377.917	2461.090	84	184	190	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Kakanui River	ORC	6B	SSRTRE	-45.191	170.901	246057	455441	21	89671	6.28	0.6	76	56.424	122.931	200.027	67	484	778	0.0	0.0	0.0	A	D	D	A	A	A	A	D	D
Orore Creek	ORC	4C	C.LAKE	-45.212	170.886	0	84727	0	1842	0.12	8.3	100	0.611	1.331	2.816	164	358	757	15.2	37.2	82.6	A	A	A	C	D	D	C	D	D
Shag River	ORC	7A	SIDE	-45.481	170.818	1117500	1352800	63	54236	3.09	1.9	37	33.131	72.183	109.058	164	310	448	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Stony Creek	ORC	4C	SIDE	-45.511	170.784	140673	160907	87	901	0.06	5.9	20	0.242	0.527	1.270	75	103	178	1.8	5.0	13.5	A	B	B	A	B	D	A	B	B
Pleasant River	ORC	7A	SIDE	-45.571	170.732	971541	1443302	76	12848	0.98	4.7	28	5.318	11.586	17.109	94	150	200	0.0	4.8	10.5	B	B	C	A	A	C	B	B	C
Waikouaiti Lagoon	ORC	4B	C.LAKE	-45.613	170.683	0	24857	95	1681	0.04	7.6	100	0.141	0.307	0.546	119	259	460	9.5	25.4	48.3	A	A	A	B	D	D	A	A	A
Waikouaiti River	ORC	7A	SIDE	-45.643	170.662	1359584	2180631	68	42643	3.07	2.9	35	23.235	50.623	64.892	127	226	277	0.0	0.0	0.0	B	C	C	A	A	A	B	C	C
Blueskin Bay	ORC	7A	SIDE	-45.727	170.608	5787209	7559191	86	9277	0.78	10.2	9	8.625	18.792	25.512	94	132	156	8.2	12.5	15.3	B	B	B	C	D	D	B	B	B
Purakunui Inlet	ORC	7A	SIDE	-45.737	170.626	1027041	1294680	88	762	0.05	11.5	4	0.650	1.417	2.229	81	100	120	7.2	9.3	11.5	B	B	B	B	C	C	B	B	B
Otago Harbour	ORC	9	DSDE	-45.773	170.724	60304035	184773975	45	10407	1.31	29.6	2	9.619	20.956	39.707	70	74	83	7.3	7.8	8.8	A	A	B	B	B	C	A	A	B
Papanui Inlet	ORC	7A	SIDE	-45.842	170.738	3237684	3968608	90	1006	0.05	12.0	1	0.634	1.381	3.087	71	77	91	6.1	6.8	8.4	A	A	B	B	B	C	A	A	B
Hoopers Inlet	ORC	7A	SIDE	-45.882	170.679	3246593	3636671	95	928	0.07	10.9	2	0.676	1.473	3.246	73	79	94	6.0	6.8	8.4	A	A	B	B	B	C	A	A	B
Tomahawk Lagoon	ORC	4B	C.LAKE	-45.914	170.539	0	193787	2	441	0.06	36.3	100	0.201	0.439	1.172	103	225	602	11.2	25.1	67.9	A	A	A	C	D	D	C	D	D
Kaikorai Stream	ORC	6C	SSRTRE	-45.937	170.391	1001228	2100301	14	5477	0.50	10.1	21	5.962	12.990	22.058	136	228	347	12.9	23.4	37.0	B	C	D	C	D	D	C	D	D
Taieri River	ORC	6B	SSRTRE	-46.056	170.210	2511015	3915461	10	570631	45.46	0.6	64	382.568	833.501	1150.545	85	400	542	0.0	0.0	0.0	B	D	D	A	A	A	B	D	D
Akatore Creek	ORC	7A	SIDE	-46.116	170.193	462359	895893	70	6965	0.69	4.7	31	5.933	12.927	15.061	135	235	265	2.7	14.1	17.6	B	C	C	A	C	D	B	C	C
Tokomairiro River	ORC	7A	SSRTRE	-46.223	170.049	765229	1058980	51	39617	3.65	1.4	41	44.040	95.949	175.481	200	387	674	0.0	0.0	0.0	C	D	D	A	A	A	C	D	D
Clutha River	ORC	6B	SSRTRE	-46.333	169.839	10535431	16401711	5	2111146	617.00	0.3	100	2044.218	4453.745	5552.632	105	229	285	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Catlins River	ORC	7A	SIDE	-46.485	169.729	11763600	14156300	65	41805	6.96	5.3	23	38.165	83.151	168.539	95	142	229	2.2	7.4	17.4	B	B	C	A	B	D	B	B	C
Tahakopa River	ORC	7A	SSRTRE	-46.563	169.477	1345484	1939721	31	31147	7.17	1.3	43	44.458	96.860	124.359	128	226	278	0.0	0.0	0.0	B	C	C	A	A	A	B	C	C
Tautuku River	ORC	7A	SIDE	-46.601	169.430	838250	1338632	62	6235	1.32	3.7	32	8.313	18.112	18.845	115	190	195	0.0	0.0	0.0	B	B	B	A	A	A	B	B	B
Waipati Estuary	ORC	7A	SIDE	-46.624	169.361	722401	1330563	34	7269	1.64	3.3	35	10.373	22.601	26.647	119	201	229	0.0	0.0	0.0	B	C	C	A	A	A	B	C	C
Waikawa Harbour	ES	7A	SIDE	-46.648	169.133	7574506	9835149	82	23802	5.79	4.9	25	38.419	83.704	154.290	109	171	268	1.7	8.7	19.8	B	B	C	A	B	D	B	B	C
Haldane Estuary	ES	7A	SIDE	-46.668	169.032	2064020	2337221	93	6769	1.71	4.1	26	9.862	21.487	41.424	103	158	254	0.0	0.0	6.5	B	B	C	A	A	B	B	B	C

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Lake Brunton	ES	7B	C.LAKE	-46.658	168.894	0	258506	0	1467	0.33	9.1	100	1.903	4.145	10.190	184	402	988	18.0	42.7	109	A	A	A	D	D	D	D	D	D
Toetoes Harbour	ES	7A	SSRTRE	-46.585	168.796	8589338	11871604	31	563711	101.10	0.7	54	641.652	1397.969	3242.334	86	271	583	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Waituna Lagoon	ES	2A	C.LAKE	-46.574	168.656	0	12588503	7	21316	2.90	50.2	100	11.428	24.899	53.748	125	272	587	13.8	30.5	66.4	A	A	A	C	D	D	C	D	D
Bluff Harbour	ES	8	SIDE	-46.605	168.360	89628434	121988796	52	7605	0.91	13.5	1	14.723	32.078	39.287	75	80	82	6.8	7.4	7.7	A	B	B	B	B	B	A	B	B
New River (Oreti) Estuary	ES	8	SIDE	-46.507	168.272	73102315	102935087	42	398458	65.10	4.9	27	480.820	1047.564	3951.101	114	187	563	1.8	10.1	52.8	B	B	D	A	C	D	B	B	D
Jacobs River (Riverton) Estuary	ES	7A	SIDE	-46.361	168.027	10151391	14697352	66	156864	29.32	2.1	37	191.723	417.707	1283.517	120	210	556	0.0	0.0	0.0	B	C	D	A	A	A	B	C	D
Waiau River	ES	3B	SSRTRE	-42.771	173.380	1092669	1839804	1	830279	489.42	0.0	100	452.702	986.304	1438.703	29	64	93	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Big River (Lake Hakapoua)	ES	9	DSDE	-46.220	166.925	10688413	38038249	0	15390	12.16	10.4	29	41.392	90.181	76.585	69	106	95	5.4	9.6	8.4	A	B	B	B	B	C	B	B	C
Preservation Inlet	ES	10	DSDE	-46.142	166.609	180913302	7298729976	1	44126	43.60	17.1	1	165.904	361.455	291.807	52	53	53	4.7	4.8	4.8	A	A	A	B	B	B	B	B	B
Chalky Inlet	ES	10	DSDE	-46.030	166.489	208778230	12729611785	0	38176	39.77	20.0	1	147.555	321.478	273.450	49	50	50	4.6	4.7	4.7	A	A	A	A	A	B	A	A	B
Breaksea/Dusky Sound	ES	10	DSDE	-45.616	166.569	515651976	30389041529	1	103572	134.26	20.6	1	554.359	1207.783	1006.493	44	45	45	4.0	4.2	4.1	A	A	A	B	B	B	B	B	B
Coal River	ES	11	DSDE	-45.494	166.704	5814735	44113235	2	6522	6.62	22.3	29	22.146	48.249	46.418	59	95	93	5.8	9.9	9.6	A	B	B	B	B	C	B	B	C
Dagg Sound	ES	10	DSDE	-45.391	166.764	28394024	778194350	1	9216	9.72	9.9	1	36.597	79.734	74.604	38	40	39	1.7	1.9	1.9	A	A	A	A	A	A	A	A	A
Thompson/Doubtful sound	ES	10	DSDE	-45.147	166.961	254867548	18978270538	1	82591	109.86	19.1	1	447.077	974.049	774.416	32	34	33	2.6	2.7	2.7	A	A	A	A	A	A	A	A	A
Nancy Sound	ES	10	DSDE	-45.102	167.019	27117750	1440801049	0	7009	8.88	10.8	1	43.460	94.687	85.935	31	32	32	1.3	1.4	1.4	A	A	A	A	A	A	A	A	A
Charles Sound	ES	10	DSDE	-45.046	167.086	30317543	990184689	4	14182	22.91	5.9	1	115.599	251.857	209.806	31	33	33	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Caswell Sound	ES	10	DSDE	-45.000	167.130	33290705	2491218702	0	24724	46.99	8.9	1	228.907	498.721	400.452	31	33	32	0.4	0.7	0.6	A	A	A	A	A	A	A	A	A
Two Thumb Bay	ES	11	DSDE	-44.953	167.178	2280973	8435863	2	3304	4.97	6.8	35	18.071	39.371	36.478	58	105	99	1.7	7.0	6.3	A	B	B	A	B	B	A	B	B
Looking Glass Bay	ES	11	DSDE	-44.918	167.212	2666036	17270010	3	1278	1.96	25.2	25	7.832	17.063	16.640	52	89	87	5.1	9.3	9.1	A	B	B	B	B	C	B	B	C
George Sound	ES	10	DSDE	-44.844	167.348	58967636	3304945089	0	25074	47.63	11.7	1	224.365	488.826	423.161	28	30	30	1.1	1.4	1.3	A	A	A	A	A	A	A	A	A
Catseye Bay	ES	11	DSDE	-44.806	167.382	1594832	5013355	5	3446	5.55	4.0	39	23.099	50.325	49.885	66	126	125	0.0	0.0	0.0	A	B	B	A	A	A	A	A	A
Bligh Sound	ES	10	DSDE	-44.765	167.483	39994109	1462615962	2	17665	33.25	8.0	2	178.960	389.900	311.806	27	30	29	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Sutherland Sound	ES	10	DSDE	-44.725	167.546	20562346	114358227	2	15559	29.39	13.9	31	164.212	357.768	267.974	71	136	106	6.5	13.8	10.4	A	B	B	B	C	C	B	C	C
Poison Bay	ES	11	DSDE	-44.653	167.623	16135457	321672860	0	6313	10.77	3.3	1	45.430	98.979	82.266	24	26	25	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Milford Sound	ES	10	DSDE	-44.564	167.802	54781767	3579420379	1	52406	99.88	9.1	2	517.932	1128.419	758.152	27	31	28	0.0	0.5	0.2	A	A	A	A	A	A	A	A	A
Hollyford River	ES	6B	SSRTRE	-44.338	168.001	3103811	4667024	2	113477	213.11	0.3	100	855.557	1864.006	1452.362	127	277	216	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Awarua River	ES	3C	SSRTRE	-44.291	168.114	228836	459797	0	5510	9.75	0.5	100	35.798	77.994	76.308	116	254	248	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Cascade River	WCRC	6B	SSRTRE	-44.025	168.349	1931803	2873150	1	43879	94.70	0.4	100	353.381	769.912	592.216	118	258	198	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waiatoto River	WCRC	6B	SSRTRE	-43.969	168.788	2732735	3946666	12	54117	125.56	0.4	100	392.101	854.271	671.894	99	216	170	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Okuru River	WCRC	6B	SSRTRE	-43.909	168.885	3128239	4386557	25	51463	107.14	0.5	100	363.361	791.656	657.024	108	234	194	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waita River	WCRC	6D	SSRTRE	-43.796	169.092	445784	627421	21	13127	25.03	0.3	100	53.043	115.565	114.202	67	146	145	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Moeraki (Blue) River	WCRC	4C	SSRTRE	-43.699	169.255	136992	199244	1	10658	24.56	0.1	100	63.181	137.652	117.498	82	178	152	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Paringa River	WCRC	5C	SSRTRE	-43.627	169.433	972465	1395896	6	36625	84.15	0.2	100	222.291	484.307	422.882	84	182	159	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Ohinemaka River	WCRC	6D	SSRTRE	-43.627	169.496	219375	316944	0	7112	12.90	0.3	100	32.030	69.783	69.732	79	172	171	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Mahitahi River	WCRC	6B	SSRTRE	-43.596	169.586	828911	1184195	5	20137	49.75	0.3	100	142.000	309.377	258.810	91	197	165	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Makawhio River (Jacobs River)	WCRC	6B	SSRTRE	-43.566	169.632	1285453	1791819	18	17081	39.38	0.4	83	99.717	217.254	176.161	15	147	119	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Manakaiaua River	WCRC	6D	SSRTRE	-43.541	169.675	525427	751847	3	5915	11.89	0.5	71	22.698	49.452	56.091	13	97	110	0.0	0.0	0.0	A	B	B	A	A	A	A	A	A

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Ohinetamatatea River (Saltwater Creek)	WCRC	6E	SSRTRE	-43.457	169.761	283366	404773	3	9610	17.24	0.3	100	39.303	85.629	105.947	72	157	195	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Three Mile Lagoon	WCRC	7B	C.LAKE	-43.241	170.125	0	351518	58	2584	4.62	0.9	100	5.923	12.905	12.888	41	89	88	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Okarito Lagoon	WCRC	7B	C.LAKE	-43.221	170.158	0	18664663	14	30243	60.07	3.6	100	96.035	209.231	226.899	51	110	120	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Saltwater Lagoon	WCRC	7B	C.LAKE	-43.099	170.330	0	7538565	4	2066	2.87	30.4	100	5.745	12.516	12.451	63	138	138	6.6	15.1	15.0	A	A	A	B	C	D	B	C	D
Poerua River (Hikimutu Lagoon)	WCRC	6C	SSRTRE	-43.047	170.404	847270	1195083	0	25834	47.29	0.3	100	90.365	196.879	297.877	61	132	200	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Duffers Creek/Te Rahotaiepa River	WCRC	6D	C.LAKE	-42.992	170.583	0	192306	0	6576	9.50	0.2	100	14.649	31.915	34.726	49	106	116	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waitaha River	WCRC	6C	SSRTRE	-42.957	170.659	576737	778394	22	33749	81.94	0.1	100	184.068	401.030	499.217	71	155	193	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Mikonui River	WCRC	6C	SSRTRE	-42.901	170.765	145017	196813	18	15741	41.11	0.1	100	92.728	202.026	188.770	72	156	146	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Totara River	WCRC	6D	SSRTRE	-41.861	171.452	2577812	4445826	1	13544	23.88	1.1	50	37.412	81.509	132.698	11	59	93	0.0	0.0	0.0	A	A	B	A	A	A	A	A	A
Taramakau River	WCRC	6C	SSRTRE	-42.565	171.123	2136444	2873440	22	100592	157.96	0.2	100	423.577	922.849	901.560	85	185	181	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Saltwater Creek/New River	WCRC	6D	SSRTRE	-42.527	171.153	540852	963955	0	14605	15.12	0.6	79	36.963	80.532	110.848	10	135	185	0.0	0.0	0.0	A	B	B	A	A	A	A	A	A
Grey River	WCRC	6C	SSRTRE	-42.441	171.191	2040072	2040072	0	394696	343.37	0.1	100	844.728	1840.412	3164.845	78	170	292	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Deverys Creek	WCRC	4B	C.LAKE	-42.195	171.311	0	142735	0	710	0.81	2.0	100	1.574	3.430	12.042	62	135	473	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Punakaiki River	WCRC	4C	SSRTRE	-42.124	171.324	143197	250711	0	6301	7.76	0.4	100	16.004	34.868	36.041	65	142	147	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Pororari River	WCRC	6B	SSRTRE	-42.100	171.333	295821	403921	5	10409	12.07	0.4	100	30.982	67.500	74.418	81	177	195	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Waitakere River (Nile River)	WCRC	5C	SSRTRE	-41.897	171.443	175064	238869	0	12729	18.18	0.2	100	49.790	108.478	114.374	87	189	199	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Totara River	WCRC	6D	SSRTRE	-41.861	171.452	272601	367356	8	10888	12.94	0.3	100	43.542	94.866	105.753	107	233	259	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Okari Lagoon	WCRC	7A	SIDE	-41.812	171.454	2568110	3398574	71	7581	5.51	2.5	34	24.475	53.324	147.126	54	111	297	0.0	0.0	0.0	A	B	C	A	A	A	A	B	C
Buller River	WCRC	6B	SSRTRE	-41.729	171.588	5126165	5126165	11	642680	435.35	0.1	100	1141.070	2486.053	3160.198	83	181	230	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Orowaiti Lagoon	WCRC	7A	SIDE	-41.741	171.660	3453038	4519994	71	4736	3.73	4.0	28	8.183	17.829	110.743	27	50	274	0.0	0.0	4.6	A	A	C	A	A	B	A	A	C
Jones Creek	WCRC	4E	C.LAKE	-41.681	171.771	0	59875	6	2041	2.73	0.3	100	6.308	13.744	34.754	73	160	404	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Mokihinui River	WCRC	6B	SSRTRE	-41.522	171.933	1160869	1526954	14	75138	89.70	0.2	100	240.724	524.466	525.979	85	185	186	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Ngakawau River	WCRC	6B	SSRTRE	-41.606	171.873	293982	387127	14	19730	28.24	0.2	100	102.165	222.587	214.590	115	250	241	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Little Wanganui River	WCRC	6B	SSRTRE	-41.390	172.056	976400	1248904	29	20992	14.30	0.6	59	48.095	104.784	142.262	13	141	190	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Karamea River	WCRC	7A	SSRTRE	-41.262	172.088	7809114	10378445	68	130750	124.57	0.6	61	380.240	828.430	864.486	18	132	137	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Oparara River	WCRC	7A	SSRTRE	-41.212	172.094	1701331	2468446	50	14441	13.62	1.0	48	35.382	77.086	113.409	10	90	130	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Heaphy River	WCRC	5A	SSRTRE	-40.988	172.102	298221	396497	3	29819	28.61	0.2	100	97.380	212.162	197.712	108	235	219	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Big River	TDC	5C	SSRTRE	-40.764	172.255	565975	810541	51	10971	13.13	0.5	72	59.790	130.264	100.870	10	229	178	0.0	0.0	0.0	A	C	B	A	A	A	A	C	B
Anaweka River	TDC	5C	SIDE	-40.750	172.285	995741	1282105	72	2958	2.87	1.9	37	10.278	22.392	21.621	46	96	93	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Turimawiwi River	TDC	3B	SSRTRE	-40.729	172.310	119681	148683	41	5701	5.37	0.3	100	19.369	42.200	45.676	114	249	270	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Anatori River	TDC	3B	SSRTRE	-40.701	172.363	253436	324039	25	7587	6.16	0.4	74	20.018	43.614	43.735	9	168	168	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Paturau River	TDC	6B	SSRTRE	-40.639	172.428	129184	170602	2	8931	5.97	0.3	100	20.509	44.684	45.349	109	237	241	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Whanganui Inlet	TDC	8	SIDE	-40.574	172.539	47196180	59628780	79	6915	2.81	11.3	5	15.321	33.380	36.388	15	25	26	0.0	0.7	0.9	A	A	A	A	A	A	A	A	A
Green Hills Stream	TDC	3C	DSDE	-40.504	172.650	465232	1168618	9	805	0.15	14.9	16	1.248	2.719	3.121	50	102	116	4.2	10.1	11.7	A	B	B	A	C	C	A	C	C
Port Puponga	TDC	7A	SIDE	-40.527	172.737	751378	993507	58	519	0.09	10.5	9	0.773	1.685	2.273	30	57	74	1.1	4.1	6.0	A	A	A	A	B	B	A	A	A
Pakawau Inlet	TDC	7A	SIDE	-40.586	172.686	1365591	1379385	100	943	0.24	7.4	11	1.648	3.590	4.752	32	61	78	0.0	2.7	4.6	A	A	A	A	A	B	A	A	A
Waikato Estuary	TDC	7A	SIDE	-40.630	172.679	378435	382257	100	237	0.08	6.8	13	0.501	1.091	1.291	33	62	72	0.0	2.2	3.3	A	A	A	A	A	B	A	A	A

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Ruataniwha Inlet	TDC	7A	SIDE	-40.670	172.684	13502253	15028893	88	71518	73.39	1.0	43	258.065	562.247	721.178	53	110	139	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Parapara Inlet	TDC	7A	SIDE	-40.715	172.690	3603422	3899560	92	4336	2.25	4.6	23	8.931	19.458	20.297	37	71	74	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Onahau River	TDC	7A	SIDE	-40.798	172.773	660161	685996	96	2167	0.56	3.7	26	3.634	7.917	31.959	63	126	483	0.0	0.0	10.0	A	B	D	A	A	C	A	B	D
Takaka River	TDC	5B	SSRTRE	-40.816	172.800	858318	1089762	5	87206	53.35	0.2	100	201.064	438.058	583.925	120	260	347	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Takaka Estuary	TDC	7A	SIDE	-40.821	172.812	1838124	2421804	60	410	0.10	11.9	4	0.553	1.205	9.604	19	28	142	0.2	1.2	14.1	A	A	B	A	A	D	A	A	B
Motupipi River	TDC	7A	SIDE	-40.833	172.848	2565294	2988676	82	4080	1.03	6.3	19	5.895	12.843	43.450	44	84	260	0.0	3.7	23.7	A	B	C	A	A	D	A	B	C
Ligar Bay	TDC	7A	SIDE	-40.819	172.903	943945	1280300	53	407	0.09	11.4	7	0.517	1.126	1.248	25	40	43	0.7	2.4	2.8	A	A	A	A	A	A	A	A	A
Wainui Inlet	TDC	7A	SIDE	-40.812	172.942	3819984	4444235	83	4099	1.20	6.9	16	6.506	14.175	17.265	39	72	85	0.0	3.4	5.0	A	A	B	A	A	B	A	A	B
Totaranui Stream	TDC	7A	SIDE	-40.822	173.016	232247	232910	100	884	0.23	3.3	27	1.307	2.847	2.992	60	119	125	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Awaroa Inlet	TDC	7A	SIDE	-40.852	173.033	4175182	4258318	98	6666	2.11	4.9	21	9.263	20.182	20.356	40	75	75	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Bark Bay	TDC	7A	SIDE	-40.920	173.059	1567546	1988990	26	692	0.21	9.9	9	0.991	2.158	2.158	27	43	43	0.5	2.3	2.3	A	A	A	A	A	A	A	A	A
Sandfly Bay	TDC	7A	SIDE	-40.928	173.057	147098	169163	85	2146	0.70	1.2	41	2.817	6.138	6.138	62	124	124	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Frenchman Bay	TDC	7A	SIDE	-40.937	173.058	99022	108745	91	130	0.04	5.8	19	0.157	0.341	0.341	35	62	62	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Torrent Bay	TDC	7A	SIDE	-40.945	173.063	4999772	7062550	28	1510	0.49	11.8	7	1.794	3.909	3.899	22	32	32	0.5	1.6	1.6	A	A	A	A	A	A	A	A	A
Marahau River	TDC	7A	SIDE	-40.995	173.012	347155	350662	100	2749	0.95	1.6	36	3.629	7.907	9.599	54	106	126	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Otuwhero Inlet	TDC	7A	SIDE	-41.011	173.013	2016584	2479236	74	5800	2.10	3.8	28	9.040	19.695	18.037	49	94	87	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Kaiteretere Estuary	TDC	7A	SIDE	-41.041	173.020	347700	388111	88	379	0.09	7.1	15	0.417	0.908	1.174	34	59	72	0.0	2.1	3.6	A	A	A	A	A	B	A	A	A
Ferrer Creek	TDC	6C	SIDE	-41.070	173.007	390236	413107	94	1435	0.40	3.3	28	1.570	3.422	26.427	46	87	597	0.0	0.0	0.0	A	B	D	A	A	A	A	B	D
Motueka River	TDC	5B	SSRTRE	-41.082	173.023	1075640	1372982	1	206082	63.09	0.3	100	262.345	571.573	747.414	132	287	376	0.0	0.0	0.0	A	A	A	A	A	A	A	A	A
Motueka Estuary North	TDC	7A	SIDE	-41.104	173.032	955470	1108643	83	112	0.02	11.1	2	0.124	0.270	1.017	19	23	43	0.0	0.4	2.8	A	A	A	A	A	A	A	A	A
Motueka Estuary South	TDC	7A	SIDE	-41.129	173.029	3363777	3971053	80	163	0.03	11.7	1	0.159	0.347	2.370	17	19	35	0.0	0.1	1.9	A	A	A	A	A	A	A	A	A
Moutere Inlet	TDC	8	SIDE	-41.157	173.040	17558583	23218843	59	18622	2.20	10.5	9	20.759	45.227	156.118	40	71	208	2.2	5.6	21.2	A	A	C	A	B	D	A	A	C
Waimea Inlet	TDC	8	SIDE	-41.287	173.197	75693684	99818432	59	91549	21.66	8.2	15	105.603	230.078	368.272	38	66	97	0.8	3.9	7.5	A	A	B	A	A	B	A	A	B
Tahunanui Estuary	NCC	7A	SIDE	-41.284	173.222	563047	777752	47	326	0.06	11.4	7	0.380	0.828	2.073	31	49	99	1.4	3.4	9.1	A	A	B	A	B	C	A	A	B
Nelson Haven	NCC	7A	SIDE	-41.267	173.258	30800259	37895215	66	10627	3.18	10.1	7	12.749	27.776	31.790	25	36	39	0.3	1.6	1.9	A	A	A	A	A	A	A	A	A
Delaware Estuary	NCC	7A	SIDE	-41.161	173.441	5835251	6270285	93	8029	2.28	5.8	18	9.055	19.728	19.264	37	64	63	0.0	0.5	0.4	A	A	A	A	A	A	A	A	A
Whangamoa River	NCC	7A	SIDE	-41.101	173.529	902338	1102327	76	9467	2.79	1.7	37	11.071	24.121	24.012	58	114	113	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B
Croisilles Harbour	MDC	9	DSDE	-41.044	173.633	148516116	542110837	4	6820	1.95	36.0	1	8.136	17.727	17.845	18	20	20	1.6	1.8	1.8	A	A	A	A	A	A	A	A	A
Manuhakapakapa Bay	MDC	11	DSDE	-40.904	173.779	11199557	38963827	1	1013	0.29	33.3	2	1.076	2.344	2.669	18	21	22	1.5	1.8	1.9	A	A	A	A	A	A	A	A	A
Greville Harbour	MDC	11	DSDE	-40.825	173.789	37948037	128671344	1	4361	1.11	32.3	2	4.400	9.586	10.729	18	21	22	1.4	1.8	1.9	A	A	A	A	A	A	A	A	A
Otu Bay	MDC	11	DSDE	-40.755	173.836	3383235	9254589	1	1152	0.28	23.4	6	1.147	2.498	2.550	22	31	31	1.6	2.7	2.7	A	A	A	A	A	A	A	A	A
Port Hardy	MDC	9	DSDE	-40.730	173.903	78258581	493577463	0	3017	0.77	62.6	1	3.152	6.867	6.619	15	17	17	1.5	1.6	1.6	A	A	A	A	A	A	A	A	A
Catherine Cove	MDC	11	DSDE	-40.878	173.887	9603071	97906969	0	720	0.18	99.2	2	0.728	1.586	1.584	18	20	20	1.8	2.1	2.1	A	A	A	A	A	A	A	A	A
Admiralty Bay	MDC	11	DSDE	-40.945	173.869	39831357	603705437	0	859	0.27	14.9	0	1.027	2.238	2.708	17	17	17	0.4	0.4	0.4	A	A	A	A	A	A	A	A	A
Pelorous/Kenepuru Sound	MDC	9	DSDE	-40.945	174.086	932042778	11325992741	3	159073	65.44	107	5	215.995	470.590	572.708	21	28	30	2.2	3.0	3.3	A	A	A	A	A	B	A	A	B
Port Gore	MDC	11	DSDE	-40.992	174.272	98899835	1428727491	0	2168	0.84	13.3	0	2.632	5.734	6.363	16	16	16	0.1	0.1	0.1	A	A	A	A	A	A	A	A	A
Queen Charlotte Sound (Totaranui)	MDC	9	DSDE	-41.047	174.353	455510181	9614466079	1	25741	10.18	15.3	0	31.408	68.429	75.732	16	16	16	0.4	0.4	0.4	A	A	A	A	A	A	A	A	A

Estuary	Regional Council	NZCHS code	ETI class	LAT (WGS84)	LON (WGS84)	Tidal prism spring tide (m^3)	Volume spring tide (m3)	Intertidal area (%)	Catchment Area (ha)	Mean freshwater inflow (m^3/s)	Flushing time (days)	Freshwater fraction (%)	TN load (T/yr)			Estuary TN Concentration (mg/m^3)			chl-a (µg/l)			Macroalgae Band			Phytoplankton Band			ETI Susceptibility Band		
													Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current	Pristine	Pre-human	Current
Onekaka Inlet	TDC	7A	SIDE	-40.747	172.712	365553	401345	90	1734	0.77	2.1	34	2.766	6.026	12.660	46	92	186	0.0	0.0	0.0	A	B	B	A	A	A	A	B	B