SedNetNZ, SLUI and contaminant generation
Part 2 Nitrogen, phosphorus and *E. coli*

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Part 2 Nitrogen, phosphorus and *E. coli*

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Summary

Project and Client

- Horizons Regional Council (HRC) requested Manaaki Whenua – Landcare Research (MWLR) to update SedNetNZ for the HRC region and use the results to assess the impact of the Sustainable Land Use Initiative (SLUI) on phosphorus (P), nitrogen (N) and *E. coli* loads in the region's rivers.

Objectives

- Extend the prediction of outcomes from SLUI to include reduction in P, N and *E. coli* loads in rivers.
- Report the results of the analysis.

Methods

- State of Environment water sampling conducted by HRC was used to estimate the fraction of sediment that is particulate P, which dominates the P load of rivers (95%). This fraction was used with reductions of sediment loads due to farm plan implementation modelled by SedNetNZ to predict reductions in total P loads as a result of SLUI. Two scenarios were analysed: scenario 0: SLUI stops at the current level of implementation, with no new farm plans from 2018 onwards; scenario 3: 35,000 ha of new plans per year, afforestation is not constrained.
- SLUI reduces N and *E. coli* loads due to stock exclusion by fencing. Both baseline fencing (i.e. not associated with SLUI) and SLUI works fencing were calculated for each water management zone (WMZ) or subzone (WMSZ). The total length of streams within each REC2 watershed in the HRC region was calculated using the LINZ river lines. The stock exclusion baseline was calculated using results of the Survey of Rural Decision Makers for the Manawatu region. The SLUI works database was used to estimate the total length of streams where stock have been excluded by SLUI works.
- The effect of SLUI in reducing nitrogen loads in rivers was assessed using the 'access to streams' component of the Overseer® nutrient budget model along with estimates of current fencing. Spatial Overseer® nutrient budget modelling was undertaken by a) parameterising Overseer® nutrient budgets from spatial data for individual farms, and b) preparing a single Overseer® basefile to represent the farming system characteristic of a low-to-medium intensity hill- and steep-land sheep and beef farming property. Spatial Overseer® nutrient budgets were prepared for 492 of 696 SLUI farms and used to estimate the reduction in N loss due to stock exclusion. In addition to stock exclusion measures, the impact of SLUI afforestation and land retirement was assessed using average N-loss for these land uses calculated using Overseer® and the area converted to these uses.
- For each WMSZ with an associated *E. coli* measurement site the measured median value of *E. coli* was reduced according to the current level of baseline and SLUI works fencing, the proportion of different land uses within each WMSZ, and *E. coli* load reduction factors for the lower North Island (0.62 for dairy cattle and deer, 0.44 for

sheep and beef farms). An estimate of the maximum reduction achievable through total stock exclusion on median *E. coli* concentrations was also made.

Results

Phosphorus

- The percentage reduction in P load is proportional to the number and area of farm plans implemented per WMZ.
- By 2018, the estimated greatest reductions in total phosphorus loads due to SLUI are in the East Coast (–19%), Kai Iwi (–19%), and Lower Rangitikei (–18%) WMZs. Most WMZs have total phosphorus load reductions of <10%, and there is a reduction of 6% across all WMZs.
- By 2043 for scenario 0 it is predicted the greatest reduction in total phosphorus load will be in the East Coast (–43%) and Tiraumea (–42%) WMZs, whereas for scenario 3, the greatest reduction will be in Middle Whangaehu (–62%) and Owahanga (–58%) WMZs. Under both scenarios many water management zones will have reductions in P load of 30 to >50%.

Nitrogen

- The N loading differences between full and nil access to streams for SLUI farms was small, equating to only 0.77% of the total load for N.
- For the 696 SLUI farms, SLUI stock exclusion measures are predicted to have reduced nitrogen loads by 0.06% while baseline stock exclusion measures have reduced N-loss by 0.15% (a total of 0.22%).
- The reduction in N loading due to current stock exclusion is greatest in the coastal Whangaehu (–3.93%), Coastal Manawatu (–1.49%), and Kaitoke Lakes (–1.13%) WMZs. If stock were 100% excluded these WMZs would still have the greatest reduction in N loading.
- The impact of afforestation and land retirement on reducing N loads is significantly greater than stock exclusion measures. SLUI stock exclusion measures have reduced nitrogen loads by 3.7 tonnes a^{-1} (–0.06%), whereas afforestation and land retirement have reduced nitrogen loads by 145.5 t a^{-1} and 69.6 t a^{-1} respectively (–3.7%).

E. coli

- Median *E. coli* values at HRC measurement sites range from 4.5 to 735.0 MPN with a median of 166.5 MPN.
- The average reduction in median *E. coli* values as a result of SLUI fencing to date in WMSZs with an associated *E. coli* measurement sites predicted to be 2.6%. Retaruke, Paetawa, and Upper Pohangina WMSZs all have reductions greater than 10% due to SLUI works.
- When combined with baseline fencing, the average reduction in median *E. coli* values is 12.8%, with greatest reductions in the upper and lower Kumeti WMSZs.
- The reduction in median *E. coli* values that could be achieved if all streams were fenced is 34.4%, with most WMSZs having potential reductions >30%.

Conclusions

- The percentage reduction in total P load to date due to SLUI is proportional to the number and area of farm plans implemented per WMZ, with a reduction of 6% across all WMZs. Most WMZs are predicted to have total phosphorus load reductions of <10%, with the greatest load reductions in the East Coast, Kai Iwi, and Lower Rangitikei WMZs. However, by 2043, under both scenarios (0 and 3), many WMZS are predicted to have reductions in P load of 30 to >50%.
- Fencing under SLUI has made very little difference to N loading to streams (<0.1%) and even with complete stock exclusion on SLUI farms there would only be a reduction of <1%. Afforestation and land retirement have achieved larger reductions to N load (–3.7%).
- The average reduction in median *E. coli* values as a result of SLUI fencing to date in WMSZs with an associated *E. coli* measurement sites is 2.6%. However, if all streams were fenced then median *E. coli* values cold be reduced by 34%.

1 Introduction

Horizons Regional Council (HRC) requested Manaaki Whenua – Landcare Research (MWLR) to document the use of SedNetNZ in the Horizons region, including an updated assessment of the impact of soil conservation work to date and possible future work under the Sustainable Land Use Initiative (SLUI) on sediment load, a reassessment of the impact of climate change on sediment loads using updated climate change scenarios for Horizons region, and an assessment of the impact of SLUI on phosphorus (P), nitrogen (N) and *E. coli* loads in rivers.

The specific work components requested were:

1. Document the history of SedNetNZ development and the various versions and calibrations that have been used in the Horizons region, including consideration of the two versions that have been used (catchment-scale and farm-scale) and in what circumstances they are appropriate for use and how accurate they are likely to be.
2. Update the SedNetNZ model with the latest information on soil conservation works completed and new farm plans that are part of the SLUI programme and run the model to predict sediment outcomes based on SLUI work to date and for scenarios of future implementation.
3. Rerun the analysis of impacts of climate change on sediment loads using climate change scenarios from NIWAs IPCC5 downscaled climate change scenarios for Horizons region.
4. Use SedNetNZ estimates of changes in sediment load with the methodology of Dymond et al. (2016) to predict the outcome of changes in sediment load on water clarity.
5. Extend the prediction of the outcomes from SLUI to include reduction in phosphorus, nitrogen and *E. coli* loads in rivers.

This report documents work completed for component 5. Components 1 to 4 were reported by Basher et al. (2018)

2 Background

The Sustainable Land Use Initiative was the HRC response to the widespread erosion that occurred in a severe storm in February 2004 (see Manderson et al. 2013). It aims to repair and reduce hill country erosion in key catchments within the HRC region using a coordinated approach to target high priority Highly Erodible Land through a mix of whole farm plan development and implementation, incentives to offset costs of changing farming practices, as well as monitoring to assess progress towards SLUI goals. The programme began in 2006 and has resulted in significant changes of land use and land management. These have reduced erosion and sediment load into rivers in the HRC region, but the measures implemented as part of SLUI (spaced-tree planting, afforestation, land retirement, stream fencing) also have the potential to reduce loads of N, P, and *E. coli*. The work reported here will help assess progress towards SLUI goals by using results from the latest SedNetNZ modelling of sediment loads (Basher et al. 2018) that incorporates the effects of SLUI to analyse how this has affected loads of N, P, and *E. coli*. Parfitt et al. (2013) showed that the annual loss of P in part of the Manawatu River was dominated by P in suspended sediment (95% of the P flux). Therefore, reduction in sediment load as a result of SLUI works implementation will reduce the load of particulate P in rivers. The main effect SLUI has on N loads is due to stock exclusion by fencing from rivers, forestry blocks, and retired areas. There may also be an effect from changes in stocking rate attributable to SLUI that affects N loads. Similarly, the main effect that SLUI has on *E. coli* loads is due to stock exclusion from rivers by fencing. In fenced areas *E. coli* loads are reduced by up to 50% by reducing both direct *E. coli* input to rivers and from input via overland flow (Dymond et al. 2016).

Some of these effects have also been investigated by Snelder (2018), who used analysis of measured sediment and *E. coli* data to determine whether there were discernible trends between land management interventions as part of SLUI and water quality trends for sediment and *E. coli*. This showed weak but significant associations between trends in water quality variables for sediment (clarity, turbidity, suspended sediment concentration) and *E. coli* and the proportion of catchments with farm plans implemented under SLUI or other land management initiatives (riparian planting and fencing).

3 Objectives

- Extend the prediction of outcomes from SLUI to include reduction in phosphorus, nitrogen and *E. coli* loads in rivers.
- Report the results of the analysis.

4 Methods

4.1 Effect of SLUI on reduction in phosphorus loads in rivers

Parfitt et al. (2013) estimated that 95% of the total P load in the Manawatu River is due to particulate phosphorus in sediment. Other rivers in the Horizons region draining the Ruahine and Tararua ranges are likely to have similar proportions. Total *P* loads in rivers may then be estimated as a given fraction of the sediment load. This fraction is the average proportion of sediment that is particulate P. Parfitt et al. (2013) measured this fraction during 6 flood events of the Manawatu river to be 0.05% (i.e. 545 mg kg^{-1} from Table 4 of Parfitt et al. 2013). This fraction is also within the range of phosphate contents of sandstone, mudstone, and greywacke rocks in the Wairarapa as directly measured by Eden and Parfitt (1992).

The fraction of sediment that is particulate P may be estimated from the state of environment sampling conducted by Horizons Regional Council as follows. Total phosphorus in water (*TP*) is the summation of dissolved organic phosphorus (*DOP*), dissolved reactive phosphorus (*DRP*), particulate organic phosphorus (*POP*), and particulate inorganic phosphorus (*PIP*), that is:

$$TP = DOP + DRP + POP + PIP \quad (1)$$

and the particulate phosphorus ($POP + PIP$) is then given by

$$POP + PIP = TP - DOP - DRP \quad (2)$$

TP and DRP are measured in the state of environment sampling; however, DOP is not. Parfitt et al. (2013) showed that in the Manawatu river DOP is approximately one half DRP, therefore we can estimate particulate phosphorus as

$$POP + PIP = TP - 1.5 \times DRP \quad (3)$$

When $POP + PIP$ is plotted versus suspended sediment concentration (SSC) at a state of environment sampling site, $POP + PIP$ will decrease with SSC down to an asymptote (see Fig. 1 for an example for the Mangatainoka River). At this asymptote, the sediment is predominantly derived from primary sources (hills and mountains) and the $POP + PIP$ as a fraction of the SSC is the fraction we are seeking. We have examined several rivers to create relationships as displayed in Figure 1 in the Horizons region, and found that the fraction is consistently 0.05%, and therefore the total P loads for rivers are 0.05% of the sediment loads. Hence any reductions of sediment loads due to farm plan implementation (Basher et al. 2018) will produce the same relative reductions in total P loads. The modelled reductions are based entirely on SLUI works and do not account for other mitigating works achieved through other grants, private initiatives or land use change.

Predictions were made of the change in total P load between 2004 and 2043 for two scenarios of SLUI implementation (see Appendix 1):

- scenario 0: SLUI stops at the current level of implementation, with no new farm plans from 2018 onwards
- scenario 3: 35,000 ha of new plans per year; afforestation is not constrained

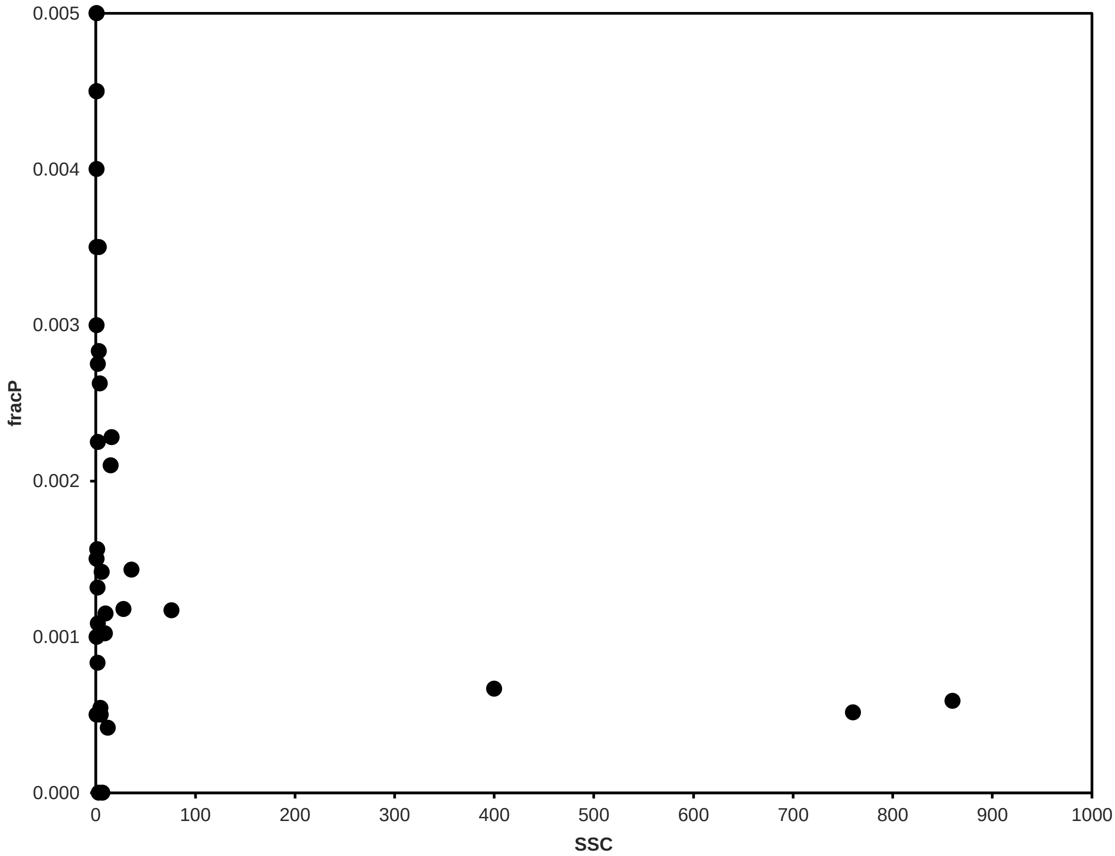

Figure 1: Example plot of relationship between *POP+ PIP* as a fraction of *SSC* at Mangatainoka at SH2 Bridge gauging site.

4.2 Effect of SLUI on reduction in nitrogen loads in rivers

The effect of SLUI in reducing nitrogen loads in rivers was assessed using the 'access to streams' component of the Overseer® nutrient budget model along with estimates of current fencing (see section 4.3). Spatial Overseer® nutrient budget modelling was undertaken by a) characterising the farm environment for individual farms, and b) preparing a single Overseer® basefile to represent the farming system characteristic of a low-to-medium intensity hill- and steep-land sheep and beef farming property.

In addition to stock exclusion measures, the impact of SLUI afforestation and land retirement was assessed, assuming the land use change was from pasture to exotic forests (SLUI job type 1) or native bush (SLUI job type 2). Average N-loss for these three different land uses was calculated based on the results of the Overseer® nutrient budget model.

Overseer® modelling at the farm block level was applied to 492 of the 696 SLUI farms. Reliable data was not available for the remaining farms. We consider this high number of individually modelled farms will provide representative averages and statistics pertinent to all SLUI farms. Overseer® nutrient budgets were parameterised from spatial data for each farm. Farm stock units were taken from Agribase (2016 version), with livestock numbers differentiated into beef (including dairy grazers), sheep, and deer stock units using ratios calculated from Agricultural Production Survey (APS) data (2012) at the district scale. Boundary discrepancies between SLUI and Agribase data were accommodated by converting stock units to a per hectare basis, intersecting the two datasets, and then recalculating and summing stocking rate per polygon area to whole farm estimates. Stocking rate calculations were based on effective grassland area calculated via overlay with the Land Cover Database (LCDB4) 2012 land cover. The average percent of male beef cattle for all farms was estimated from APS data (47%), while wool production was estimated using B+LNZ wool/sheep stock unit (ssu) averages for hill country farms (5.5 kg ssu^{-1} a^{-1}).

Blocks were created by overlaying SLUI farm boundaries firstly with LCDB4 (reclassed as 'grassland' and 'trees and scrub'), then merged to form a maximum of two blocks per farm (i.e. grassland + trees & scrub). Grassland was further overlaid with LUC dissolved at the LUC class level to provide grassland blocks. Blocks less than 2 ha were dissolved into neighbouring larger blocks, first by boundary length and then by area (to capture all possible small polygon configurations). The number of blocks was scaled to 10 per farm (including one block of trees and scrub) using manual editing and optimisation routines.

Blocks were populated with spatial data for Overseer® modelling: Slope classes were aggregated from New Zealand Land Resource Inventory (NZLRI) data; distance from coast was determined using Euclidian distance, relative yield was estimated from LUC carrying capacities from the NZLRI (converted to pasture yields then to percent of whole farm production); block rainfall, potential evapotranspiration (PET), temperature were calculated from NIWA data layers (that were specifically created for use in Overseer®); PET and rainfall variability were determined by georeferencing Overseer® maps within a spatial framework; and soils and their properties were taken from the Fundamental Soils Layer (FSL) database (Order, Overseer® (Ovr) soil group, texture, Ovr texture group, drainage). All parameterisation data was formatted to Overseer® conventions, and exported as a csv file for batch processing.

A single Overseer® basefile was constructed to reflect a low-to-medium intensity hill- and steep-land sheep and beef farming property. The basefile farm was populated with ten nutrient management blocks. Overseer® 'access to streams' was set to FALSE for pastoral blocks. A replicate file of the basefile was generated, and all pastoral block 'access to streams' was set to TRUE. According to the Overseer® Best Practice guidelines, "if cattle have access to streams they will excrete nutrients into the waterways and this is taken into account in the nutrient budget". This means the 'access to streams' dialogue only accounts for direct contributions by cattle, and does not consider possible contributions from runoff, nor sheep and deer. Current levels of stock exclusion from streams were estimated for each farm based on the methodology described in section 4.3 and used to estimate the impact of SLUI stock exclusion measures on N loads.

Batch modelling was performed across 492 farms, and results were collated and summarised.

4.3 Effect of SLUI on reduction in *E. coli* loads in rivers

Where cattle have access to waterways, they will defecate approximately 10% of their total faeces production directly into the water since they have a natural inclination to stand in water (Bagshaw 2002). The effectiveness of fencing to prevent *E. coli* from pastoral land uses reaching freshwater channels has previously been assessed by Muirhead et al. (2016) and Dymond et al. (2016), and modelled by Semadeni-Davies et al. (2017), with the effectiveness ranging from 35% to 62% reduction. For this study, the results of Muirhead et al. (2016) for the lower North Island are used to estimate the impact of restricting stock access to waterways, referred to as *E. coli* load reduction factors (LRF). Assessing the effect of SLUI on reduction in *E. coli* loads requires calculation of total stream length within each REC2 watershed, assessment of the effect of stock exclusion not related to SLUI, and assessment of the effect of stock exclusion related to SLUI. This was used to reduce measured *E. coli* loads using the LRFs.

4.3.1 Calculation of total stream length per REC watershed

To assess the impact of SLUI works in restricting access of cattle to waterways, the total length of streams within each REC2 watershed in the Horizons Region was calculated using the LINZ river lines, since the length of REC streams derived from DEM analysis is not a reliable measure.

For the calculation of river length, only grassland areas (“Low producing grassland”, “High producing exotic grassland”) were selected from LCDB 2008 and 2012 (maximum extent), as this is likely where cattle are grazing or were in the past. These land cover classes were buffered by 30 m to allow for inaccuracy of mapping (both stream lines, works, and LCDB polygons) and to include all streams located in close proximity to grasslands. Within these buffered areas, the total length of LINZ rivers was calculated per REC2 watershed (to derive the river length from LINZ river polygons, the perimeter was multiplied by 0.5).

4.3.2 Calculation of stock exclusion baseline

The calculation of stock exclusion measures other than those implemented through SLUI is a prerequisite to evaluate the impact of SLUI stock exclusion measures on reducing *E. coli* concentrations in rivers. The following method was used to calculate the baseline of stock exclusion from streams on farms.

The results of the Survey of Rural Decision Makers (SRDM – Brown 2017) for the Manawatu region were used to inform the percentage of farms with practices in place to restrict stock from major and minor streams. In the Manawatu-Whanganui area, 180 farmers were surveyed. These farmers were further queried on what proportions of streams have stock exclusion measures implemented. Of the 180 farmers surveyed, 52% had some fencing on major streams, whereas only 31% had some fencing of minor streams. Table 1 lists the percentage of streams fenced within the different stock classes. The result of the survey was used to estimate the baseline fencing so that the impact of SLUI works could be more precisely determined. It is possible that one or more SLUI farms were included in the SRDM. However, due to the number of farms surveyed, we assume that if SLUI farms were included, the results would not significantly skew the estimation of the baseline fencing.

Table 1: Percentage of streams fenced per land use class in the Manawatu-Whanganui region (Brown 2017)

Land use class	Major stream (%)	Minor stream (%)
Grazing livestock not owned by the farm	61.8	32.9
Farming sheep	30.4	4.8
Farming beef	36.9	23.4
Farming sheep & beef	17.7	3.4
Dairying	73.5	60.8

In line with the Sustainable Dairying Water Accord, the SRDM distinguishes between major and minor streams. Major and minor streams were identified using a model relating mean annual flow to width by NIWA using the River Environment Classification (REC, Version 2). Major waterways meet the definition of Accord waterways of >1 metre wide, >30 centimetres deep, and permanently flowing. Minor streams are any REC stream smaller than that.

MPI land use data associated with REC2 were used to identify the proportion of land uses within areas of pasture, grouped into three classes: 1) Dairy, 2) Sheep, beef, deer, and other animals, and 3) other (e.g. arable land). These data were related to the results of the SRDM survey to provide an estimation of the proportion of streams fenced independent of SLUI.

4.3.3 Calculation of stock exclusion resulting from SLUI works

From the SLUI works database, all job types 1–5 were selected, with the exception of a number of subtypes that do not result in stock exclusion:

- Job_type 1: afforestation
- Job_types 2–5: different forms of retirement with a lot of crossover in these types of works:
  - 2 retirement
  - 3 riparian retirement
  - 4 wetland retirement
  - 5 managed retirement

Within job_types 1–5 (stock exclusion), the following subtypes, which do not result in stock exclusion and are therefore excluded from the analysis, are: other works; poplars/willows; protected area and other.

These works were again buffered by 30 m and the length of all river lines within these polygons summed, resulting in the total length of LINZ river lines where SLUI works have excluded stock.

To include the LINZ river polygons in the analysis, the method was reversed in that all SLUI works within 50 m distance to LINZ river polygons were selected. These works polygons were buffered by 100 m, and the LINZ river polygons extracted from within these buffered works polygons. The perimeter of resulting river polygons was multiplied by 0.5 to approximate the length of river fenced. The sum of these lengths is an estimation of the total length of LINZ river polygon areas where stock have been excluded by SLUI works.

4.3.4 Impact of SLUI stock exclusion on *E. coli* loads

To calculate the reduction in median *E. coli* concentrations for each water management subzone (WMSZ) it is necessary to know the proportion of streams fenced and the land use within each subzone. The calculation of stock exclusion is explained in section 4.3.1 and is derived as:

- the estimated baseline fencing derived from SRDM and MPI land use data
- the length of streams/rivers fenced through SLUI calculated by dividing the length of SLUI fencing by the total length of unfenced streams/rivers within grasslands (i.e. total length of streams minus the estimated length of baseline fences)

Median *E. coli* concentrations were calculated based on the data obtained at HRC measurement sites. Data for 49 measurement sites were provided by Horizons Regional Council and used to characterise the WMSZs upstream of the sites (49 of 124 WMSZs). Of these 30 sites have SLUI farms in the upstream area. Monthly measurements of *E. coli* dating back to 1989 (the period varies from site to site) were used to calculate the median values. Reductions to the median values were made according to the proportion of land uses within each WMSZ associated with the respective measurement sites using the "most likely" *E. coli* load reduction factors (LRF) for the lower North Island from Muirhead (2016):

- Load reduction factor for fencing dairy cattle and deer: 0.62
- Load reduction factor for fencing beef cattle only on sheep and beef farms: 0.44

In addition to approximating the impact of SLUI works on *E. coli* loads where possible (restricted due to the limited number of measurement sites), the maximum reduction possible was calculated for each WMSZ using the estimates of current stock access and total stock exclusion along with *E. coli* load reduction factors for different land uses to estimate the additional percentage reduction in *E. coli* load that could be achieved if all streams were fenced. This provides an estimation of the maximum effectiveness achievable through total stock exclusion.

4.3.5 Assumptions

The method relies on LCDB for accurately mapping areas of pasture. The analysis does not consider stock numbers, but relies on the assumption that cattle are evenly distributed through areas of grassland and contributing to existing *E. coli* concentrations at equal rates. The evaluation of SLUI relies on the estimation of baseline fencing, and therefore assumes that the SRDM are a valid representation of existing fences independent of SLUI. It also assumes that the fencing data derived from the SRDM represents streams that are fenced on both banks. The load reduction factors by Muirhead (2016) are also only an approximation used here to provide an estimate of the impact of SLUI on *E. coli* loads.

5 Effect of SLUI on reduction in phosphorus loads in rivers

The phosphorus load reductions modelled by SedNetNZ incorporating SLUI works for the two different scenarios 0 and 3[1] for phosphorus reductions to 2043 are given in Table 2 and Appendix 1. Figure 2 maps the percentage reduction in total phosphorus loads achieved by 2043 by scenarios 0 and 3 for each water management zone (WMZ) in the Horizons region. The percentage reduction is proportional to the number and area of farm plans implemented per WMZ. By 2018, SLUI has achieved greatest impact in reducing estimated total phosphorus loads in the East Coast (–19%), Kai Iwi (–19%), and Lower Rangitikei (–18%) WMZs. Most WMZs have total phosphorus load reductions of <10%. Across all WMZS the reduction is 6%. For scenario 0, by 2043 the greatest reduction achieved is in the East Coast (–43%) and Tiraumea (–42%) WMZs and the load reduction across all WMZs is 16%. For scenario 3, the greatest reduction is in the Middle Whangaehu (–62%) and Owahanga (–58%) WMZs and the load reduction is 30% across all WMZs.

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[1] Scenario 0 – SLUI stops at the current level of implementation, with no new farm plans from 2018 onwards. Scenario 3 – 35,000 ha of new plans per year; afforestation is not constrained

Table 2: Modelled percentage reductions in phosphorus loads by 2018 due to SLUI farm plan implementation and predicted reductions by 2043 for Scenarios 0 and 3 for water-management zones in the Horizons region

		By 2043	
Water management zone	**By 2018**	**Scenario 0**	**Scenario 3**
Akitio	–11	–28	–50
Cherry Grove	–2	–5	–16
Coastal Rangitikei	–4	–14	–26
East Coast	–19	–43	–57
Kai Iwi	–19	–35	–54
Lower Rangitikei	–18	–38	–51
Lower Whangaehu	–14	–34	–55
Lower Whanganui	–7	–16	–27
Manawatu Hopelands to Tiraumea Confluence	–4	–11	–32
Manawatu Tamaki Confluence to Hopelands	–5	–27	–40
Manawatu Weber Road to Tamaki Confluence	–5	–12	–25
Mangatainoka	–1	–5	–8
Middle Manawatu	–13	–31	–46
Middle Rangitikei	–3	–8	–20
Middle Whangaehu	–8	–33	–62
Middle Whanganui	–4	–9	–49
Mowhanau	–7	–11	–15
Northern Coastal	–3	–6	–40
Oroua	–10	–21	–37
Owahanga	–13	–34	–58
Paetawa	–7	–18	–35
Pipiriki	–2	–5	–23
Te Maire	–1	–13	–42
Tiraumea	–13	–42	–55
Turakina	–13	–30	–51
Upper Gorge	–1	–2	–2
Upper Manawatu	–3	–14	–33

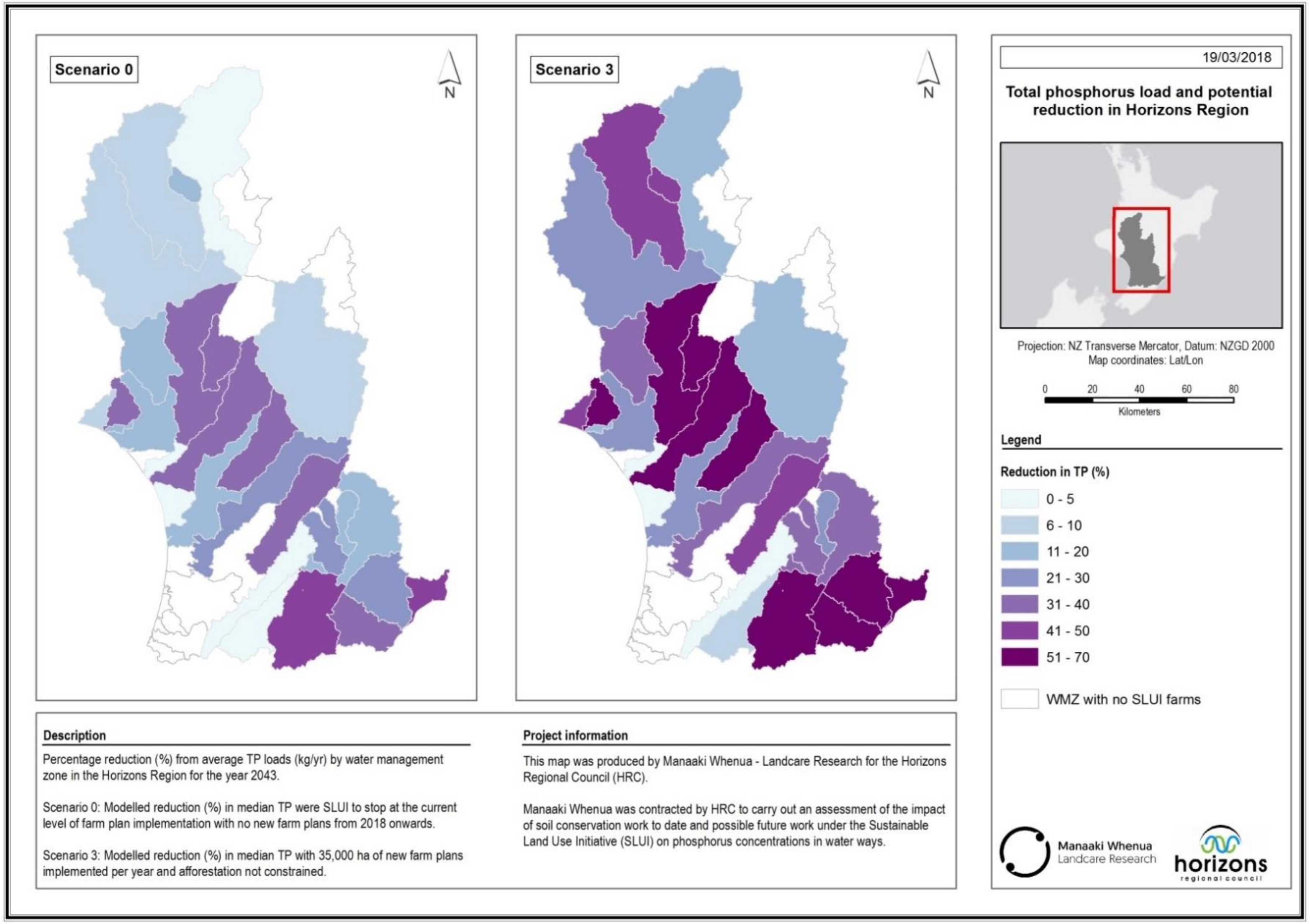

Figure 2: **Reduction of total phosphorus loads for SLUI scenarios 0 and 3 in the water management zones of Horizons region.**

6 Effect of SLUI on reduction in nitrogen loads in rivers

Average farm N-loss was 11.8 kg ha^{-1} a^{-1}, which aligns with hill country sheep and beef averages from other studies. Likewise, the range was similar to Overseer® benchmark values for sheep and beef farms (5–20 kg N ha^{-1} a^{-1}).

The N loading difference predicted between full and nil access to streams was small (see Table 3), equating to less than 1%. Total differences for the 492 farms was 31 tonnes N a^{-1}. Extrapolating these representative results to all 696 farms results in total differences of 45.2 tonnes N a^{-1} (Table 3).

The actual reduction of N-loss must therefore lie between the two loads modelled with nil and full stock access to streams. Section 4.3 outlines how the baseline of stock exclusion was estimated to work out what the impact of SLUI fencing is. Table 3 lists the N loads based on the modelled baseline of stock exclusion (Fig. 3), SLUI fences only, as well as the combination of estimated baseline and SLUI works. For all 696 SLUI farms, SLUI stock exclusion measures have reduced nitrogen loads by 0.06% or 3.7 tonnes N a^{-1}; all stock exclusion measures have reduced N-loss by 0.22% or 12.7 tonnes N a^{-1}. The maximum reduction possible with no access of stock to water ways will reduce nitrogen loads by only 0.77%.

Table 3: Results of modelled N-loss on the 696 SLUI farms and modelled reduction as a result of stock exclusion measures

	No stock exclusion	No stock access	Modelled baseline fences	SLUI fences	Baseline + SLUI Fences
Total N loss (t a^{-1})	5,875	5,830	5,866	5,872	5,863
Difference (t a^{-1})		45.2	9.0	3.7	12.7
Reduction (%)		0.77	0.15	0.06	0.22

The modelled N-loss of SLUI farms with no stock exclusion is shown in Figure 4 (Map A). Map B in the same figure displays the % reductions in N-loss achieved due to the current level of stock exclusion, which includes both the modelled baseline and SLUI works within each farm. The total reduction in N load on SLUI farms as a result of restricting stock access to waterways is 0.22%. The greatest average reduction (%) of SLUI farms is in the Coastal Whangaehu (–3.93%), Coastal Manawatu (–1.49%) and Kaitoke Lakes (–1.13%) WMZs (Appendix 2, column 15). Spatial variation in the impact of stock exclusion is more pronounced when considering the potential reduction achievable at 100% stock exclusion on all SLUI farms (Appendix 2, column 16). Coastal Whangaehu, coastal Manawatu, and Kaitoke Lakes WMZs would still have the greatest reductions in N. Total stock exclusion would increase N load reductions by 2–5 times in most WMZs with SLUI farms. Appendix 2 tabulates the results of the analysis for SLUI farms at WMZ level.

The absence of major differences may be because Overseer® 'access to streams' excludes sheep and deer (average sheep:beef:deer ratio for the modelled farms is 67:31:2). Likewise, farms with low initial N loss values tend not to demonstrate large reductions attributable to mitigations (unlike dairy farms with high N loss values).

The impact of SLUI afforestation and land retirement on nitrogen loads is shown in Table 4. Afforestation (13,220 ha) has led to a reduction of 84.6% in areas where SLUI has initiated land use change from pasture to forestry. Nitrogen loads on retired land (6,950 ha mainly to native bush) has led to a predicted reduction of 76.9% in nitrogen loads. This equates to a reduction of N load of 145.5 t a^{-1} and 69.6 t a^{-1} respectively. The impact of afforestation and land retirement on reducing N loads is therefore significantly greater than stock exclusion measures. Total reduction in N-loss achieved on SLUI farms is 218.7 N t a^{-1} (reduction of 3.7% across all SLUI farms), based on SLUI stock exclusion, afforestation and land retirement

Table 4: Impact of afforestation and land retirement on nitrogen loads

Land use	Area (ha)	kg N ha^{-1} a^{-1}	t N a^{-1}	Reduction (t N a^{-1})*	Reduction (%)
Forestry	13,220	2	26.4	145.5	84.6
Land retirement	6,950	3	20.8	69.6	76.9

* Calculated assuming land was previously under pasture generating an N load of 13 kg ha^{-1} a^{-1}

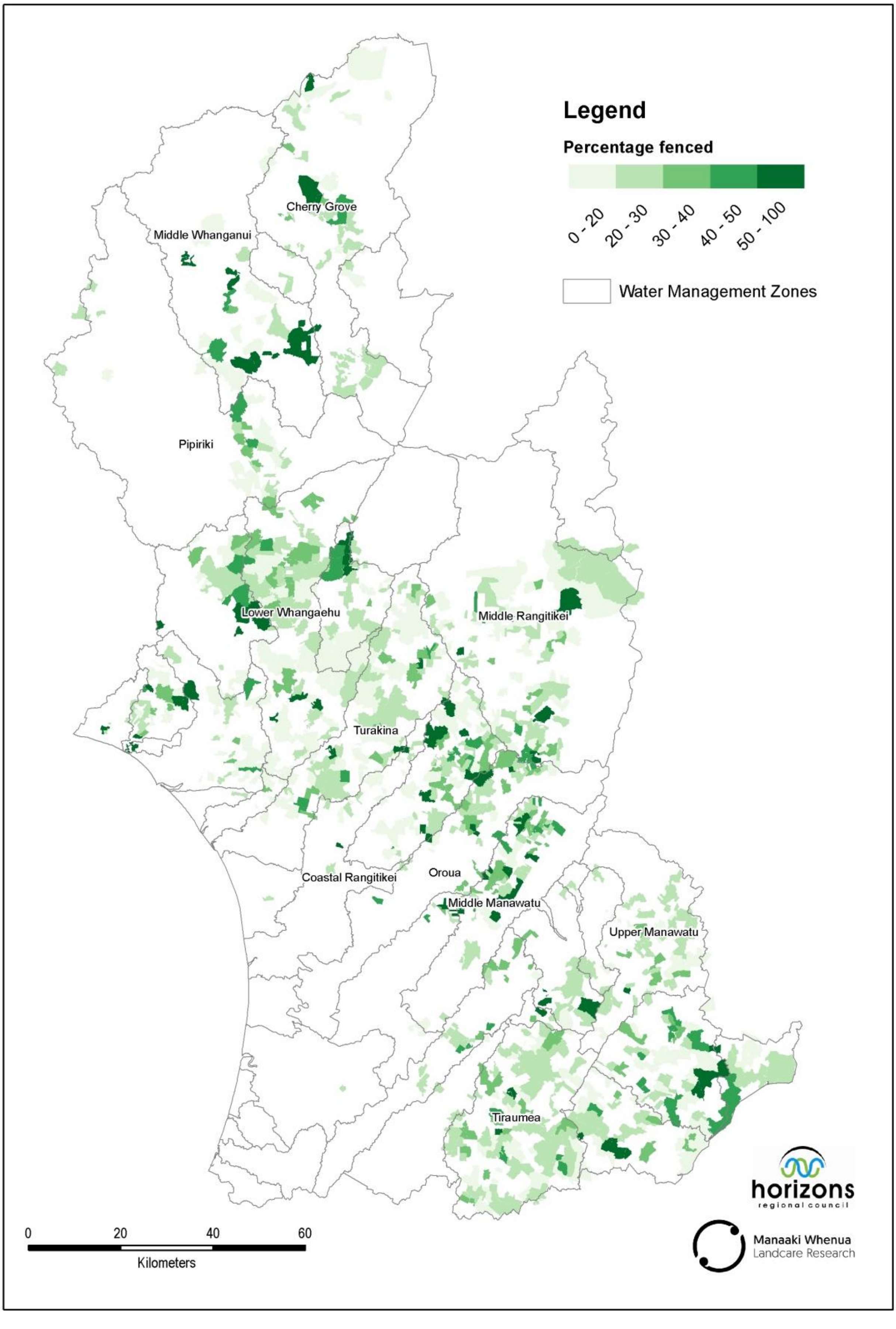

Figure 3: Proportion of waterways fenced (SLUI fences + baseline) on SLUI farms in the Horizons Region 2017.

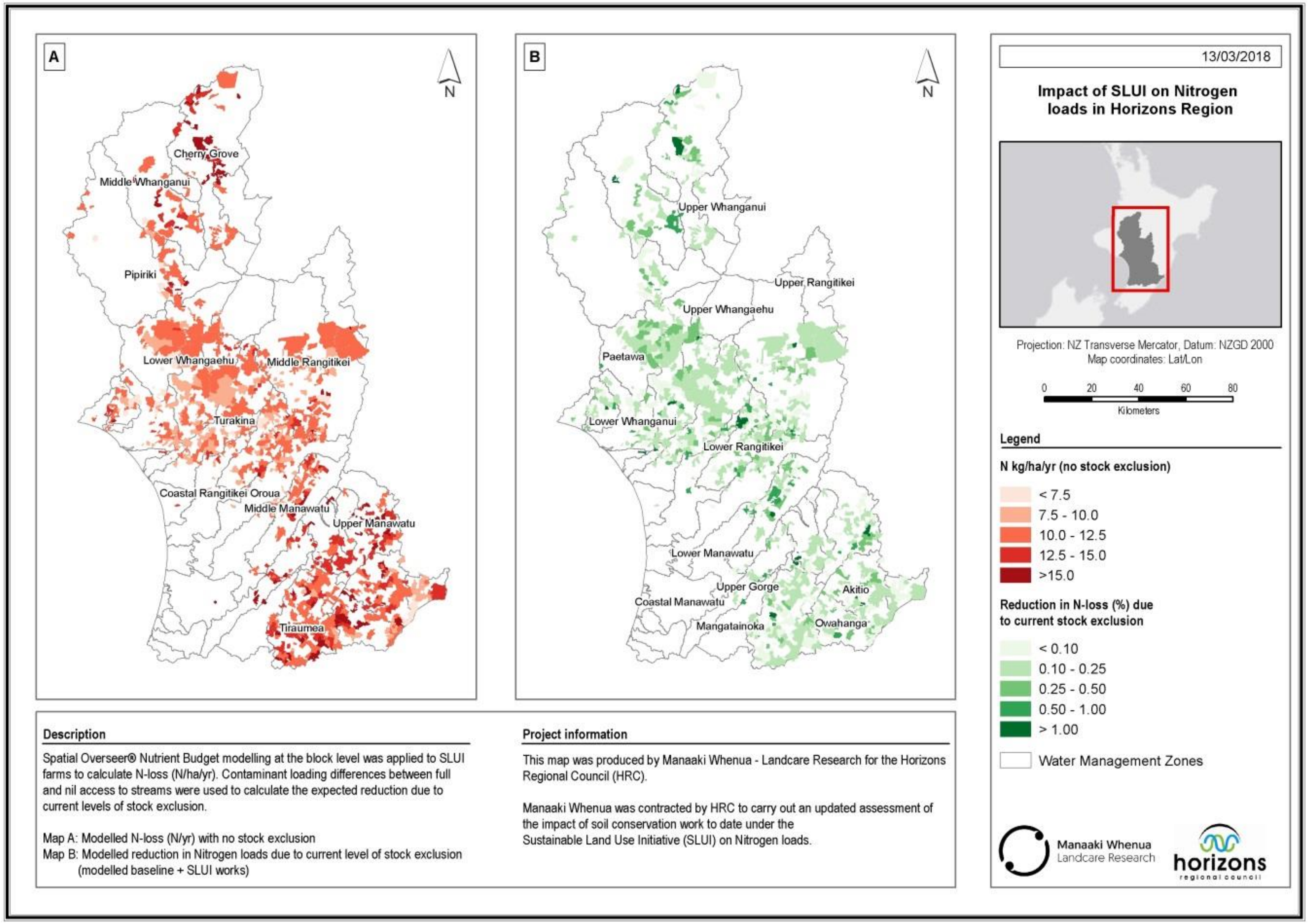

Figure 4: Map A, Modelled N-loss of SLUI farms with no stock exclusion; Map B, Impact of current stock exclusion on Nitrogen loads of SLUI farms.

7 Effect of SLUI on reduction in *E. coli* loads in rivers

Fencing of waterways minimizes *E. coli* directly defecated into waterways. Appendix 3 tabulates the full results of the analysis at WMSZ level, including the predicted reduction in *E. coli* load due to SLUI. Figure 5 maps current stock exclusion in the Horizons Region. Figure 5A displays the baseline stock exclusion according to the SRDM survey and available land use data, while Figure 5B shows the result of SLUI stock exclusion measures (i.e. the proportion of waterways with stock access that have been fenced through SLUI works). Based on the SRDM survey, the average stock exclusion of the WMSZs in the Horizons Region is 24%. Of the remaining streams with stock access (76%), the SLUI works have restricted access on average by an additional 5.8% in WMSZs with SLUI farms (3.3 % when including all WMSZs). This has increased the level of stock exclusion across all WMSZs to 26.6% overall.

Figure 6A displays the median *E. coli* loads at measurement sites (see. Appendix 3). These range between 4.5 and 735.0 MPN[2]; the median is 166.5 MPN. Each measurement site is linked to a WMSZ upstream, which allows reductions in *E. coli* to be calculated in absolute terms. A relative reduction in median *E. coli* loads was estimated based on stock exclusion measures to date and the load reduction factors for different stock classes. Figure 6B shows the expected reductions achieved due to SLUI works only, with Figure 6C a representation of the maximum potential reduction achievable at nil stock access.

For WMSZs with SLUI farms, the predicted average reduction in *E. coli* loads is 2.6% due to SLUI alone. For example, Retaruke WMSZ has the greatest reduction in median *E. coli* values (13.0%) as a result of SLUI. Paetawa and Upper Pohangina WMSZs also have reductions greater than 10% due to SLUI works.

Whanganui at Te Rewa is a measurement site associated with the Paetawa WMSZ with a median *E. coli* value of 108.0 MPN. In the Paetawa WMSZ, 96 km of SLUI stock exclusion measures have been implemented, which equates to 23% of all LINZ waterways within grasslands. For this WMSZ, assuming 11% of waterways had already been fenced prior to SLUI (SRDM baseline), and an additional 23% of waterways were excluded from stock through SLUI, then the total stock exclusion achieved is 34%. Based on the 23% (which equates to 25.8% of unfenced streams (all streams minus the 11% baseline)), the reduction in *E. coli* loads achieved in the Paetawa WMSZ by SLUI is therefore 11.4%, which brings the median *E. coli* value down from 108.0 to 95.3 MPN.

Based on the current stock exclusion, which includes the modelled baseline (from SRDM) and SLUI works, the average reduction in *E. coli* load across all WMSZs achieved is 12.8%. The Lower and Upper Kumeti WMSZs have the lowest levels of stock access and therefore the largest reduction in median *E. coli* values of 37% and 31% respectively. With 100% stock exclusion from waterways, a reduction of 34.4% in median *E. coli* values is achievable across all WMSZs, with greatest possible reductions in the Foxton Loop, Makatote, Upper Moawhango, Waimarino, lower Manawatu and middle Oroua WMSZs (>40%). The land

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[2] Most probable number, a measure of *E. coli* concentration

use in Foxton Loop is predominantly dairy, so stock exclusion measures would have greater impact there because of the stock type (see LRFs in section 4.3.4), whereas the Lower Moawhango has a low proportion of streams fenced.

The measure of percentage reduction possible with no stock access can be misleading, since the length of waterways with stock access needs to be considered. Makatote WMSZ has almost no rivers (0.8 km) in areas of pasture since it is located on the western flanks of Mt Ruapehu, but has a potential reduction of 43%, which would be very easy to achieve with the short length of stream requiring fencing. This is an example of the limitations associated with the methodology used as it relies on accurate land cover, land use, and representative SRDM results. Nonetheless, the results are a good indication of current levels of stock access and SLUI achievements to date.

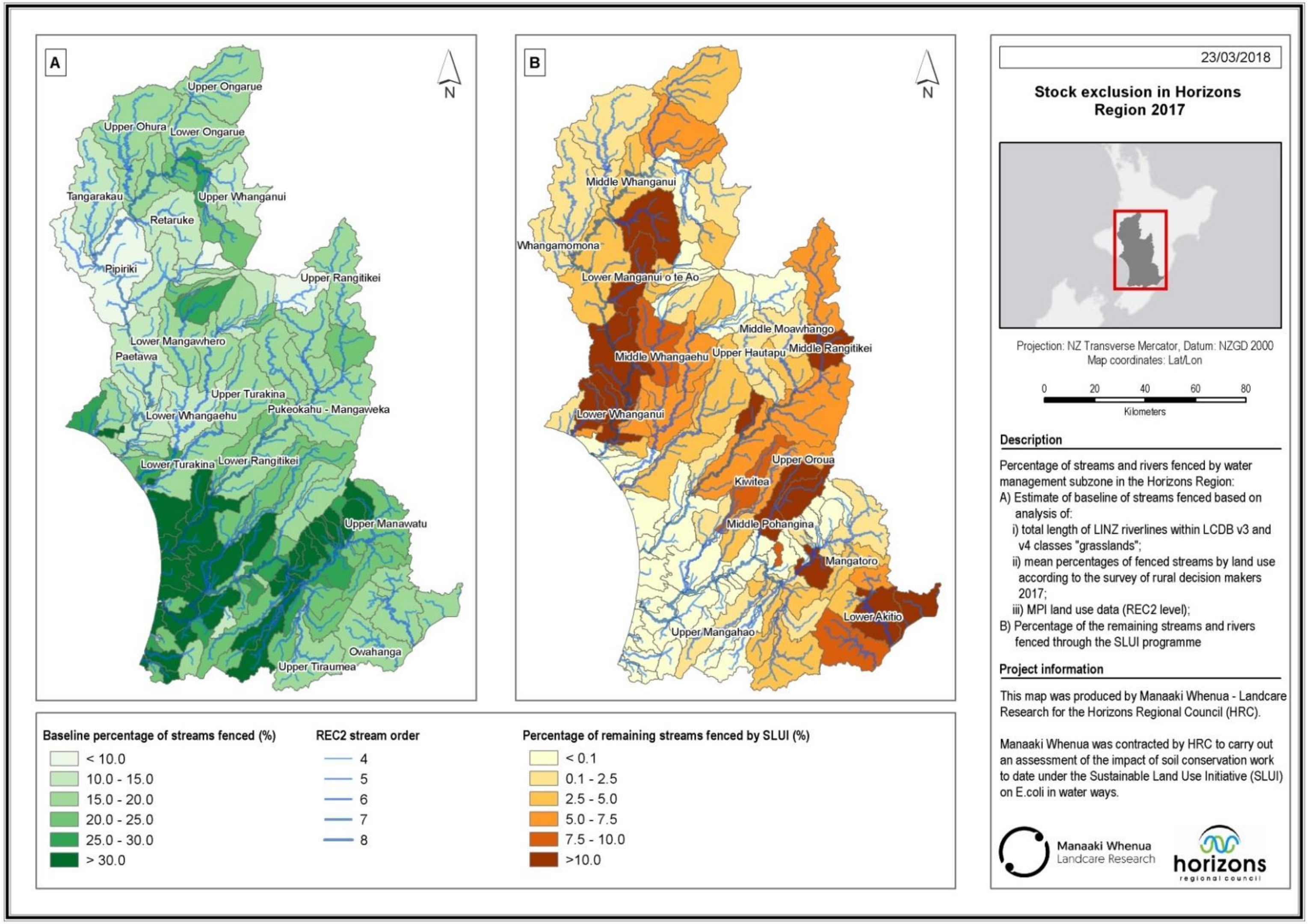

Figure 5: Map A, Average baseline stock exclusion (%) of water management subzones in the Horizons Region 2017; Map B, Percentage of remaining streams and rivers fenced by SLUI.

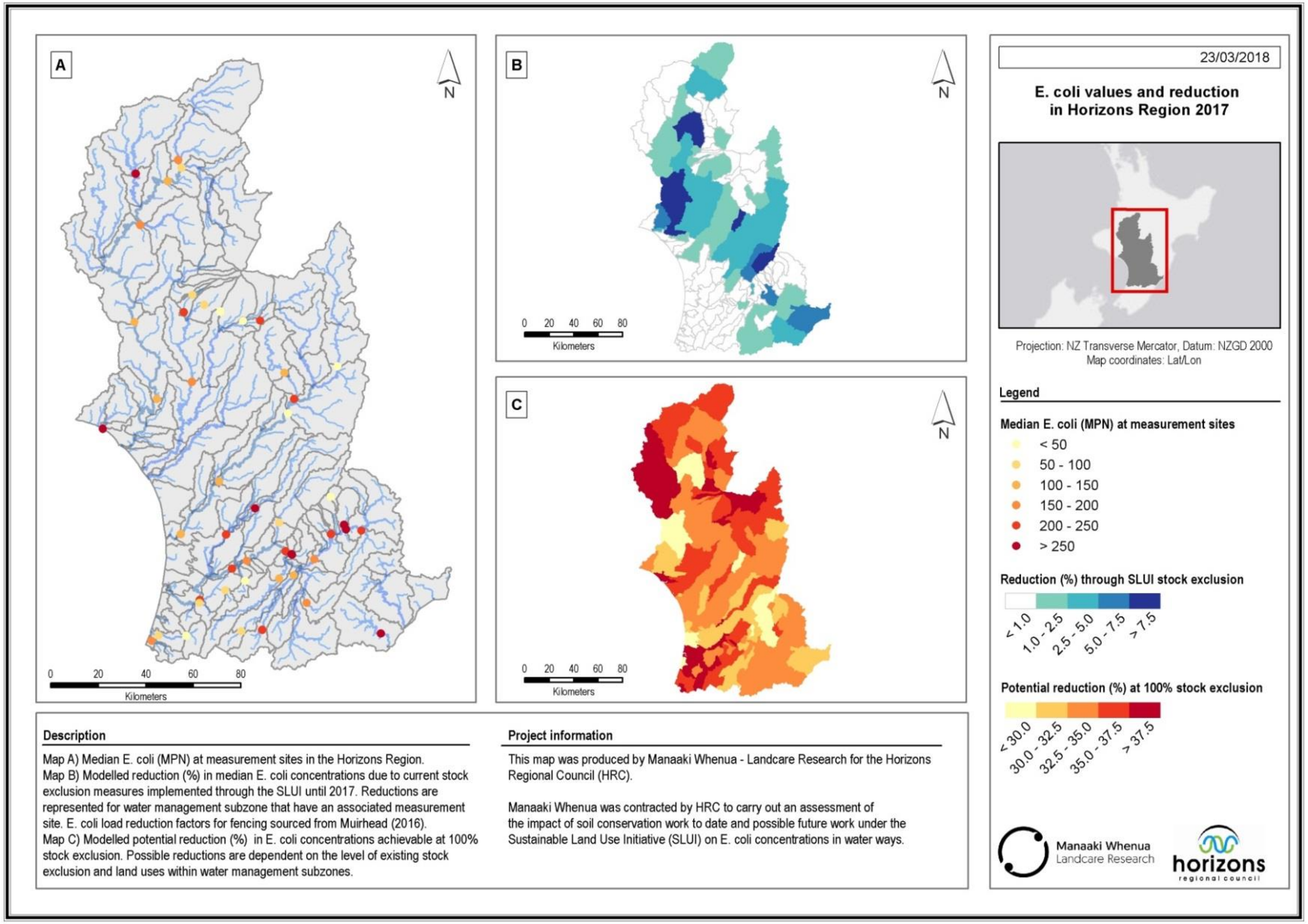

Figure 6: Map A, Median *E. coli* values at measurement sites in the Horizons Region; Map B, Modelled reduction in median *E. coli* concentrations through SLUI works until 2017; Map C, Modelled potential reduction in *E.coli* concentrations at nil stock access to streams.

8 Conclusions

The estimated percentage reduction in total P load to date due to SLUI is proportional to the number and area of farm plans implemented per WMZ with a reduction of 6% across all WMZs. Most WMZs have total phosphorus load reductions of <10% with the greatest load reductions in the East Coast, Kai Iwi, and Lower Rangitikei WMZs. However, by 2043 under both scenarios (0 and 3) many WMZS are predicted to have reductions in P load of 30 to >50%.

Fencing under SLUI has made very little difference to N loading to streams (<0.1%), and even with complete stock exclusion on SLUI farms there would only be an estimated reduction of <1%. The predicted impact of afforestation and land retirement on reducing N loads is significantly greater than stock exclusion measures. SLUI stock exclusion measures are predicted to have reduced nitrogen loads by 3.7 tonnes N a^{-1} (0.06%), whereas afforestation and land retirement have reduced nitrogen loads by 145.5 t a^{-1} and 69.6 t a^{-1} respectively (3.7% reduction).

The average reduction in median *E. coli* values as a result of SLUI fencing to date in WMSZs with an associated *E. coli* measurement sites is 2.6%. However, if all streams were fenced then median *E. coli* values could be reduced by 34%.

9 Acknowledgements

We thank Jon Roygard and Grant Cooper for initiating this work, and Staci Boyte, Willie Mckay, Malcolm Todd and the Horizons data team for providing the SLUI and other data on which this report is based and for discussing the work with us. Ian Lynn, Ray Prebble and Staci Boyte reviewed an earlier draft of this report.

10 References

Bagshaw CS 2002. Factors Influencing Direct Deposition of Cattle Faecal Material in Riparian Zones. MAF Technical Paper No: 2002/19. Wellington, Ministry of Agriculture and Forestry.

Basher L, Spiekermann R, Dymond J, Herzig A, Hayman E, Ausseil A-G 2018. SedNetNZ, SLUI and contaminant generation Part 1 Sediment and water clarity. Manaaki Whenua – Landcare Research Contract Report LC3135 For Horizons Regional Council.

Brown P. 2017. Survey of Rural Decision Makers. Landcare Research NZ Ltd. Available at http://www.landcareresearch.co.nz/science/portfolios/enhancing-policy-effectiveness/srdm/srdm2017 DOI: 10.7931/J28913S8 (accessed 29 March 2018).

Dymond JR, Serezat D, Ausseil A-G, Muirhead RW 2016. Mapping of *Escherichia coli* sources connected to waterways in the Ruamahanga catchment, New Zealand. Environmental Science and Technology 50: 1897–1905.

Eden DD, Parfitt RL 1992. Amounts and sources of phosphate in hill country rocks south-eastern North Island, New Zealand. Australian Journal of Soil Research 30: 357–370.

Semadeni-Davies A., Elliot S, Muirhead R 2017. Modelling the effect of stock exclusion on *E. coli* in rivers and streams. MPI Technical Paper No: 2017/10. Wellington, Ministry of Primary Industries.

Manderson A, Mackay A, Lambie J, Roygard J 2013. Sustainable land use initiative by Horizons. New Zealand Journal of Forestry 57: 4–8.

Muirhead R 2016. Effectiveness of fencing to reduce *E. coli* inputs to streams from pastoral land use. A report produced by AgResearch for the National Institute of Water and Atmospheric Research. Mosgiel, AgResearch.

Parfitt RL, Frelat M, Dymond JR, Clark M, Roygard J 2013. Sources of phosphorus in two subcatchments of the Manawatu River, and discussion of mitigation measures to reduce the phosphorus load. New Zealand Journal of Agricultural Research 56: 187–202.

Snelder T 2018. Assessment of recent reductions in *E. coli* and sediment in rivers of the Manawatū-Whanganui Region, including associations between water quality trends and management interventions. Land and Water People Client Report 2017-06.

Appendix 1 – Phosphorus scenario results

Scenario 0: Modelled Total Phosphorus (TP) loads (kg a^{-1}) incorporating SLUI works until 2017, followed by the discontinuation of SLUI with no new farm plans from 2018 onwards

Water Management Zone	TP_04	TP_13	TP_18	TP_23	TP_28	TP_33	TP_38	TP_43	43-04	43/04 diff %
Upper Whangaehu	719.2	719.2	719.0	719.0	719.0	719.0	719.0	719.0	–0.3	0.0
Middle Rangitikei	591.8	588.0	572.6	554.9	544.6	543.9	543.9	543.9	–47.8	–8.1
Pipiriki	585.5	581.8	572.4	560.8	553.9	553.3	553.3	553.3	–32.2	–5.5
Middle Whanganui	534.9	532.1	514.5	494.7	485.7	484.3	484.3	484.3	-50.6	–9.5
Cherry Grove	406.0	404.1	397.7	391.2	387.2	386.3	386.3	386.3	–19.8	–4.9
Lower Whangaehu	387.0	377.2	334.1	288.5	259.4	257.3	257.3	257.3	–129.7	–33.5
Turakina	383.1	370.8	333.4	291.5	273.1	267.5	267.5	267.5	–115.7	–30.2
Oroua	298.5	288.2	268.3	247.5	238.5	235.7	235.7	235.7	–62.8	–21.0
Middle Manawatu	297.5	285.6	258.7	228.0	211.1	206.5	206.5	206.5	–91.0	–30.6
Tiraumea	249.6	247.0	217.9	178.6	150.2	144.7	144.7	144.7	–104.9	–42.0
Lower Rangitikei	248.9	237.3	204.1	172.0	156.3	153.6	153.6	153.6	–95.3	–38.3
Lower Whanganui	181.0	177.2	168.7	158.5	153.6	152.7	152.7	152.7	–28.3	–15.6
Upper Rangitikei	170.3	170.3	169.8	169.8	169.8	169.8	169.8	169.8	–0.5	–0.3
Paetawa	156.1	154.5	145.3	133.4	127.6	127.4	127.4	127.4	–28.7	–18.4
Upper Manawatu	138.8	138.5	134.6	127.0	121.0	119.1	119.1	119.1	–19.7	–14.2
Akitio	137.9	135.8	123.2	108.9	101.8	99.6	99.6	99.6	–38.3	–27.8
Upper Whanganui	132.2	132.3	132.2	132.1	132.1	132.1	132.1	132.1	–0.1	-0.1
Coastal Rangitikei	119.9	119.9	115.7	109.3	103.9	102.8	102.8	102.8	–17.1	–14.3
Owahanga	117.0	113.1	101.5	85.7	78.3	76.7	76.7	76.7	–40.3	–34.5
Middle Whangaehu	114.0	114.0	104.4	90.8	79.0	76.7	76.7	76.7	–37.3	–32.7
Mangatainoka	101.1	101.1	99.9	98.2	96.9	96.5	96.5	96.5	–4.6	–4.5

Water Management Zone	TP_04	TP_13	TP_18	TP_23	TP_28	TP_33	TP_38	TP_43	43-04	43/04 diff %
Upper Gorge	100.7	100.6	99.6	98.8	98.6	98.6	98.6	98.6	–2.1	–2.1
Kai Iwi	81.5	76.3	66.0	57.0	53.6	53.1	53.1	53.1	-28.4	–34.9
East Coast	62.5	59.3	50.5	41.8	36.3	35.4	35.4	35.4	–27.0	–43.3
Coastal Manawatu	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	–0.0	0.0
Manawatu Tamaki Confluence to Hopelands	60.0	58.9	56.8	50.5	45.1	43.6	43.6	43.6	–16.5	–27.4
Lower Manawatu	55.2	55.1	55.0	55.0	55.0	55.0	55.0	55.0	–0.1	–0.2
Coastal Whangaehu	39.7	39.7	39.7	39.6	39.6	39.6	39.6	39.6	–0.1	–0.3
Te Maire	37.8	37.8	37.4	35.7	34.0	32.7	32.7	32.7	–5.0	–13.3
Northern Coastal	26.5	26.4	25.8	25.2	24.9	24.8	24.8	24.8	–1.7	–6.3
Manawatu Weber Road to Tamaki Confluence	25.2	24.5	24.1	23.1	22.4	22.3	22.3	22.3	–2.9	–11.7
Ohau	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	0.0	0.0
Manawatu Hopelands to Tiraumea Confluence	11.8	11.7	11.4	10.8	10.5	10.5	10.5	10.5	–1.4	–11.5
Southern Whanganui Lakes	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	–0.0	–0.4
Upper Tamaki	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	0.0	0.0
Waikawa	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	0.0	0.0
Mowhanau	5.4	5.1	5.0	4.9	4.8	4.8	4.8	4.8	–0.6	–11.0
Northern Manawatu Lakes	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	–0.0	–0.1
Kaitoke Lakes	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	0.0	0.0
Lake Horowhenua	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	0.0	0.0
Upper Kumeti	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	–0.0	0.0
Waitarere	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0	0.0
Lake Papaitonga	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.0	0.0
Total	**6,697.9**	**6,604.6**	**6,280.6**	**5,903.9**	**5,688.9**	**5,647.2**	**5,647.2**	**5,647.2**	**–1,050.8**	**–15.7**

Scenario 3: Modelled Total Phosphorus loads (t a^{-1}) incorporating SLUI works until 2017, followed by a continuation of SLUI with 35,000 ha of farm plans implemented from 2018 onwards.

Water Management Zone	TP_04	TP_13	TP_18	TP_23	TP_28	TP_33	TP_38	TP_43	43-04	43/04 diff %
Upper Whangaehu	719.2	719.2	719.0	719.0	719.0	719.0	719.0	719.0	–0.3	0.0
Middle Rangitikei	591.8	588.0	572.6	547.1	513.7	490.0	480.6	475.9	–115.9	–19.6
Pipiriki	585.5	581.8	572.4	547.6	507.9	471.5	455.9	453.6	–131.9	–22.5
Middle Whanganui	534.9	532.1	514.5	461.7	379.5	309.3	280.1	275.4	–259.5	–48.5
Cherry Grove	406.0	404.1	397.7	385.5	366.0	348.8	341.9	339.9	-66.1	–16.3
Lower Whangaehu	387.0	377.2	334.1	279.4	222.5	188.9	174.4	173.3	–213.7	–55.2
Turakina	383.1	370.8	333.4	283.2	239.4	204.0	190.7	189.4	–193.8	–50.6
Oroua	298.5	288.2	268.3	242.4	217.9	197.2	189.3	187.6	–110.9	–37.1
Middle Manawatu	297.5	285.6	258.7	224.6	195.0	172.7	163.1	161.6	–135.9	–45.7
Tiraumea	249.6	247.0	217.9	174.3	135.8	120.0	114.3	112.3	–137.3	–55.0
Lower Rangitikei	248.9	237.3	204.1	168.6	143.0	129.9	125.2	122.3	–126.6	–50.9
Lower Whanganui	181.0	177.2	168.7	156.1	145.3	136.8	132.7	131.5	–49.5	–27.4
Upper Rangitikei	170.3	170.3	169.8	169.8	169.8	169.8	169.8	169.8	–0.5	–0.3
Paetawa	156.1	154.5	145.3	129.2	113.6	104.6	101.3	101.1	–55.0	–35.2
Upper Manawatu	138.8	138.5	134.6	125.7	113.3	101.8	95.6	92.9	–45.8	–33.0
Akitio	137.9	135.8	123.2	106.3	90.8	76.7	69.9	68.4	–69.4	–50.4
Upper Whanganui	132.2	132.3	132.2	132.1	132.1	132.1	132.1	132.1	–0.1	–0.1
Coastal Rangitikei	119.9	119.9	115.7	107.0	97.1	92.3	90.0	88.8	–31.1	–26.0
Owahanga	117.0	113.1	101.5	82.7	65.4	54.0	50.3	49.6	–67.4	–57.6
Middle Whangaehu	114.0	114.0	104.4	86.8	61.8	46.1	42.9	42.9	–71.1	–62.4
Mangatainoka	101.1	101.1	99.9	98.1	96.4	94.4	93.1	92.8	–8.3	–8.2

Water Management Zone	TP_04	TP_13	TP_18	TP_23	TP_28	TP_33	TP_38	TP_43	43-04	43/04 diff %
Upper Gorge	100.7	100.6	99.6	98.8	98.6	98.6	98.5	98.5	–2.2	–2.2
Kai Iwi	81.5	76.3	66.0	56.5	50.7	43.3	37.9	37.6	–43.9	–53.9
East Coast	62.5	59.3	50.5	40.0	31.0	27.9	27.4	27.1	–35.4	–56.6
Coastal Manawatu	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	0.0	0.0
Manawatu Tamaki Confluence to Hopelands	60.0	58.9	56.8	49.2	40.8	37.1	36.5	36.2	–23.8	–39.7
Lower Manawatu	55.2	55.1	55.0	55.0	55.0	55.0	55.0	55.0	–0.1	–0.2
Coastal Whangaehu	39.7	39.7	39.7	39.6	39.6	39.6	39.6	39.6	–0.1	–0.3
Te Maire	37.8	37.8	37.4	34.6	30.1	24.8	22.6	21.8	–15.9	–42.2
Northern Coastal	26.5	26.4	25.8	24.5	21.2	17.3	15.9	15.8	–10.7	–40.3
Manawatu Weber Road to Tamaki Confluence	25.2	24.5	24.1	22.9	21.5	20.3	19.5	18.9	–6.3	–25.1
Ohau	21.6	21.6	21.6	21.6	21.6	21.6	21.6	21.6	0.0	0.0
Manawatu Hopelands to Tiraumea Confluence	11.8	11.7	11.4	10.2	8.8	8.1	8.0	8.0	–3.8	–32.1
Southern Whanganui Lakes	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	0.0	–0.4
Upper Tamaki	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	0.0	0.0
Waikawa	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	0.0	0.0
Mowhanau	5.4	5.1	5.0	4.9	4.7	4.6	4.6	4.6	–0.8	–14.7
Northern Manawatu Lakes	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	0.0	–0.1
Kaitoke Lakes	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	0.0	0.0
Lake Horowhenua	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	0.0	0.0
Upper Kumeti	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	0.0	0.0
Waitarere	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0	0.0
Lake Papaitonga	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.0	0.0
Total	**6,697.9**	**6,604.6**	**6,280.6**	**5,784.8**	**5,248.3**	**4,857.8**	**4,698.9**	**4,664.8**	**–2,033.2**	**–30.4 %**

Appendix 2 – Nitrogen results

Impact of SLUI stock exclusion measures on Nitrogen loads (kg a^{-1}) per water management zone in the Horizons Region.

The statistics presented here are based on the Nitrogen loads and stock exclusion measures of SLUI farms only. WMZs with no SLUI farms are shaded grey.

1) LINZ rivers in LCDB "grasslands" (km); **2)** Stock exclusion baseline (km) – SEB; **3)** SLUI stock exclusion (km) – SLUI SE; **4)** SEB %; **5)** SLUI SE %; **6)** Total SE % (4+5); **7)** Modelled Nitrogen (kg a^{-1}) with no SE; **8)** Modelled Nitrogen (kg a^{-1}) with 100% SE; **9)** Modelled Nitrogen (kg a^{-1}) SEB; **10)** Modelled Nitrogen (kg a^{-1}) SLUI SE; **11)** Modelled Nitrogen (kg a^{-1}) Total SE; **12)** Reduction Modelled Nitrogen (kg a^{-1}) due to SLUI SE; **13)** Reduction Nitrogen % SEB; **14)** Reduction Nitrogen % due to SLUI SE; **15)** Reduction Nitrogen % due to total SE; **16)** Maximum reduction Nitrogen % with no stock access on SLUI farms

Water management zone	No. SLUI farms	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Akitio	40	557.46	104.02	67.32	18.7	12.1	30.7	319199	316842	318762	319051	318613	148.7	0.14	0.05	0.18	0.74
Owahanga	28	334.54	62.49	42.87	18.7	12.8	31.5	242974	241275	242665	242860	242553	114.0	0.13	0.05	0.17	0.7
East Coast	8	209.14	35.57	49.40	17.0	23.6	40.6	142715	142026	142586	142668	142539	47.1	0.09	0.03	0.12	0.49
Upper Tamaki	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0	0	0.0	0	0	0	0
Oroua	26	383.46	75.87	40.80	19.8	10.6	30.4	150670	149781	150505	150575	150410	95.3	0.11	0.06	0.17	0.59
Ohau	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0	0	0.0	0	0	0	0
Lake Horowhenua	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0	0	0.0	0	0	0	0
Coastal Manawatu	1	4.65	1.30	0.00	28.0	0.0	28.0	3426	3246	3376	3426	3376	0.0	1.49	0	1.49	5.55
Waikawa	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0	0	0.0	0	0	0	0
Lake Papitonga	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0	0	0.0	0	0	0	0
Waitarere	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0	0	0.0	0	0	0	0
Northern Manawatu Lakes	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0	0	0.0	0	0	0	0
Upper Rangitikei	1	109.96	19.76	16.51	18.0	15.0	33.0	94031	93636	93960	93991	93920	40.0	0.08	0.04	0.12	0.42
Middle Rangitikei	68	1169.98	229.44	81.68	19.6	7.0	26.6	683283	678218	682336	682976	682029	307.1	0.14	0.04	0.18	0.75
Moawhanau	1	12.16	2.91	4.04	23.9	33.2	57.1	4871	4844	4865	4862	4856	8.9	0.13	0.18	0.32	0.56
Kai Iwi	22	157.93	22.80	31.34	14.4	19.8	34.3	75614	75062	75541	75524	75451	90.1	0.1	0.12	0.22	0.74
Lower Whanganui	25	218.09	30.34	66.30	13.9	30.4	44.3	112752	111676	112616	112686	112550	65.4	0.12	0.06	0.18	0.96
Te Maire	2	38.27	6.79	1.46	17.7	3.8	21.6	13224	13114	13204	13221	13201	3.4	0.16	0.03	0.18	0.85

Water management zone	No. SLUI farms	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Middle Whanganui	21	534.95	85.91	201.69	16.1	37.7	53.8	288950	286422	288378	288326	287766	624.6	0.2	0.22	0.41	0.88
Turakina	57	1000.82	175.63	77.15	17.5	7.7	25.3	431483	428386	430926	431300	430743	182.8	0.13	0.04	0.17	0.72
Southern Whanganui Lakes	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0	0	0.0	0	0	0	0
Upper Whangaehu	1	7.33	1.25	0.64	17.1	8.7	25.8	4194	4171	4190	4193	4189	1.3	0.09	0.03	0.13	0.55
Middle Whangaehu	13	372.76	69.83	38.47	18.7	10.3	29.1	183600	181828	183256	183447	183103	153.2	0.19	0.08	0.27	0.97
Coastal Whangaehu	1	6.29	2.50	0.00	39.8	0.0	39.8	2293	2075	2206	2293	2206	0.0	3.93	0	3.93	10.51
Kaitoke Lakes	1	7.07	1.68	0.00	23.7	0.0	23.7	3898	3715	3855	3898	3855	0.0	1.13	0	1.13	4.93
Lower Rangitikei	49	618.71	116.11	80.99	18.8	13.1	31.9	278082	276038	277688	277842	277448	239.9	0.14	0.09	0.23	0.74
Coastal Rangitikei	10	94.98	17.45	2.32	18.4	2.4	20.8	39751	39307	39666	39743	39658	8.1	0.21	0.02	0.23	1.13
Paetawa	13	181.38	24.39	90.69	13.4	50.0	63.4	150705	149542	150553	150499	150347	206.0	0.1	0.14	0.24	0.78
Upper Whanganui	2	36.20	6.24	0.59	17.2	1.6	18.9	19392	19255	19369	19390	19367	2.0	0.12	0.01	0.13	0.71
Cherry Grove	29	641.96	127.89	45.93	19.9	7.2	27.1	407052	402973	406131	406682	405761	369.7	0.23	0.09	0.32	1.01
Upper Kumeti	0	0.00	0.00	0.00	0.0	0.0	0.0	0	0	0	0	0	0.0	0	0	0	0
Tamaki – Hopelands	13	255.78	75.13	30.24	29.4	11.8	41.2	141688	140574	141258	141652	141240	36.3	0.3	0.03	0.32	0.79
Middle Manawatu	35	396.50	78.04	74.93	19.7	18.9	38.6	212293	210514	211968	211994	211669	298.7	0.15	0.14	0.29	0.84
Northern Coastal	1	4.66	1.04	3.29	22.3	70.5	92.9	2206	2187	2201	2199	2195	6.7	0.19	0.31	0.49	0.85
Lower Manawatu	5	44.85	8.40	7.89	18.7	17.6	36.3	18625	18444	18591	18593	18559	32.3	0.18	0.17	0.36	0.98
Weber – Tamaki	1	11.38	3.41	0.00	30.0	0.0	30.0	5984	5933	5969	5984	5969	0.0	0.25	0	0.25	0.85
Hopelands – Tiraumea	2	6.18	1.20	0.91	19.4	14.8	34.1	4652	4615	4645	4648	4641	3.8	0.14	0.08	0.23	0.79
Upper Manawatu	38	525.33	105.21	21.78	20.0	4.1	24.2	287943	285192	287395	287816	287269	126.3	0.19	0.04	0.23	0.96
Upper Gorge	11	127.04	31.20	7.35	24.6	5.8	30.4	90578	89906	90415	90527	90364	50.8	0.18	0.06	0.24	0.75
Lower Whangaehu	63	1317.13	239.20	71.22	18.2	5.4	23.6	622207	617711	621390	621956	621139	250.9	0.13	0.04	0.17	0.73
Pipiriki	22	213.85	38.36	28.24	17.9	13.2	31.1	160986	159929	160803	160920	160738	65.8	0.11	0.04	0.15	0.66
Mangatainoka	2	13.12	2.93	0.00	22.3	0.0	22.3	9085	8874	9030	9085	9030	0.0	0.61	0	0.61	2.38
Tiraumea	81	1059.01	224.36	46.28	21.2	4.4	25.6	666873	662791	665957	666747	665831	126.5	0.14	0.02	0.16	0.62

Appendix 3 – *E. coli* results

Water Management Subzone	LINZ River length (km)	Baseline stock exclusion (km)	SLUI stock exclusion (km)	Percent stock exclusion baseline (%)	Percent stock exclusion due to SLUI (%)	Current stock exclusion (%)	Dairy (%)	Sheep and beef (%)	Other (%)	Median *E. coli* (MPN)	Reduction due to SLUI (%)	Modelled reduction in *E. coli* due to current level of stock exclusion (%)	Potential additional reduction (%) with no stock access
Aokautere	28.74	4.68	0.00	16.3	0.0	16.3	3.2	61.4	35.3		0.0	7.3	37.6
Cherry Grove	292.85	74.69	0.08	25.5	0.0	25.5	12.5	74.1	13.4	88.0	0.0	11.9	34.7
Coastal Manawatu	142.42	44.38	0.00	31.2	0.0	31.2	55.5	19.6	25.0	231.5	0.0	17.9	39.5
Coastal Rangitikei	657.42	212.68	0.00	32.4	0.0	32.4	25.9	58.8	15.3	102.5	0.0	16.0	33.5
Coastal Whangaehu	218.68	54.85	0.00	25.1	0.0	25.1	24.6	51.7	23.7		0.0	12.5	37.3
Coastal Whanganui	76.72	14.36	0.00	18.7	0.0	18.7	9.4	53.6	37.0		0.0	8.7	38.0
Eastern coastal zone	307.20	52.70	41.67	17.2	16.4	30.7	0.0	70.9	29.1		7.2	13.5	30.5
Foxton Loop	15.84	3.48	0.00	22.0	0.0	22.0	56.8	22.5	20.8		0.0	12.5	44.4
Hokio	6.29	1.23	0.00	19.6	0.0	19.6	12.7	52.9	34.4		0.0	9.3	38.2
Hopelands – Tiraumea	97.37	28.30	0.91	29.1	1.3	30.0	23.7	66.4	9.8		0.6	14.6	34.1
Kahuterawa	81.37	18.11	0.00	22.3	0.0	22.3	8.6	39.2	52.2	49.0	0.0	10.5	36.7
Kai Iwi	315.43	47.52	42.78	15.1	16.0	28.6	0.2	47.6	52.3		7.0	12.6	31.4
Kaitoke Lakes	105.35	22.43	0.00	21.3	0.0	21.3	1.7	63.0	35.2		0.0	9.5	35.0
Kiwitea	555.98	138.58	35.43	24.9	8.5	31.3	9.9	80.4	9.7		3.9	14.4	31.6
Koputaroa	114.54	34.84	0.00	30.4	0.0	30.4	24.8	51.4	23.9		0.0	15.2	34.7
Lake Horowhenua	25.25	5.80	0.00	23.0	0.0	23.0	22.8	40.1	37.0		0.0	11.6	38.9
Lake Papaitonga	7.07	1.78	0.00	25.2	0.0	25.2	19.0	51.9	29.0		0.0	12.3	36.5
Lower Akitio	581.98	100.78	56.79	17.3	11.8	27.1	0.0	75.8	24.2		5.2	11.9	32.1
Lower Hautapu	189.36	32.55	2.23	17.2	1.4	18.4	0.0	89.3	10.6	215.0	0.6	8.1	35.9
Lower Kumeti	77.63	48.77	0.00	62.8	0.0	62.8	76.3	12.7	11.0		0.0	37.3	22.1
Lower Makotuku	110.28	27.94	0.04	25.3	0.1	25.4	2.9	86.9	10.1	221.8	0.0	11.3	33.3

Water Management Subzone	LINZ River length (km)	Baseline stock exclusion (km)	SLUI stock exclusion (km)	Percent stock exclusion baseline (%)	Percent stock exclusion due to SLUI (%)	Current stock exclusion (%)	Dairy (%)	Sheep and beef (%)	Other (%)	Median *E. coli* (MPN)	Reduction due to SLUI (%)	Modelled reduction in *E. coli* due to current level of stock exclusion (%)	Potential additional reduction (%) with no stock access
Lower Manawatu	79.50	19.42	0.00	24.4	0.0	24.4	37.1	33.7	29.2	218.5	0.0	13.1	40.4
Lower Mangahao	108.24	36.22	2.72	33.5	3.8	36.0	32.9	56.0	11.0		1.9	18.2	32.4
Lower Manganui o te Ao	287.51	41.32	25.56	14.4	10.4	23.3	0.0	30.3	69.7		4.6	10.2	33.8
Lower Mangaone Stream	8.73	1.47	0.00	16.9	0.0	16.9	1.4	13.4	85.3		0.0	7.7	38.0
Lower Mangatainoka	84.27	25.35	0.34	30.1	0.6	30.5	27.5	59.9	12.7	127.0	0.3	15.1	34.5
Lower Mangawhero	840.74	150.70	53.05	17.9	7.7	24.2	0.0	77.9	22.1	158.0	3.4	10.7	33.3
Lower Moawhango	424.34	72.63	15.59	17.1	4.4	20.8	0.8	88.4	10.8		2.0	9.2	35.0
Lower Ohau	124.85	39.69	0.00	31.8	0.0	31.8	30.1	33.8	36.1	80.0	0.0	16.7	35.8
Lower Ohura	228.90	41.15	1.90	18.0	1.0	18.8	0.8	87.9	11.4		0.4	8.3	35.9
Lower Ongarue	774.54	139.83	37.48	18.1	5.9	22.9	0.3	61.1	38.6	176.5	2.6	10.1	34.0
Lower Oroua	198.43	83.96	0.00	42.3	0.0	42.3	50.5	39.0	10.6		0.0	22.9	31.2
Lower Pohangina	117.52	25.87	0.00	22.0	0.0	22.0	6.0	70.1	23.9		0.0	10.0	35.4
Lower Rangitikei	1080.86	190.98	56.88	17.7	6.4	22.9	6.3	77.9	15.7	133.0	2.9	10.4	35.0
Lower Tamaki	73.85	32.21	0.00	43.6	0.0	43.6	37.1	36.3	26.6		0.0	23.2	29.9
Lower Tiraumea	228.72	57.16	5.59	25.0	3.3	27.4	7.5	69.1	23.4		1.5	12.6	33.2
Lower Tokomaru	347.33	136.94	0.00	39.4	0.0	39.4	45.3	34.0	20.7		0.0	21.4	32.9
Lower Turakina	960.57	190.55	37.51	19.8	4.9	23.7	6.1	71.6	22.3		2.2	10.8	34.6
Lower Whakapapa	62.40	9.99	0.00	16.0	0.0	16.0	2.5	14.3	83.2		0.0	7.5	39.2
Lower Whangaehu	817.95	120.42	40.79	14.7	5.8	19.7	1.2	59.4	39.5		2.6	8.7	35.6
Lower Whanganui	305.58	44.47	49.07	14.6	18.8	30.6	4.7	30.1	65.1		8.7	14.2	32.2
Main Drain	135.55	53.28	0.00	39.3	0.0	39.3	41.1	43.9	14.9		0.0	20.7	32.0

Water Management Subzone	LINZ River length (km)	Baseline stock exclusion (km)	SLUI stock exclusion (km)	Percent stock exclusion baseline (%)	Percent stock exclusion due to SLUI (%)	Current stock exclusion (%)	Dairy (%)	Sheep and beef (%)	Other (%)	Median *E. coli* (MPN)	Reduction due to SLUI (%)	Modelled reduction in *E. coli* due to current level of stock exclusion (%)	Potential additional reduction (%) with no stock access
Makakahi	464.39	168.25	0.00	36.2	0.0	36.2	28.3	52.8	18.9	214.3	0.0	18.2	32.1
Makara	21.04	4.71	0.00	22.4	0.0	22.4	2.5	63.5	34.0		0.0	10.0	34.7
Makatote	0.76	0.02	0.00	2.5	0.0	2.5	0.0	1.2	98.8		0.0	1.1	42.9
Makino	406.11	98.72	2.36	24.3	0.8	24.9	8.9	78.9	12.2		0.4	11.4	34.4
Makohine	220.42	46.00	35.43	20.9	20.3	36.9	9.9	63.1	27.0		9.4	17.2	29.3
Makuri	301.71	60.96	4.77	20.2	2.0	21.8	1.2	78.4	20.4	180.0	0.9	9.6	34.6
Manakau	56.57	12.91	0.00	22.8	0.0	22.8	20.9	47.5	31.6		0.0	11.3	38.2
Mangaatua	258.90	101.75	0.00	39.3	0.0	39.3	29.0	56.4	14.6	508.5	0.0	19.7	30.4
Mangaone River	319.25	78.88	6.15	24.7	2.6	26.6	7.9	84.7	7.3		1.2	12.1	33.4
Mangaore	57.94	15.48	0.00	26.7	0.0	26.7	24.7	26.5	48.8	91.5	0.0	14.1	38.6
Mangapapa	43.90	16.55	2.57	37.7	9.4	43.6	24.8	43.1	32.1	255.0	4.8	22.0	28.5
Mangaramarama	131.05	36.98	3.22	28.2	3.4	30.7	11.4	76.4	12.2		1.6	14.2	32.1
Mangatera	246.53	94.73	0.00	38.4	0.0	38.4	31.6	60.3	8.1	498.3	0.0	19.3	30.9
Mangatewainui	140.25	48.81	0.00	34.8	0.0	34.8	20.0	48.1	31.9		0.0	17.2	32.1
Mangatoro	554.11	119.28	12.09	21.5	2.8	23.7	2.8	86.3	11.0	229.0	1.2	10.6	34.0
Mangaturuturu	16.85	1.74	0.00	10.3	0.0	10.3	0.0	9.0	91.0		0.0	4.5	39.5
Matarawa	211.65	41.22	5.20	19.5	3.1	21.9	8.2	72.6	19.3		1.4	10.1	35.8
Middle Manawatu	294.32	82.07	0.00	27.9	0.0	27.9	18.9	50.6	30.5	194.5	0.0	13.6	35.3
Middle Manganui o te Ao	45.94	6.40	1.74	13.9	4.4	17.7	0.0	33.0	67.0		1.9	7.8	36.2
Middle Mangatainoka	242.93	99.85	0.00	41.1	0.0	41.1	51.5	34.7	13.8		0.0	22.5	32.2
Middle Moawhango	325.04	55.39	1.93	17.0	0.7	17.6	0.0	45.3	54.7		0.3	7.8	36.2
Middle Oroua	13.75	3.20	0.00	23.2	0.0	23.2	26.7	32.8	40.5	222.5	0.0	12.1	40.0

Water Management Subzone	LINZ River length (km)	Baseline stock exclusion (km)	SLUI stock exclusion (km)	Percent stock exclusion baseline (%)	Percent stock exclusion due to SLUI (%)	Current stock exclusion (%)	Dairy (%)	Sheep and beef (%)	Other (%)	Median *E. coli* (MPN)	Reduction due to SLUI (%)	Modelled reduction in *E. coli* due to current level of stock exclusion (%)	Potential additional reduction (%) with no stock access
Middle Pohangina	521.39	95.64	61.17	18.3	14.4	30.1	1.7	65.4	32.9	85.0	6.4	13.4	31.1
Middle Rangitikei	405.65	90.36	33.49	22.3	10.6	30.5	7.4	65.4	27.1	23.0	4.9	14.0	31.8
Middle Whangaehu	748.94	136.60	42.61	18.2	7.0	23.9	0.6	88.8	10.6		3.1	10.6	33.6
Middle Whanganui	709.87	123.50	28.89	17.4	4.9	21.5	0.0	64.3	35.7	166.5	2.2	9.4	34.6
Mowhanau Estuary	79.26	24.89	3.99	31.4	7.3	36.4	25.3	66.8	8.0	559.0	3.6	17.8	31.1
Northern Coastal	167.56	44.89	2.53	26.8	2.1	28.3	11.2	55.0	33.7		1.0	13.3	33.7
Northern Manawatu Lakes	152.17	71.73	0.00	47.1	0.0	47.1	39.1	35.5	25.4		0.0	25.2	28.2
Orautoha	107.46	21.51	3.19	20.0	3.7	23.0	0.0	67.2	32.8		1.6	10.1	33.9
Oruakeretaki	110.52	55.84	0.67	50.5	1.2	51.1	40.6	24.7	34.7	211.5	0.7	28.2	27.0
Owahanga	686.12	120.50	44.21	17.6	7.8	24.0	0.4	73.3	26.3	285.0	3.4	10.6	33.5
Paetawa	418.15	47.53	95.78	11.4	25.8	34.3	0.0	21.7	78.3	106.0	11.4	15.1	28.9
Piopiotea	144.03	32.52	1.07	22.6	1.0	23.3	4.7	44.2	51.1		0.4	10.7	35.1
Pipiriki	78.43	5.67	2.00	7.2	2.8	9.8	0.0	2.8	97.2	109.5	1.2	4.3	39.7
Porewa	377.63	77.87	6.88	20.6	2.3	22.4	8.2	75.2	16.7	735.0	1.1	10.3	35.5
Pukeokahu - Mangaweka	776.61	128.71	41.34	16.6	6.4	21.9	0.1	42.4	57.5	50.0	2.8	9.6	34.4
Pungapunga	96.99	15.30	4.95	15.8	6.1	20.9	0.4	42.1	57.5		2.7	9.2	34.9
Raparapawai	91.33	39.79	0.00	43.6	0.0	43.6	35.2	40.5	24.3		0.0	22.8	29.6
Ratana	17.16	5.88	0.00	34.3	0.0	34.3	20.6	64.1	15.3		0.0	16.6	31.8
Retaruke	764.44	114.03	192.26	14.9	29.6	40.1	0.0	37.6	62.4		13.0	17.6	26.4
Southern Wanganui Lakes	148.77	50.66	0.00	34.1	0.0	34.1	20.9	39.0	40.0		0.0	17.1	33.2
Tamaki – Hopelands	338.48	99.51	29.65	29.4	12.4	38.2	20.9	69.7	9.4	188.0	6.0	18.4	29.8

Water Management Subzone	LINZ River length (km)	Baseline stock exclusion (km)	SLUI stock exclusion (km)	Percent stock exclusion baseline (%)	Percent stock exclusion due to SLUI (%)	Current stock exclusion (%)	Dairy (%)	Sheep and beef (%)	Other (%)	Median *E. coli* (MPN)	Reduction due to SLUI (%)	Modelled reduction in *E. coli* due to current level of stock exclusion (%)	Potential additional reduction (%) with no stock access
Tangarakau	469.18	65.48	2.68	14.0	0.7	14.5	0.0	28.1	71.9		0.3	6.4	37.6
Te Maire	276.73	67.15	1.51	24.3	0.7	24.8	12.5	55.9	31.6	135.0	0.3	11.7	35.6
Tidal Rangitikei	47.53	18.61	0.00	39.2	0.0	39.2	27.4	28.6	44.0		0.0	20.7	32.1
Tokiahuru	80.96	14.81	2.88	18.3	4.4	21.9	0.7	13.2	86.2	39.8	2.0	9.8	35.1
Turitea	41.32	10.76	0.00	26.0	0.0	26.0	6.1	38.0	55.9		0.0	12.1	34.4
Tutaenui	341.11	115.02	0.00	33.7	0.0	33.7	20.1	65.6	14.3		0.0	16.3	32.0
Upokongaro	165.66	23.64	8.58	14.3	6.0	19.5	0.0	42.7	57.3		2.7	8.6	35.4
Upper Akitio	191.44	33.81	8.48	17.7	5.4	22.1	0.6	57.9	41.6		2.4	9.8	34.4
Upper Gorge	101.77	32.54	0.42	32.0	0.6	32.4	34.4	49.2	16.4	207.5	0.3	16.6	34.8
Upper Hautapu	371.19	67.34	1.63	18.1	0.5	18.6	1.3	58.4	40.3	110.0	0.2	8.3	36.1
Upper Kumeti	10.98	6.04	0.00	55.0	0.0	55.0	23.6	12.5	63.9		0.0	30.7	25.1
Upper Makotuku	12.81	2.22	0.00	17.4	0.0	17.4	0.4	18.7	80.9	61.5	0.0	7.7	36.7
Upper Manawatu	975.97	240.34	11.18	24.6	1.5	25.8	11.4	80.4	8.3	426.7	0.7	11.9	34.3
Upper Mangahao	243.05	58.78	2.13	24.2	1.2	25.1	7.2	24.8	67.9	135.0	0.6	12.0	36.0
Upper Manganui o te Ao	13.85	2.15	0.00	15.5	0.0	15.5	0.0	14.9	85.1		0.0	6.8	37.2
Upper Mangaone Stream	424.71	143.38	7.16	33.8	2.5	35.4	26.3	67.8	5.9		1.2	17.4	31.7
Upper Mangatainoka	66.54	13.86	0.00	20.8	0.0	20.8	2.0	26.3	71.6	58.0	0.0	9.4	35.9
Upper Mangawhero	214.18	54.01	3.67	25.2	2.3	26.9	4.2	49.9	45.9	95.5	1.0	12.2	33.2
Upper Moawhango	16.92	0.92	0.00	5.4	0.0	5.4	0.0	1.3	98.7		0.0	2.4	41.6
Upper Ohau	55.93	10.43	0.00	18.6	0.0	18.6	2.7	8.4	88.9	45.0	0.0	9.0	39.4
Upper Ohura	1189.99	237.93	2.24	20.0	0.2	20.2	2.3	56.1	41.5	477.5	0.1	9.0	35.7

Water Management Subzone	LINZ River length (km)	Baseline stock exclusion (km)	SLUI stock exclusion (km)	Percent stock exclusion baseline (%)	Percent stock exclusion due to SLUI (%)	Current stock exclusion (%)	Dairy (%)	Sheep and beef (%)	Other (%)	Median *E. coli* (MPN)	Reduction due to SLUI (%)	Modelled reduction in *E. coli* due to current level of stock exclusion (%)	Potential additional reduction (%) with no stock access
Upper Ongarue	554.21	95.51	12.26	17.2	2.7	19.4	2.7	23.2	74.1		1.2	8.9	37.0
Upper Oroua	407.35	92.13	16.52	22.6	5.2	26.7	14.1	46.0	39.9	455.3	2.5	12.9	35.4
Upper Pohangina	152.24	25.47	29.71	16.7	23.4	36.2	0.0	25.5	74.5		10.3	15.9	28.1
Upper Rangitikei	175.05	26.87	8.36	15.3	5.6	20.1	0.0	11.4	88.6		2.5	8.9	35.1
Upper Tamaki	42.96	11.35	0.00	26.4	0.0	26.4	8.3	39.1	52.6	9.0	0.0	12.5	34.7
Upper Tiraumea	847.00	167.28	25.61	19.7	3.8	22.8	0.9	79.8	19.3		1.7	10.1	34.1
Upper Tokomaru	32.44	4.41	0.00	13.6	0.0	13.6	0.0	13.4	86.6	64.0	0.0	6.0	38.1
Upper Turakina	1154.14	205.86	45.92	17.8	4.8	21.8	0.3	82.9	16.8		2.1	9.6	34.5
Upper Whakapapa	90.98	19.57	2.24	21.5	3.1	24.0	0.0	11.8	88.2		1.4	10.5	33.5
Upper Whangaehu	106.59	14.77	0.00	13.9	0.0	13.9	0.8	22.2	76.9	4.5	0.0	6.2	38.5
Upper Whanganui	95.92	12.89	1.41	13.4	1.7	14.9	0.0	8.0	92.0		0.7	6.6	37.4
Waihi	320.63	61.60	8.74	19.2	3.4	21.9	0.0	88.6	11.4		1.5	9.7	34.3
Waikawa	31.62	10.41	0.00	32.9	0.0	32.9	18.0	15.5	66.4	193.0	0.0	17.7	36.0
Waimarino	8.42	0.64	0.00	7.6	0.0	7.6	0.0	5.3	94.7		0.0	3.3	40.7
Waitangi	44.59	10.41	0.00	23.3	0.0	23.3	6.9	40.1	53.0	223.0	0.0	10.9	35.8
Waitarere	4.11	2.18	0.00	52.9	0.0	52.9	25.4	24.6	50.0		0.0	28.1	25.0
Weber – Tamaki	121.48	24.56	0.58	20.2	0.6	20.7	6.0	86.4	7.6		0.3	9.3	35.8
Whangamomona	192.44	17.63	2.53	9.2	1.4	10.5	0.0	29.1	70.9		0.6	4.6	39.4
Average				**24.0**	**3.3**	**26.6**	**12.6**	**47.9**	**39.5**	**192.9**	**2.6**	**12.8**	**34.4**

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