Ruamahanga Catchment Modelling

Greater Wellington Regional Council

Water quality freshwater objectives and load setting

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Jacobs New Zealand Limited

Level 3, 86 Customhouse Quay,
PO Box 10-283
Wellington, New Zealand
T +64 4 473 4265
F +64 4 473 3369
www.jacobs.com

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Contents

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Glossary

Item	Description
FMU	Freshwater Management Unit (catchment/watershed or water management area of which FWO and load targets will be set)
FWO	Freshwater Objective (an in-stream concentration, usually relating to a NOF band goal)
Limit	An FMU generated load (tonnes/year) that cannot be exceeded
Target	An FMU generated load (tonnes/year) which is a target to achieve by a certain date (i.e. 2040)
NPSFM	National Policy Statement for Freshwater Management 2014 (amended)
NOF	National Objectives Framework (within the NPSFM), which sets the attribute tables and band categories (i.e. B band for nitrate-N based on median and 95th concentration percentiles in mg/L)
Analyte	Various water quality parameters (i.e. nitrate-N, dissolved reactive phosphorus) that were analysed to set FWO
MAS	Minimum Acceptable State (the current in-stream concentration and NOF band based off ~3–5 years of observed water quality data at relevant FMU sites)
Native Load	Load (tonnes/year) that comes off native forest landuse
Background Natural Load	Load (tonnes/year) that is always present in the soil, even after deforestation from native bush. For the purposes of this assessment, the leaching and runoff rates are considered the same as native bush.
Non-Native Load	Load from every landuse except for native forest, such as leaching and runoff from farming (stock, fertilizers etc) that can be mitigated to achieve FWO and targets.

1. Background

This document provides a summary on the methodology applied in setting Freshwater Objectives (FWOs) for a range of River and Lake Sites and Freshwater Management Units (FMUs) within the Ruamahanga Catchment. This follows the scenario water quality modelling which was undertaken to assess the potential reductions in nutrient concentrations that may occur with different adoptions of sustainable land management practices (see Jacobs 2018).

FWO is the intended environmental outcome in an FMU, which may be an in-stream nutrient concentration and/or an attribute band (i.e. A, B, C or D), as set out in the National Policy Statement for Freshwater Management 2014 (amended) (NPSFM), and more specifically with the National Objectives Framework (NOF).

Following presentation of the Ruamahanga water quality scenario modelling results (Jacobs 2018), the Whaitua Committee were tasked with identifying target FWOs as a NOF attribute band for Ammoniacal - Nitrogen (NH_4-N), Nitrate-Nitrogen (NO_3-N), *E. coli* and Periphyton. A target date (2025, 2040 and 2080) were associated with these attributes. For example, the Tauanui River NO_3-N FWO set by the Whaitua is an A band by 2040.

The Whaitua FWO attribute bands and target dates were used to set in-stream concentrations, that will help guide the limit and target setting process (relating to loads of the contaminants) within each FMU. For example, an in-stream concentration that fits the target FWO attribute state (i.e. A band) and is achievable within water quality modelling scenarios will have an associated annual load (tonnes/year) for the scenario, where the annual load can then be calculated and set as a limit or a target.

For the purposes of reporting, a limit is assumed to be a load that will be required to be met immediately while a target is a load limit set for a specific date, linking to the FWO in-stream concentration chosen by the Whaitua (i.e. 2040).

It is recommended that the baseline modelling report (Jacobs 2018b) and the technical scenarios modelling report (Jacobs 2018) are read to understand the assumptions and limitations that feed into setting of FWO and loads.

2. Methodology

A summary of the methodology to carry out the FWO assessment is as follows:

- Obtain Whaitua FWOs for Ruamahanga rivers, lakes and relevant FMU;
- Identify river and lake water quality monitoring sites that correspond to each FMU;
- Analyse the existing water quality data (nutrients and *E. coli*) within each FMU and identify the current NPSFM NOF band for relevant analytes and the 'Minimum Acceptable State' (MAS);
- Set the in-stream concentrations for nutrients and *E. coli* for each river FMU to achieve the Whaitua FWO, based on the modelled scenario results;
- Set target lake concentrations (nutrients and *E. coli*) for each lake FMU to achieve the Whaitua FWO based on the modelled scenario results;
- Cross check the scenario applied to the lakes correlates (as a minimum requirement) with all FMUs draining to that lake;
- Set target FMU generated loads for nutrients based upon the FWO in-stream concentrations;
- Carry out an analysis of the baseline and target attenuated loads for nutrients;

- Carry out an analysis of the native, background and anthropogenic contributes to the baseline and target FMU generated loads; and
- Set the target FMU loads for suspended sediment.

This is detailed further in the following section.

2.1 Whaitua FWOs

Draft Whaitua FWO were provided in two documents, titled:

- Summary sheet of all draft FWOs for Ruamahanga whaitua - lakes - updated Dec 17
- Summary sheet of all draft FWOs for Ruamahanga whaitua - rivers - updated Dec 17

An example of this is included below (**Figure 2.1**).

RIVERS	NOF attributes					
River	E.coli	E.coli	Periphyton	Periphyton	Ammonia toxicity	Ammonia toxicity
	Now	Objective	Now	Objective	Now	Objective
Tauanui River	D*	A	C/D*	B	A*	A
Turanganui River	B*	B	C/D*	B	A*	A
Taueru River	C	C	D*	C	A	A
Makahakaha Stream	A*	A	?	B	A*	A
Huangarua River	B	B	C	B	A	A

Figure 2.1 : Example of river FWO set by the Whaitua (target dates not included in this image)

The FWOs in these two documents were used to guide the setting of in-stream concentrations for each of the River sites. These documents are attached to this memo as **Appendix A**.

2.2 River sites and FMUs within the Ruamahanga Catchment

There are 24 river sites in the Ruamahanga catchment for which the Whaitua have proposed FWO. There are only 21 FMUs within the Ruamahanga catchment, as some river sites have been agglomerated into one FMU.

An assessment of the current water quality in the Ruamahanga catchment was undertaken utilising monitoring by Greater Wellington Regional Council (GWRC) at sites across the catchment. There are 18 sites which have long-term monthly water quality monitoring and are suitable to assess the current baseline state of a range of water quality parameters. These are outlined in **Table 1**.

Table 1 : FMUs and water quality monitoring sites in Ruamahanga

FMU	River site name	Corresponding monitoring site for In-Stream Concentrations
Kopuaranga River	Kopuaranga – Stuarts	Kopuaranga River at Stuarts
Whangaehu River	Whangaehu - confluence	Whangaehu River at 250m from Confuence
Upper Ruamahanga River	Ruamahanga – McLays	Ruamahanga River at McLays
	Ruamahanga – Double Bridges	Ruamahanga River at Double Bridges

FMU	River site name	Corresponding monitoring site for In-Stream Concentrations
Mangatarere River	Mangatarere – SH2	Mangatarere River at SH2
Parkvale Stream	Parkvale – Weir	Parkvale Stream at Weir
Waipoua River	Waipoua – Colombo	Waipoua River at Colombo Rd Bridge
Waingawa River	Waingawa – South Road	Waingawa River at South Road
Waiohine River	Waiohine – Gorge	Waiohine River at Gorge
	Waiohine – Bicknells	Waiohine River at Bicknells
Tauherenikau River	Tauherenikau - Websters	Tauherenikau River at Websters
Western Lake streams	N/a	-
Eastern Hill streams	N/a	-
Huangarua River	Huangarua – Ponatahi	Huangarua River at Ponatahi Bridge
Makahakaha Stream	Makahakaha - confluence	-
Tauanui River	Tauanui – confluence	-
Turanganui River	Turanganui – confluence	-
Taueru River	Taueru - Gladstone	Taueru River at Gladstone
Ruamahanga River Main Stem[1]	Ruamahanga- Wardells	
	Ruamahanga- Gladstone	Ruamahanga River at Gladstone Bridge
	Ruamahanga- Waihenga	Ruamahanga River at Waihenga
	Ruamahanga- Pukio	Ruamahanga River at Pukio
	Ruamahanga -upstream of Lake Wai Outlet	Ruamahanga River at Boat Ramp
Otukura Stream	Otukura - confluence	-
Valley floor streams	N/a	-
South Coast streams	N/a	-
1- Ruamahanga River Main Stem is not an FMU, however is an in-stream concentration FWO site		

2.3 Water Quality Monitoring Data Analysis

Monthly water quality data was provided by GWRC for the monitoring sites in **Table 1**. The data was from 2012 to the end of 2017.

The monthly water quality data from GWRC included information on:

- Total Phosphorus (TP) and Dissolved Reactive Phosphorus (DRP)
- Total Nitrogen (TN), Nitrate-Nitrogen (NO_3-N), Ammoniacal-Nitrogen (NH_4-N)
- Dissolved Inorganic Nitrogen (DIN)
- *E. coli.*

The first step involved assessing the monitoring data to determine each FMU's current attribute state for each analyte and median (50th percentile), 95th percentile or maximum in-stream concentrations, as well as assessing the exceedances of 260 and 540 cfu/100ml for *E. coli*. This was used to guide a 'Minimum Acceptable State' (MAS), representing the baseline water quality concentration and attribute state that should be maintained or improved on.

2.3.1 Sample Size and Hazen Williams analysis

Assessing the observed water quality data followed recommendations from:

- McBride, G. 2016. National Objectives Framework- Statistical considerations for design and assessment. NIWA. Report prepared for Ministry for the Environment.

McBride (2016) describes the approach undertaken to assess monitoring data for setting attribute state (NOF bands) relative to the NPSFM. A key component of this is the minimum sample size required to have confidence in the statistical outputs (i.e. percentiles). McBride (2016) recommends a minimum of 3 years of monthly water quality data, but preferable 5 years is used to determine attribute states. Repeat assessments in the future would then be undertaken using either a rolling average (removing the 'oldest' year as a new year of data becomes available) or adjacent data approach (comparing years 1-3 against years 4-6). See Table 2.

Table 2 : Data selection regime for annual assessments using five years' data (McBride 2016).

Year (since commencement of an assessment regime)								
1	2	3	4	5	6	7	8	9
√	√	√	√	√				
x	√	√	√	√	√			
x	x	√	√	√	√	√		
x	x	x	√	√	√	√	√	
x	x	x	x	√	√	√	√	√

"√" denotes data to be used in the assessment; "x" denotes data that are available but are not used; blank cells denote "no data".

Following the recommendations in McBride 2016, the most recent 5 years of water quality records (~60 samples) were selected and analysed in a Hazen Williams Calculator to determine median and 95th percentiles for each of the analytes in **Section 2.3.** This occurred at the 17 sites. For some sites, data availability for analysis was less, and a threshold of roughly 3 years (>33 samples) was selected as the cut-off requirement for a sites observed data to be considered statistically significant, and useable for FWOs and in-stream concentrations. An example of this output is in **Table 3.**

Table 3 : Hazen Williams concentration (mg/L) outputs for Huangarua River FMU

Attribute	NH_4-N	DIN	DRP	E-Coli	NO_3-N	TP	TN
50th percentile	0.005	0.24	0.006	80	0.23	0.014	0.45
95th percentile	0.019	0.67	0.029	613	0.66	0.076	1.13
Maximum	0.030	0.82	0.036	18,000	0.79	0.320	1.83
Average Max (5 year)	0.014						

Further to the Hazen William analysis in **Table 3**, an assessment of the NH_4-N average maximum concentrations was undertaken. This is required in the NPSFM (2014) to set a NOF attribute state for NH_4-N. Using a single maximum value from 3–5 years of water quality data was considered to be un-representative of the sites typical water quality conditions, as one value may be an outlier and can lead to band shifts (i.e. a site would move from A to B band). Hence, the maximum value from each of the 3–5 years of water quality data was determined (i.e. a maximum for 2013, 2014, 2015 etc.), and then all values were averaged to determine NH_4-N 'average maximum concentrations'. The results of this for all sites are contained in **Appendix B**.

For *E. coli* the NPSFM swimmability bands also require an assessment of the percentage of measurements above 260 and 540 cfu/100ml to determine the attribute status. This was calculated by counting the number of exceedances of these values, and then dividing that by the total number of samples.

2.3.2 NOF Attribute States

Following steps in **Section 2.3.1**, the NOF attribute states were calculated for NO_3-N and NH_4-N, based on the thresholds outlined in the NPSFM (2014).

This was undertaken for the 17 sites with observed water quality data (see **Table 1**), and the concentrations were used to determine their current freshwater attribute state (i.e. A, B, C or D band). The outputs were compared to the 'now' attribute states outlined in **Section 2.1**. In some cases, using current data (updated to 2017 and for longer monitoring periods) and following the approach recommended by McBride (2016), has resulted in band shifts in these monitoring sites.

For example, Parkvale Stream at Renalls Weir is now a C band for NO_3-N, when previous assessments had identified this site as a B band (see **Table 4**).

Table 4 : NOF attribute state for Parkvale Stream at Renalls Weir

	NO_3-N	NH_4-N
NOF Band	C	B
50^{th} (mg/L)	1.74	0.012
95th or Average max (mg/L)	3.90	0.095

For the remaining 8 sites, which have no observed water quality data, the assessments for FWO's used modelling outputs (from 1992 to 2014) to determine the in-stream concentrations and attribute states, or assigned a proxy site with data as agreed with by GWRC. The results for all sites are contained in **Appendix B**.

2.3.3 In-stream concentrations, Minimum Acceptable State (MAS)

Following the analysis of observed water quality data and calculation of percentiles, the MAS was assigned for NO_3-N, NH_4-N, DIN, DRP and *E. coli*. MAS represents the 50^{th} and 95^{th} percentiles concentrations (mg/L) for water quality constituents as determined from the Hazen Williams analysis. The Hazen Williams analysis was also applied to the *E. coli* swimmability assessments, but not applied to determine average maximum concentrations (mg/L) for NH_4-N. These results set the current state of the in-stream water quality condition, which should be maintained or improved through the adoption of various mitigation packages which were modelled as scenarios.

These states are also linked to the attribute state (NOF band) for NO_3-N, NH_4-N, and where the Whaitua has set FWO to move the attribute state to a different band, the MAS has formed the baseline of the analysis from which scenario modelling percentage reductions have been applied. The results of this for all sites with data are contained in **Appendix C**. An example of MAS concentrations for water quality analytes has been presented in Table 5.

Table 5 : MAS in-stream concentrations (mg/L) for water quality analytes measured at Huangarua at Ponatahi Bridge

MAS	DIN	DRP	NH_4-N	NO_3-N
Median (50th)	0.24	0.006	0.005	0.23
95th (or average max for NH_4-N)	0.67	0.029	0.014	0.66

2.4 FWO in-stream concentrations

The Whaitua FWOs are targeting a shift in attribute state (i.e. B to A band) in some sites, by a certain date. To link the Whaitua FWO with in-stream concentrations (which can then be linked back to loads generated at the FMU), the following approach has been undertaken.

1. Consider the Whaitua FWO outlined in **Section 2.1** against the NOF bands determined from monitoring data in **Section 2.3.**

2. Calculate the percentage (%) reductions determined from each of the scenario modelling packages (BAU, Silver and Gold) at different timescales, for each analyte (DRP, TP etc.). This was completed in Jacobs 2018.

    a. The percentage reductions are based off assessing the scenario concentration results against the baseline modelling, with an example presented in **Table 6**

    b. This is to determine if it is feasible to move from the current MAS and attribute state, to the FWO target defined by the Whaitua.

Table 6 : NO_3-N percentage (%) reductions as modelled through scenarios BAU 2025 to Silver 2040

River Site	BAU 2025		BAU 2040		BAU 2080		Silver 2025		Silver 2040	
	50th	95th	50th	95th	50th	95th	50th	95th	50th	95th
Huangarua at Ponatahi Bridge	-3.8	0.6*	-3.9	0.0	-3.9	0.0	-11.4	-7.9	-16.0	-11.5
Kopuaranga at Stuarts	-10.2	-9.1	-10.2	-9.1	-10.2	-9.1	-13.2	-11.4	-17.5	-15.9
Makahakaha Stream Mouth	0.0	0.0	0.0	0.0	0.0	0.0	-3.6	-3.4	-6.0	-5.6
Mangatarere_at_SH2	-0.8	0.0	-0.9	0.0	-3.4	-2.0	-6.6	-0.4	-6.8	-0.5
Otukura Stream Mouth	-1.1	-5.1	-1.1	-5.1	-1.1	-5.1	-15.1	-18.1	-15.1	-18.1
Parkvale Weir	-0.2	0.6	-0.2	0.6	-0.2	0.6	-11.6	-6.3	-11.6	-6.3
Rua US of Lake Wairarapa Outlet	-5.6	-1.1	-5.6	-1.1	-5.8	-1.6	-17.4	-5.5	-18.2	-8.3
Taueru River at Gladstones	-0.04	-0.01	-0.04	-0.01	-0.04	-0.01	-3.6	-3.0	-8.9	-8.1

* In some situations there has been a minor increase in concentrations during BAU, usually attributed to changes (minor reductions) in the flow regime where BAU considered groundwater takes at 100% of their consented rate, while baseline modelling ramped up over time.

3. Apply the percentage reduction that were simulated in models to the MAS median and 95th percentile value for all scenarios to all FMUs (BAU, Silver and Gold) to determine the NOF bands obtained with each simulated scenario.

4. For each analyte (NO_3-N, NH_4-N & *E. coli*) choose the model scenario which best achieves the Whaitua FWO objectives for the analyte based on the reduced concentrations from Step 3.

    a. Review the lowest effort scenario applicable to achieve the FWO Objective (for example whether maintain would achieve the FWO objective or if Silver is required).

    b. Where an FMU's FWO is the same as its current state (i.e. maintain in A band), apply the BAU scenario and consider the Whaitua 'target date' (i.e. 2080 would be BAU2080). BAU scenarios should be applied to achieve improved water quality and prevent degradation.

    c. Where an FMU has a Whaitua FWO that requires a change in attribute state (i.e. B to A band by 2040 for NO_3-N) review whether BAU or Silver scenarios are able to achieve the FWO (Gold has not been considered in any assessments at this stage as is considered the least likely to be adopted within the catchment).

    d. Should both BAU and Silver scenarios be acceptable to change NOF bands, choose the lowest scenario for each analyte.

    e. Where an FMU's Whaitua FWO requires a shift in the NOF band (i.e. C to A in NO_3-N for Parkvale Stream at Renalls Weir by 2040) but this cannot be achieved by modelling:

        i. Apply the maximum threshold values for the respective FWO NOF band as the 'target' in-stream concentration. For example, NO_3-N A band would be <1.0 mg/L (median) and <1.5 mg/L (95th). These would become the FWO in-stream concentrations.

        ii. These sites have applied the "target date" Silver scenario with the note that additional mitigations are required to achieve the target. For example, Parkvale Stream at Renalls Weir has applied Silver 2040 + additional mitigations as the objective scenario.

5. Finally, for consistency, for each FMU choose the overall model scenario which best achieves all Whaitua FWO objectives for all analytes (NO_3-N, NH_4-N & *E. coli*) and also achieves downstream objectives:

    a. Review all analytes for each FMU and choose the highest model scenario as the overall applied scenario (for example for Taueru River at Gladstone, BAU 2040 was required to achieve the objective for NH_4-N, however Silver 2040 was required to achieve *E. coli* objective, therefore Silver 2040 was chosen as the overall objective scenario for the FMU).

    b. Review downstream FMUs to ensure that the downstream sites do not require a higher level of reduction (i.e. Lake Wairapapa requires Silver 2040 + additional mitigations to achieve FWO targets, and therefore any non-native FMU draining to the lake must apply Silver 2040 to achieve this target).

6. Calculate the FWO in-stream concentration for all analytes for each FMU based upon the overall model scenario:

    a. For each FMU identify the reduced concentration associated with the overall target model scenario.

    b. As identified above, where an FMU's Whaitua FWO requires a shift in the NOF band for an analyte but this cannot be achieved by modelling apply the maximum threshold values for the respective FWO NOF band as the 'target' in-stream concentration.

7. This ‘reduced’ in-stream concentration that meets the Whaitua FWO for all analytes now becomes the FWO concentration.

There are four FMUs that have no in-stream monitoring locations or definable model river reaches. Each of these FMUs encompass a wide area of many smaller streams with varying landuse types. To set in-stream concentrations (FWOs) and apply scenario reductions, adjacent proxy sites were used to set the values. These proxy sites were generally adjacent FMUs that have similarities in landuse and soils, and were agreed with GWRC on 28/3/2018. The four FMUs and the representative proxy sites are:

- Eastern Hill Streams – used proxy site “Huangarua at Ponatahi Bridge” to set FWO
- Valley Floor Streams – used proxy site “Otukura Stream” to set FWO
- Western Lake Streams – used proxy site “Tauherenikau at Websters” to set FWO
- South Coast Streams - used proxy site “Tauherenikau at Websters” to set FWO

2.4.1 FWO ‘Target’ in-stream concentrations example 1

The Whaitua Committee set the Taueru River FMU FWO as an A band by 2040 for NO_3-N and NH_4-N, and a C band for *E. coli* by 2040. The observed data at Taueru River at Gladstones indicates that the FMU currently has concentrations that result in B Band for NO_3-N, A Band for NH_4-N and a D Band for *E. coli*.

The percentage reductions for Taueru River at Gladstones (see **Table 6** as an example for NO_3-N) have been applied to NO_3-N, NH_4-N and *E. coli* to calculate the in-stream concentrations for each modelled scenario, the resulting in-stream concentrations are shown in **Table 7.**

From the table, the lowest effort scenario to achieve each objective for Taueru FMU is Silver 2025 for NO_3-N, maintain for NH_4-N, and Silver 2040 for *E. coli*. Therefore, to achieve all FWO targets it is necessary to apply Silver 2040, which is the overall recommended scenario.

Table 7 : Taueru FMU observed and reduced in-stream concentrations for modelled scenarios

Analyte	Observed Data					Whaitua Objective		Scenario concentrations				
	NOF BAND	50th	95th /max	%>260 CFU/100 mL	%>540 CFU/100 mL	NOF BAND	Date	Scenario	50th	95th /max	%>260 CFU/100 mL	%>540 CFU/100 mL
NO_3-N	B	0.78	1.53	-	-	A	2040	BAU 2025	0.77	1.53	-	-
								BAU 2040	0.77	1.53	-	-
								BAU 2080	0.77	1.53	-	-
								Silver 2025	0.75	1.48	-	-
								Silver 2040	0.71	1.41	-	-
								Silver 2080	0.71	1.41	-	-
								Gold 2025	0.71	1.41	-	-
								Gold 2040	0.71	1.41	-	-
								Gold 2080	0.71	1.41	-	-

Analyte	Observed Data					Whaitua Objective		Scenario concentrations				
	NOF BAND	50th	95th /max	%>260 CFU/100 mL	%>540 CFU/100 mL	NOF BAND	Date	Scenario	50th	95th /max	%>260 CFU/100 mL	%>540 CFU/100 mL
NH_4-N	A	0.006	0.048	-	-	A	2040	BAU 2025	0.005	0.048	-	-
								BAU 2040	0.005	0.048	-	-
								BAU 2080	0.005	0.048	-	-
								Silver 2025	0.005	0.047	-	-
								Silver 2040	0.005	0.044	-	-
								Silver 2080	0.005	0.044	-	-
								Gold 2025	0.005	0.044	-	-
								Gold 2040	0.005	0.044	-	-
								Gold 2080	0.005	0.044	-	-
E. coli	D	120	1,375	19%	10%	C	2040	BAU 2025	114	1362	18%	10%
								BAU 2040	114	1362	18%	10%
								BAU 2080	114	1362	18%	10%
								Silver 2025	107	1279	17%	8%
								Silver 2040	99	1171	15%	7%
								Silver 2080	95	1130	14%	6%
								Gold 2025	100	1189	15%	7%
								Gold 2040	95	1130	14%	6%
								Gold 2080	95	1130	14%	6%

Prior to setting the limits a downstream check was carried out. Taueru at Gladstone flows to the Ruamahanga River, the recommended scenario to achieve the Ruamahanga in-stream targets is BAU 2040. Therefore, Silver 2040 is an acceptable scenario to apply to the Taueru FMU.

The FWO in-stream concentrations for Taueru have been applied for the FMU from the Silver 2040 reduced concentrations, including for DIN and DRP. The MAS concentrations and target FWO concentrations are contained in **Table 8**.

Table 8 : Taueru Stream FMU in-stream concentrations and FWO targets

Analyte	Minimum Acceptable State (MAS)				Objective Targets				
	50th	95th /max	%>260 CFU/100 mL	%>540 CFU/100 mL	Scenario	50th	95th /max	%>260 CFU/100 mL	%>540 CFU/100 mL
NO_3-N	0.78	1.53	-	-	Silver 2040	0.71	1.41	-	-
NH_4-N	0.006	0.048	-	-		0.005	0.044	-	-
DIN	0.81	1.56	-	-		0.71	1.45	-	-
DRP	0.015	0.051	-	-		0.009	0.021	-	-
E. coli	120	1,375	19%	10%		99	1,171	15%	7%

2.4.2 FWO ‘target’ in-stream concentrations example 2

The Whaitua Committee set the Parkvale Stream FMU FWO as an A band by 2040 for NO_3-N and NH_4-N, and a C band for *E. coli* by 2040. The observed data at Parkvale Stream at Renalls Weir indicates that the FMU currently has concentrations that result in C Band for NO_3-N, B Band for NH_4-N and an E Band for *E. coli*.

The percentage reductions for Parkvale Stream at Renalls Weir (see **Table 6** for an example of NO_3-N reductions) have been applied to NO_3-N, NH_4-N and *E. coli* to review the achieved in-stream concentrations for each modelled scenario in **Table 9.**

Table 9 : Parkvale FMU observed in-stream concentrations and reduced in-stream concentrations for modelled scenarios

Analyte	Observed Data					Whaitua Objective		Scenario concentrations				
	NOF BAND	50th	95th /max	%>260 CFU/100 mL	%>540 CFU/100 mL	NOF BAND	Date	Scenario	50th	95th /max	%>260 CFU/100 mL	%>540 CFU/100 mL
NO_3-N	C	1.74	3.90	-	-	A	2040	BAU 2025	1.73	3.92	-	-
								BAU 2040	1.73	3.92	-	-
								BAU 2080	1.73	3.92	-	-
								Silver 2025	1.53	3.66	-	-
								Silver 2040	1.53	3.66	-	-
								Silver 2080	1.53	3.66	-	-
								Gold 2025	1.52	3.64	-	-
								Gold 2040	1.52	3.64	-	-
								Gold 2080	1.52	3.64	-	-
NH_4-N	B	0.012	0.100	-	-	A	2040	BAU 2025	0.012	0.101	-	-
								BAU 2040	0.012	0.101	-	-
								BAU 2080	0.012	0.101	-	-
								Silver 2025	0.012	0.101	-	-
								Silver 2040	0.012	0.101	-	-
								Silver 2080	0.012	0.101	-	-
								Gold 2025	0.012	0.101	-	-

								Gold 2040	0.012	0.101	-	-
								Gold 2080	0.012	0.101	-	-
E. coli	E	350	2205	64%	28%	C	2040	BAU 2025	250	2218	64%	28%
								BAU 2040	250	2218	64%	28%
								BAU 2080	250	2218	64%	28%
								Silver 2025	250	2148	64%	28%
								Silver 2040	250	2079	64%	28%
								Silver 2080	250	2007	64%	28%
								Gold 2025	250	2112	64%	28%
								Gold 2040	250	2007	64%	28%
								Gold 2080	250	2007	64%	28%

Table 9 shows none of the modelled scenarios can achieve the objectives set for any of the three analytes. To achieve the Whaitua FMU FWO significant reductions from the MAS concentrations are required (>70% for 95th NO_3-N).

Additional mitigations are required for this FMU to achieve the objectives, above what is simulated in the scenarios. The best scenario applied is Silver 2040, as this is the highest likely level of mitigation to be applied by 2040. As such the objective scenario is Silver 2040 + extra mitigations required.

Silver 2040 + extra mitigations will not prevent the BAU 2040 of the Ruamahanga River downstream being achieved.

The FWO in-stream concentrations were set at the upper threshold for the NOF bands based on the Whaitua FWO targets, and further consideration will be needed to determine if this is feasible. The resulting MAS and objective targets are contained in **Table 10**.

Table 10 : Parkvale Stream FMU in-stream concentrations and FWO (mg/L)

Analyte	Minimum Acceptable State (MAS)				Objective Targets				
	50th	95th / max	%>260 CFU/100 mL	%>540 CFU/100 mL	Scenario	50th	95th / max	%>260 CFU/100 mL	%>540 CFU/100 mL
NO_3-N	1.74	3.90	-	-	Silver 2040 + extra mitigations required	1.00	1.50	-	-
NH_4-N	0.012	0.100	-	-		0.012	0.050	-	-
DIN	1.75	3.95	-	-		1.01	1.55	-	-
DRP	0.025	0.076	-	-		0.019	0.051	-	-
E. coli	350	2,205	64%	28%		130	1,200	34%	20%

2.5 FWO lake concentrations

The same methodology has been applied to the lake FWO, however only for TN, TP, NH_4-N and *E. coli*. As with the in-stream river locations, to link the Whaitua FWO NOF bands to FWO lake concentrations (which can then be linked back to loads generated at the FMU), the following approach has been undertaken.

1. Consider the Whaitua FWO outlined in **Section 2.1** against the NOF bands determined from monitoring data in **Section 2.3.**

2. Consider the percentage (%) reductions determined from each of the scenario modelling packages (BAU, Silver and Gold) at different timescales, for each analyte (TN, TP etc.).

    a. The % reductions are based off Waikato Universities lake modelling outputs, which show the % decrease in the median concentrations under the different scenarios (Allen 2017 and Allen 2017b).

    b. This is to determine if it is feasible to move from the current MAS and attribute state, to the FWO target defined by the Whaitua Committee.

3. Apply the percentage reduction that were simulated in Waikato University models to the MAS concentrations for all scenarios to Lake Wairarapa and Lake Onoke to determine the NOF bands obtained with each simulated scenario.

4. For each analyte (TN, TP, NH_4-N & *E. coli*) choose the model scenario which best achieves the Whaitua FWO objectives for the analyte based on the reduced concentrations from Step 3. For example, Silver 2040 for Lake Wairarapa.

5. For each upstream FMU that drains into the lake, apply the same overall model scenario which best achieves the selected Whaitua Committees lake FWO objectives for all lake analytes (TN, TP, NH_4-N & *E. coli*)

6. Calculate the FWO's concentrations for the lake for all analytes based upon the chosen modelled scenario:

    a. Where an FMU's Whaitua FWO requires a shift in the NOF band for an analyte but this cannot be achieved by modelling, apply the maximum threshold values for the respective FWO NOF band as the in-lake concentration.

2.6 Periphyton objectives (DIN and DRP)

The periphyton objectives were defined by the Whaitua Committee for the Ruamahanga FMUs. The NPSFM (2014 amended) requires consideration of DIN and DRP when assigning FWOs for periphyton. This document does not assess the periphyton concentrations assigned as FWOs, which was undertaken by GWRC. However, the DIN and DRP concentrations were determined based on:

1. Discussions with GWRC identified that without additional shading (solar radiation) and water temperature reductions, empirical models were showing significant decreases in DIN and DRP were required to shift NOF bands, greater than any simulated scenario reductions.

2. Based on the absence of a suitable method and data for modelling periphyton in Ruamahanga, the adopted approach was to assign FWO for DIN and DRP that followed the scenarios applied to NO_3-N and NH_4-N.

3. DRP MAS concentrations were subsequently decreased for each FMU by assigning the relevant scenario applied for the other analytes.

4. DIN FWO were determined by adding the NO_3-N and NH_4-N FWO concentrations, based on the assumption that these two nitrogen compounds make up the majority of dissolved inorganic nitrogen. While the percentage reduction approach could have been assigned (as per DRP), this method ensured all sites were captured, particularly those which had set FWO to upper NOF bands, outside of the simulated scenario results.

2.7 FWO ‘target’ generated FMU loads (NO_3-N and TP)

The FMU “target” loads comprise two different inputs. The first is the “target” leaching loads, these are associated with land use across the catchment and provide the largest part of the loads entering the Ruamahanga catchment. The second is the direct inputs from Waste Water Treatment Plants (WWTP), of which five are present within the catchment. Calculating these loads is undertaken in two different approaches, however they have been combined as a single set of results. These loads are both linked to the FWO in-stream concentrations. The following approach to determine load targets has been undertaken.

1. The current leaching/runoff load for each FMU for NO_3-N and TP was calculated from the OVERSEER baseline map, which was slightly modified to include direct NO_3-N and TP inputs to streams (due to the allowance of stock in streams in the base case). The combined leaching/runoff and direct inputs from streams[1] results in a higher total load out of the baseline OVERSEER map. This baseline leaching map was used to determine loads in FMUs through a GIS approach, which clipped the baseline shapefile to the area of the FMU and summed all leaching from different land uses within each FMU.

2. Nutrient loads of TP and NO_3-N from the WWTP were calculated off the input daily timeseries in the various models (baseline, BAU, Silver and Gold). This was undertaken by summing the daily load across the simulation and calculating the average annual load input to each FMU (i.e. for each WWTP there is a synthetic daily timeseries of concentration and flow from 1/7/1992-30/6/2014, which results in 22 years of data, the average annual load was used as the annual load input). See Jacobs 2018 for more detail. The WWTP load is an order of magnitude smaller than the leaching load (for NO_3-N), and as such has been treated independently of the leaching load.

3. The current total FMU load for NO_3-N and TP was then calculated by adding together the leaching inputs and the WWTP loads. This occurred for four FMUs;

    a. Mangatarere – Carterton WWTP

    b. Valley Floor Streams (draining to Ruamahanga River) – Greytown and Masterton WWTP’s,

    c. Western Lake Streams – Featherston WWTP and;

    d. Eastern Hill streams – Martinborough WWTP

4. The current baseline “nested” load for each FMU was then calculated, this is the load input to the FMU both from the land within the FMU and from any upstream FMUs. For example, Mangatarere FMU flows into the Waiohine FMU, and therefore the ‘nested’ Waiohine FMU load is the sum of both FMUs.

5. After calculating the baseline loads, the ‘target’ load for each FMU for NO_3-N and TP was determined. This was undertaken using the OVERSEER map for the identified scenario (for example Taueru FMU scenario is Silver 2040, therefore the OVERSEER Silver 2040 leaching map was used). The OVERSEER scenario maps have been updated to include the farm scale mitigations (see Jacobs 2018) and the retired and pole planted land. The selected OVERSEER leaching map was clipped to the FMU and the total load for NO_3-N and TP was calculated.

6. In addition, the target WWTP load calculated in step 2 for the four FMUs, encompassing five WWTP was selected based on the Silver 2040 scenario, as advised through correspondence with GWRC on 30/4/2018. This decision related to the Whaitua’s Committees 2040 swimmability goal for the Ruamahanga River, which requires a significant reduction in *E. coli* from the WWTP’s.

[1] Under BAU, Silver and Gold, stock exclusion meant no direct inputs to streams occurred from animals, with nutrient losses now smaller as they are confined to leaching (NO_3-N) and runoff (TP).

7. The “target” total FMU load for NO_3-N and TP was then calculated by adding together the leaching loads and the WWTP loads for relevant FMUs.

8. Following step 4, the “nested” target loads for each FMU were calculated. The scenario applied is based on each FMU target scenario.

2.7.1 FWO “Target’ loads example 1

The Mangatarere FMU has Carterton WWTP within the catchment, therefore the baseline load comprises the baseline leaching load and the average annual baseline WWTP loads for NO_3-N and TP. **Table 11** shows the current data for both leaching and the WWTP, and the relative contributions of each to the total current load.

Mangatarere “target” scenario is Silver 2040 + extra mitigations to achieve the in-stream Whaitua FWO target bands. Therefore, the Silver 2040 OVERSEER map was used to define the “target” leaching load. This value is shown in **Table 11**. The WWTPs will all have Silver 2040 applied, irrespective of the FMU leaching goal, the reduced WWTP load is contained in **Table 11.**

The overall Mangatarere target load is calculated by adding together both loads (**Table 11**). As there are no FMUs upstream of Mangatarere the “nested” load is the same as the FMU derived load.

Table 11 : Mangatarere FMU baseline NO_3-N and TP loads

FMU load	Baseline load (Tonnes/yr)		Target Loads (Tonnes/yr)			Load reduction (%)	
	NO_3-N	TP	Scenario	NO_3-N	TP	NO_3-N	TP
Mangatarere FMU total load	324.2	22.1	Silver 2040 +	288.7	11.7	11%	47%
Leaching load (OVERSEER map)	324.0	17.8		288.7	11.5	11%	35%
	99.96%	80.6%		99.99%	98.6%		
Carterton WWTP load (model output)	0.1	4.3		0.04	0.2	68%	96%
	0.04%	19.4%		0.01%	1.4%		

2.7.2 FWO ‘Target’ loads example 2

The “Target” scenario for the Waiohine River FMU to achieve the Whaitua FWO has been assessed as BAU 2040 to improve water quality.

There is no WWTP within the Waiohine FMU, and as such the baseline load is 100% comprised by leaching. The baseline FMU leaching loads for the Waiohine FMU are shown in **Table 12**. This table also shows the BAU 2040 FMU leaching loads for Waiohine, which show a decrease of 1% to NO_3-N and 5% to TP.

Mangatarere FMU drains into the Waiohine FMU; the “target” scenario for the Mangatarere FMU is Silver 2040 + extra mitigations to achieve the in-stream Whaitua FWO target bands (**Table 11**). The “nested” target load for the Waiohine River FMU includes the loads from both catchments, as shown in **Table 12**. The reduction in load for the Waiohine is 8.2% and 20.3% for NO_3-N and TP respectively.

Table 12: Waiohine FMU baseline and FWO targets loads

	Baseline load (leaching map) (Tonnes/yr)		Target Loads (leaching map) (Tonnes/yr)		
	NO_3-N	TP	Scenario	NO_3-N	TP
Waiohine FMU derived load	122.4	9.0	BAU 2040 (+Silver 2040 for Mangatarere)	121.1	8.6
Waiohine "nested" load (including Mangatarere)	446.4	31.1		409.8	20.2

2.8 FMU "target" attenuated loads (NO_3-N and TP)

Further to assessing the generated load, an assessment was carried out to estimate the approximate attenuated load, which is useful for nested load assessments in the lakes and provides a better representation of the load reaching the lakes.

The target loads described in **Section 2.7** are the generated loads from the land. The load is then attenuated through various natural process such as soil storage, denitrification, nitrification, adsorption etc. Modelling incorporates these attenuation factors in numerous subcatchments within Ruamahanga. The attenuated load is what determines the in-stream concentrations.

Understanding the attenuated load is important when considering the nested loads, particularly those that enter Lake Onoke and Lake Wairarapa. For this reason, an attenuation assessment was undertaken for each FMU which involved:

- Identifying the modelled attenuation factor applied to Nitrate-N and Total Phosphorus for each of the 237 sub catchments within the Source model.
- Overlay the FMUs against the sub-catchment map, and undertake a weighted average assessment based on area to determine the average attenuation factor for NO_3-N and TP in each FMU
- Apply this attenuation factor to each FMUs generated load, and sum the 'nested attenuated' load draining to the lakes.

The attenuated load has been outlined in **Appendix E** and is derived off attenuation factors presented in **Table 13**.

Table 13 : Weighted average attenuation factors per FMU

FMU name	NO_3-N (% reduction)	TP (% reduction)*
Eastern hill streams	71.8	25.0
Huangarua	79.6	25.0
Kopuaranga	66.1	38.7
Makahakaha	62.1	25.0
Mangatarere	30.2	52.4
Otukura Stream	74.9	25.0
Parkvale Stream	58.3	15.8
South coast streams	75.0	25.0

Streams discharging to Lake Wairarapa from the west	73.6	25.0
Tauanui	75.0	25.0
Taueru	59.2	25.0
Tauherenikau	79.9	11.6
Turanganui	75.0	25.0
Upper Ruamahanga	72.9	25.2
Valley floor streams	72.4	24.3
Waingawa	79.7	25.2
Waiohine	60.4	25.1
Waipoua	62.5	48.6
Whangaehu	74.9	25.1

* Phosphorus attenuation rates is deliberately low in modelling, to allow suitable calibrations to in-stream concentrations. As described in Jacobs 2018c, this is primarily due to the OVERSEER TP sub-models and the TP input generation rates (kg/ha/yr) being too low for native forest land (up to 3 times greater than OVERSEER simulations) with high erosion carrying particulate P.

2.9 Background Natural Loads

In addition to developing the current baseline and target loads, further assessments were undertaken to understand how the OVERSEER natural loads compared to observed water quality data, to determine the potential background load that would occur within the Ruamahanga Catchment if it were entirely native (in an unmodified state). Jacobs 2018c documents a comparative assessment of native water quality monitoring sites against OVERSEER leaching and runoff rates for NO_3-N and TP. Various native monitoring sites[2] were assessed to determine their annual average 'generated' load, through back calculation of flow weighted concentration data and estimated attenuation rates (a value of 0.5 attenuation was applied).

The 'observed' native leaching (NO_3-N) and runoff (TP) loads, delineated to the relevant catchment area of the monitoring site, were then compared against the OVERSEER loads used throughout the baseline and scenario models.

The purpose of this exercise was to identify whether the OVERSEER native loads for NO_3-N and TP were representative of the Ruamahanga native catchments, and whether native loads vary across the catchment due to different topography, geology, soils and climate conditions.

Native monitoring sites were primarily available for the Western Hill catchments (Tararua Ranges) and South Eastern Hill catchment (Huarangis), limiting the understanding of the potential native loads for the Eastern Hills (i.e. Taueru River). The following sites were assessed:

Western hill catchments (Tararuas)

- Waiohine at Gorge

2 Native monitoring sites were identified as long-term GWRC monitoring sites where the upstream catchment almost entirely comprises of native bush. Site vary from 93% to 99.7% native bush by area, with most native sites over 97% native bush.

- Beef Creek at Headwaters
- Waiorongomai at Forest Park
- Ruamahanga River at McLays

Eastern/Southern hill catchments (Haurangis)

- Tauanui River at Whakatomotomo Road
- Motuwaireka headwaters

Table 14 and **Table 15** present the average yield across Ruamahanga for the various native sites, comparing the observed water quality data corrected with a 0.5 attenuation factor against the OVERSEER modelling outputs. The method used to estimate the observed leaching and runoff generation rates (kg/ha/yr) is a flow binning approach outlined by Roygard, McArthur and Clark (2012).

Table 14 : Nitrate-N observed and modelled (OVERSEER) leaching rates (kg/ha/yr)

Location	Site Name	OVERSEER annual yield	Observed annual yield (flow binning)	Difference between OVERSEER and observed
Western Hill Catchments	Waiohine at Gorge	1.1	2.6	+136%
	Beef Creek at Headwaters	3.4	2.3	-32%
	Wairongomai at Forest Park	1.4	1.0	-28%
	Ruamāhanga River at McLays	1.7	1.7	0.0%
	Average	**1.9**	**1.9**	**0.0%**
Eastern Hill Catchments	Tauanui River at Whakatomotomo	1.0	0.6	-40%

Table 15 : Total Phosphorus observed and modelled (OVERSEER) runoff rates (kg/ha/yr)

Location	Site Name	OVERSEER annual yield	Observed annual yield (flow binning)	Difference between OVERSEER and observed
Western Hill Catchments	Waiohine at Gorge	0.2	1.2	500%
	Beef Creek at Headwaters	0.3	1.0	233%
	Wairongomai at Forest Park	0.2	0.5	150%
	Ruamāhanga River at McLays	0.2	0.8	300%
	Average	**0.2**	**0.9**	350%
Eastern Hill Catchments	Tauanui River at Whakatomotomo	0.2	0.4	100%

These tables show the modelled OVERSEER nitrate-N yields are comparable to the estimated yields calculated from the un-attenuated observed water quality data. However, the total phosphorus yields assigned to native land in OVERSEER are substantially underestimated, particularly in the Western Hill catchments (by a factor of roughly 3.5).

The OVERSEER rates were used in Source catchment modelling to simulate in-stream concentrations. While the Western (and Eastern) Hill catchments use lower input concentrations for TP (than the observed data indicates), this is offset through the calibration process which subsequently applied a smaller attenuation factor (than is likely occurring in reality) to ensure in-stream concentrations were calibrated to observed water quality data. See **Table 13** as an example.

It should be noted that while the TP yields that are observed are greater than what was simulated within OVERSEER, this is still significantly less than what is generated from non-native farming land. For example, it is not uncommon in the Ruamahanga Catchment that OVERSEER TP runoff rates for dairy and sheep and beef farming (on a range of soils and typically >1200 mm/year rainfall) exceed 4.0 kg/ha/yr.

The increased erosion from these catchments are also likely to be contributing to TP load, entrained with sediment. However, there was little particulate sediment and phosphorus data to confirm this assumption. This may explain the higher TP loads in the native catchments above the OVERSEER results. Therefore, while the current modelling utilises OVERSEER as the primary input of TP, future model updates should include a sediment derived phosphorus load due to erosion. OVERSEER has limitations in its phosphorus sub-models as described in Freeman et al. 2016. A key limitation is that it does not model P loss to water from river/stream bank erosion or mass flow events (i.e. landslides).

The main application of this natural yield assessment relates to setting load targets and limits for FMUs within Ruamahanga, and assigning a portion of the load that is considered to be the 'background natural'. In essence, a typical FMU nitrate-N or TP load may have:

- Native load generated from native forested land (if it exists within an FMU);
- 'Background natural' load (equivalent to the native load) that is assumed to continue to be generated from the land that was deforested for human use; and
- 'Non-native' load generated from all other land use practices on the deforested land, including additional leaching from stock and fertilisers.

The comparison between the flow binning approach and OVERSEER in Table 14 and Table 15 indicates we could assign a 'background natural' load for nitrate-N based off the OVERSEER data. However, at this stage, we have only assessed sites in the upper reaches and would need to evaluate the reliability of OVERSEER data in lowland, fully mixed catchments. If the calculated loads for the lowland catchments at the water quality monitoring sites begin to diverge significantly from the OVERSEER loads, this may indicate that:

- OVERSEER upper catchment native forest yields are not appropriate for areas with different soils, and;
- The non-native farming and lifestyle OVERSEER leaching and runoff inputs that feed into these mixed monitoring sites are not representative of the current land use and actual leaching/runoff rates.

The current approach used in Source modelling considers the OVERSEER load generated off a farm to be the total load leached off that land use/soil and climatic combination. This total load includes both the non-native load and the background natural load, and this total load will potentially be set as a limit or target per FMU within Ruamahanga Catchment.

Partitioning of the total load into the non-native and background-natural components would mean the reductions required to achieve FWO's (i.e. 30% nitrate-N total load reduction by 2040) would then be assigned only to the non-native loads, when the current approach applies this to the total load. This may mean a greater reduction (e.g. 35%) is required against the non-native load to achieve the same objective.

Uncertainty in the background natural load value may mean the non-native load is greater (or smaller) than it should be, and thus mitigations applied at the catchment scale may extend beyond what is feasible or alternatively, have little impact on reducing loads (e.g. if the background load from OVERSEER is too small). For example, if TP OVERSEER yields of 0.18 kg/ha/yr were used, this would result in an underestimated background natural load and subsequently a larger non-native load that farmers would be required to mitigate to achieve the FWO (when in reality, a high portion of this could be from naturally bound TP in sediment).

Following this assessment, the following approach was undertaken to refine the target loads:

- The total FMU load defined in **Section 2.7** are refined to identify the load that may be occurring from any existing native bush within the FMUs;

- This load is removed from the total load in each FMU leaving a non-native load target (with this non-native load still including a background natural load).

The native and non-native loads are presented in **Appendix F**.

At this stage it is considered appropriate to continue to use the OVERSEER rates to assign load targets, as the model calibration incorporates this inaccuracy through modifying attenuation rates, and subsequently simulates in-stream concentrations with suitable accuracy (see Jacobs 2018b). This is propagated through scenarios modelling and the relative changes in TP reductions that were simulated.

In addition, the loads are targets for each FMU, and are unlikely to be enforced in a regulatory framework. The current modelling approach could assume that the farm mitigations in OVERSEER represent the best estimate of expected reductions in phosphorus runoff loads (excluding that entrained in sediment) for particular farm and soil types within Ruamahanga, within the bounds of known limitations of OVERSEER (see Freeman et al. 2016).

Therefore, until further assessment of nitrate-N in the lowland reaches is undertaken, OVERSEER sub-models for TP are improved and the sediment/phosphorus dynamics in the native reaches are better understood, background natural loads will not be assigned to the FMU's. This will require greater data collection in the catchment, and may require phosphorus loads in the model to be partitioned into 'Sediment P' and 'Runoff P'.

2.10 FWO 'Target' FMU loads (Suspended Sediment)

Following a review of the limited suspended sediment monitoring data, and the assumptions and limitation involved with the calibration of the Suspended Sediment Concentration (SSC) model (see Jacobs 2018b), a decision was made by GWRC to set management criteria for sediment based only on the loads generated from SedNetNZ, rather than setting in-stream FWO concentration targets.

The SedNetNZ model has been described in detail in Jacobs 2018 and Jacobs 2018b. As more data becomes available, the SedNetNZ model can be updated appropriately to refine load targets, together with an improved calibrated sediment model.

SedNetNZ annual load maps in tonnes/year were developed for the baseline, BAU, Silver and Gold scenarios. Each scenario incorporated increasing mitigations (such as pole planting, retirement of land, riparian planting etc.) and subsequently, greater reductions in sediment loads from hillslope and streambank erosion.

The sediment loads generated within the entire catchment were split based on native versus non-native land uses (everything else). This enables the non-native load to be assessed based on priority FMUs that contribute the most load to the Ruamahanga River and subsequent lakes.

The following approach was undertaken:

1. Generate sediment loads for native and non-native land uses for every FMU within the Ruamahanga catchment, including both hillslope and streambank erosion.
    a. This was completed for the baseline, BAU 2080 and Silver 2080 scenarios only, as requested by GWRC.
    b. Mitigations that reduce streambank erosion (i.e. stock exclusion and riparian planting) are applied only to the non-native load within each FMU.
2. Calculate the percentage each erosion process contributes to its individual FMU load (i.e. landslide erosion in Kopuaranga FMU contributes ~57% of the FMU's total non-native load).
3. Calculate the percentage each erosion process, within each FMU, contributes to the total Ruamahanga sediment load (i.e. landslide erosion in Kopuaranga FMU contributes ~3.8% of the total load (native + non-native) within Ruamahanga catchment).
4. Under BAU 2080 and Silver 2080, calculate the amount of sediment load that is reduced due to each mitigation (i.e. pole planting, retirement, stock exclusion, riparian planting and constructed wetlands).

The outputs of the Baseline, BAU 2080 and Silver 2080 models were provided to GWRC, whom used this data to rank the FMUs based on their highest contributing non-native sediment load. This enabled a scenario to be selected for each FMU (noting this is generally independent of the scenarios assigned for other nutrients and contaminants such as *E. coli*).

For all FMU's except the top 5 (which contribute up to 60% of the non-native load), BAU 2080 was assigned. For the top 5 FMUs, BAU 2080 + 20% of Silver 2080 was assigned, as decided by GWRC This means the difference in further load reductions between BAU and Silver was determined, and 20% was added to the BAU reductions to set a target load. In theory, this has some limitations, as discussed in **Section 4**.

The top 5 FMU's contributing the most non-native load are:

- Huangarua River
- Taueru River
- Kopuaranga River
- Whangaehu River and;
- Eastern Hill Streams

The SSC loads are presented in **Appendix G**.

3. Results

The results of this assessment have been provided to GWRC, summary tables of the results are contained in the appendices:

- A summary table of the “target’ in-stream concentrations is provided in Appendix C;
- A summary table of the “target” FMU generated nutrient loads is contained in Appendix D.
- A summary table of the FMU background nutrients loads is contained in Appendix E.
- A summary table of the “target” FMU attenuated nutrients loads is contained in Appendix F.
- Summary tables of the “target” FMU sediment loads is contained in Appendix G.

4. Discussion

The method applied to determine the FWO and loads is based on the simulated percentage reductions in concentrations from BAU, Silver and Gold scenarios. Jacobs 2018 and Jacobs 2018b should be read to understand the limitations and assumptions around these scenarios, which may impact on the FWO in-stream concentrations and subsequent loads.

In addition, this methods objective is to meet the water quality goals defined by the Whaitua Committee (as exhibited in **Figure 2.1**) and does not take into account the economic results, which may make these water quality changes economically unfeasible.

This assessment also identifies that some FMUs will need additional mitigation measures applied above the modelled scenarios. This assessment has not attempted to identify the additional mitigations required, which will need further consideration at a later date.

A limitation of the load setting approach using the OVERSEER maps means that where a simulated scenario could not achieve the FWO, the ‘target’ loads applied represent the nearest ‘best’ scenario. For example, where Silver 2040 + extra mitigations is necessary, the Silver 2040 load map has been used to calculate target loads. Subsequently these loads may need to be reduced further for specific FMUs to meet the FWO. This could be undertaken with additional modelling simulations, through reducing the OVERSEER load in the problem FMUs and simulating the in-stream concentration in a stepwise approach until the FWO is met.

However, based on the uncertainty around the OVERSEER leaching map (see Jacobs 2018b) and assumptions made in modelling, these loads are likely suitable for setting initial targets. The phosphorus sub-models in OVERSEER are acknowledged as requiring further updates and have limitations in regards to their TP loads from certain erosion processes (i.e. streambank). Therefore, the current approach of assigning loads is considered to utilise the best available data at the time of the project.

Future updates to OVERSEER maps that are better representation of the variations in Ruamahanga at the farm scale (through nutrient farm budgets) will improve the accuracy of load targets (particularly with total phosphorus), and would be used to run additional model simulations to update each FMU's load target and simulated concentration reductions.

The target loads applied for the WWTPs are based on Silver 2040 scenarios, which consider 100% land treatment of waste water effluent. Applying these reductions does not take into account the economic feasibility of upgrading these plants.

Sediment loads are based on SedNetNZ, which is developed off soil and landuse data from 2004 (Dymond *et al.* 2016). Subsequently, the landuse layer is outdated. Assessments of native and non-native loads used the more recent GWRC landuse layer for partitioning. The SedNetNZ map is suitable to use for guiding target sediment reductions in the various FMUs, given the absence of monitoring data within the catchment. Implementation of routine SSC monitoring across the catchment will mean a more detailed daily sediment model can be created for the Ruamahanga in the future. In addition, updates to the SedNetNZ model can also be incorporated in future policy changes, which will better capture the landuse and climate changes that will differ over time.

A decision was made by GWRC to apply BAU + 20% Silver for sediment load targets on the top 5 FMU's. This approach assumes that the Silver mitigations applied which reduce sediment (i.e. constructed wetlands, riparian planting, pole planting, retirement etc.) can directly be scaled down to 1/5th of what is applied in Silver, and have the same effects. This may vary in reality, as land erosion rates change within the catchment, some areas/farms are much more erodible than others. Subsequently, applying 1/5th of the mitigations on the most erosion prone land, may actually mean a reduction in sediment that is greater than 20% of the load for the entire Silver scenario (or less than 20% if mitigations are applied to less erosive land). No assessments have been undertaken to verify the numbers associated with this 20% of Silver load reductions.

5. References

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Appendix A. Whaitua Objectives

Summary of draft Ruamāhanga whaitua freshwater objectives - for Committee email out 21.12.2017

Summarises current state and draft objectives from Oct-Dec 2017 workshops

* indicates where current state is based on modelled information or expert best-gues, otherwise all current state analyses based on monitoring data

LAKES	NOF attributes										Non-NOF attributes								
River	E.coli	E.coli	Phytoplankton	Phytoplankton	Total nitrogen	Total nitrogen	Total phosphorus	Total phosphorus	Ammonia toxicity	Ammonia toxicity	Trophic level index	Trophic level index	Total suspended sediment	Total suspended sediment	Macrophytes	Macrophytes	FMU group	For any improve objective, when by?
	Now	Objective	Now	Objective	Now	Objective	Now	Objective	Now	Objective	Now	Objective	Now	Objective	Now	Objective		
Lake Wairarapa	A	A	D	C	C	C	D	C	A	A	Very poor	Poor	Poor	Fair	D	C	Lakes	2080
Lake Onoke	B/C	A	B	B	C	B	B	B	A	A	Poor	Average	Poor	Fair	D	C	Lakes	2040

Summary of draft Ruamāhanga whaitua freshwater objectives - for Committee email out 21.12.2017

Summarises current state and draft objectives from Oct-Dec 2017 workshops

* indicates where current state is based on modelled information or expert best-gues, otherwise all current state analyses based on monitoring data

RIVERS	NOF attributes								Non-NOF attributes			
River	**E.coli**	**E.coli**	**Periphyton**	**Periphyton**	**Ammonia toxicity**	**Ammonia toxicity**	**Nitrate toxicity**	**Nitrate toxicity**	**MCI**	**MCI**	**When by?**	**FMU group**
	Now	Objective	Now	Objective	Now	Objective	Now	Objective	Now	Objective		
Tauanui River	D*	A	C/D*	B	A*	A	A*	A	Fair*	Good	2040	Aorangi rivers
Turanganui River	B*	B	C/D*	B	A*	A	A*	A	Fair*	Good	2040	Aorangi rivers
Taueru River	C	C	D*	C	A	A	B	A	Good	Good	2040	Eastern hill rivers
Makahakaha Stream	A*	A	?	B	A*	A	B*	A	Fair*	Good	2040 (periphyton 2030)	Eastern hill rivers
Huangarua River	B	B	C	B	A	A	A	A	Fair	Good	2080	Eastern hill rivers
Eastern hill streams[1]	?	B	?	B	?	A	?	A	?	Fair	Maintain	Eastern hill streams group
Ruamāhanga - Wardells	C*	C	B*	B	B*	A	A*	A	Fair*	Fair	2040	Main stem Ruamāhanga River
Ruamāhanga - Gladstone Br	D	C	B	B	B	A	A	A	Fair*	Fair	2040	Main stem Ruamāhanga River
Ruamāhanga - Waihenga	A	A	B	B	B*	A	A*	A	Fair*	Fair	2040	Main stem Ruamāhanga River
Ruamāhanga - Pukio	B	B	?	B	A*	A	A*	A	Good*	Good	Maintain	Main stem Ruamāhanga River
Ruamāhanga - upstream of	B*	B	?	B	A*	A	A*	A	Fair*	Fair	Maintain	Main stem Ruamāhanga River
Kopuaranga River	D	C	D	C	A	A	A	A	Fair	Good	2040	Northern rivers
Whangaehu River[3]	D	C	?	C	A	A	A	A	Fair*	Good	2040	Northern rivers
Parkvale Stream	E	C	B	B	B	A	B	A	Fair*	Good	2040	Valley floor streams group
Otukura Stream[4]	D*	C	?	B	B*	A	B*	A	?	Fair	2040	Valley floor streams group
Valley floor streams[4]	?	C	?	B	?	A	?	A	?	Good	2040	Valley floor streams group
Upper Ruamāhanga River	D	C	A	A	A	A	A	A	Fair	Good	2040	Western hill rivers
Waipoua River	B	A	B*	A	A	A	B	A	Fair	Good	2040	Western hill rivers
Waingawa River	A	A	A	A	A	A	A	A	Good	Good	Maintain	Western hill rivers
Mangatarere Stream	D	B	C	B, then A	B	B (top of band)	B	A	Fair	Good	2040 (2080 for MCI)	Western hill rivers
Waiohine River	A	A	A	A	A	A	A	A	Fair	Good	2080	Western hill rivers
Tauherenikau River	A	A	A*	A	A	A	A	A	Fair	Good	2040	Western hill rivers
Western lake streams[5]	?	A	?	A	?	A	?	A	?	Good or better	Maintain	Western hill rivers
South coast streams[6]	?	A	?	A	?	A	?	A	?	Fair	Maintain	South coast streams group

Where there is an absence of modelling or monitoring data to the establish current state, objectives have been established by comparing the FMU with water bodies in the same or similar FMU group as indicated by the footnote number

1 From Eastern hill rivers characteristics

2 From other Main stem Ruamāhanga river characteristics

3 From Kopuaranga River characteristics

4 From Parkvale Stream and/or Otukura Stream characteristics

5 From other Western Hill rivers characteristics

6 From Western Hill rivers characteristics

Appendix B. FMU current in-stream concentrations and attribute state

FMU Name	Monitoring Site Name-Rivers	Data period (no. of samples)	Type	Analyte	Current in-stream concentrations (mg/L and cfu/100 mL)				Current NOF Band
					50th percentile	95th percentile	%>260	%>540	
Whangaehu	Whangaehu River at 250m from Confluence	July 2012 – July 2017 (60 samples)	Observed monitoring point	NO_3-N	0.59	2.35	-	-	B
				NH_4-N	0.005	0.059	-	-	B
				DIN	0.60	2.40	-	-	N/a
				DRP	0.030	0.093	-	-	
				E. coli	185	4,800	36%	14%	D
Kopuaranga	Kopuaranga River at Stuarts	July 2012 – July 2017 (61 samples)	Observed monitoring point	NO_3-N	0.99	1.39	-	-	A
				NH_4-N	0.005	0.026	-	-	A
				DIN	0.99	1.42	-	-	N/a
				DRP	0.014	0.033	-	-	
				E. coli	170	1,800	31%	19%	D
Upper Ruamahanga	Ruamahanga River at McLays	July 2012 – July 2017 (58 samples)	Observed monitoring point	NO_3-N	0.02	0.05	-	-	A
				NH_4-N	0.005	0.005	-	-	A
				DIN	0.03	0.05	-	-	N/a
				DRP	0.004	0.004	-	-	
				E. coli	7	44	0%	0%	A
	Ruamahanga River at Double Bridges	January 1999 – July 2003 (56 samples)	Observed monitoring point (old)	NO_3-N	0.09	0.43	-	-	A
				NH_4-N	0.005	0.019	-	-	A
				DIN	0.10	0.45	-	-	N/a
				DRP	0.005	0.009	-	-	
				E. coli	-	-	-	-	-
Waipoua	Waipoua River at Colombo Rd Bridge	July 2012 – July 2017 (61 samples)	Observed monitoring point	NO_3-N	0.82	1.51	-	-	B
				NH_4-N	0.005	0.008	-	-	A
				DIN	0.83	1.52	-	-	N/a
				DRP	0.004	0.009	-	-	
				E. coli	44	1,100	12%	10%	C

FMU Name	Monitoring Site Name-Rivers	Data period (no. of samples)	Type	Analyte	Current in-stream concentrations (mg/L and cfu/100 mL)				Current NOF Band
					50th percentile	95th percentile	%>260	%>540	
Waingawa	Waingawa River at South Rd	July 2012 – July 2017 (61 samples)	Observed monitoring point	**NO_3-N**	0.06	0.22	-	-	A
				NH_4-N	0.005	0.023	-	-	A
				DIN	0.07	0.24	-	-	N/a
				DRP	0.004	0.006	-	-	
				E. coli	14	184	3%	1%	A
Mangatarere	Mangatarere River at State Highway 2	July 2012 – July 2017 (61 samples)	Observed monitoring point	**NO_3-N**	1.06	2.07	-	-	B
				NH_4-N	0.067	0.295	-	-	B
				DIN	1.19	2.24	-	-	N/a
				DRP	0.048	0.284	-	-	
				E. coli	140	840	19%	9%	D
Waiohine	Waiohine River at Gorge	August 2012 – June 2017 (60 samples)	Observed monitoring point	**NO_3-N**	0.03	0.06	-	-	A
				NH_4-N	0.005	0.010	-	-	A
				DIN	0.03	0.06	-	-	N/a
				DRP	0.004	0.005	-	-	
				E. coli	8	82	0%	0%	A
	Waiohine River at Bicknells	August 2012 – July 2017 (62 samples)	Observed monitoring point	**NO_3-N**	0.37	0.88	-	-	A
				NH_4-N	0.005	0.043	-	-	A
				DIN	0.38	0.91	-	-	N/a
				DRP	0.011	0.029	-	-	
				E. coli	44	234	4%	0%	A
Parkvale	Parkvale Stream at Renalls Weir	July 2012 – July 2017 (60 samples)	Observed monitoring point	**NO_3-N**	1.74	3.90	-	-	C
				NH_4-N	0.012	0.100	-	-	B
				DIN	1.75	3.95	-	-	N/a
				DRP	0.025	0.076	-	-	
				E. coli	350	2,205	64%	28%	E
Tauherenikau	Tauherenikau River at Websters	July 2012 – July 2017		**NO_3-N**	0.04	0.14	-	-	A
				NH_4-N	0.005	0.009	-	-	A

FMU Name	Monitoring Site Name-Rivers	Data period (no. of samples)	Type	Analyte	Current in-stream concentrations (mg/L and cfu/100 mL)				Current NOF Band
					50th percentile	95th percentile	%>260	%>540	
		(60 samples)	Observed monitoring point	**DIN**	0.04	0.15	-	-	N/a
				DRP	0.004	0.005	-	-	
				E. coli	19	210	5%	3%	A
Western Lake Streams	N/a	No data	No data	**N/a**	-	-	-	-	-
Taueru	Taueru River at Gladstone	July 2012 – July 2017 (60 samples)	Observed monitoring point	**NO_3-N**	0.78	1.53	-	-	B
				NH_4-N	0.006	0.048	-	-	A
				DIN	0.81	1.56	-	-	N/a
				DRP	0.015	0.051	-	-	
				E. coli	120	1,375	19%	10%	D
Huangarua	Huangarua River at Ponatahi Bridge	July 2012 – July 2017 (61 samples)	Observed monitoring point	**NO_3-N**	0.23	0.66	-	-	A
				NH_4-N	0.005	0.014	-	-	A
				DIN	0.24	0.67	-	-	N/a
				DRP	0.006	0.029	-	-	
				E. coli	80	921	15%	7%	B
Makahakaha	Makahakaha Stream	1992 – 2014 (22 years) of modelling	Modelled data (no monitored site)	**NO_3-N**	0.78	1.69	-	-	B
				NH_4-N	0.006	0.020	-	-	A
				DIN	0.78	1.71	-	-	
				DRP	0.017	0.033	-	-	
				E. coli	74	122	0%	0%	A
Eastern hill streams	N/a	No data	No data	**N/a**	-	-	-	-	-
Tauanui	Tauanui River	1992 – 2014 (22 years) of modelling	Modelled data (no monitored site)	**NO_3-N**	0.13	0.34	-	-	A
				NH_4-N	0.006	0.044	-	-	A
				DIN	0.13	0.35	-	-	N/a
				DRP	0.004	0.009	-	-	
				E. coli	138	525	19%	5%	D

FMU Name	Monitoring Site Name-Rivers	Data period (no. of samples)	Type	Analyte	Current in-stream concentrations (mg/L and cfu/100 mL)				Current NOF Band
					50th percentile	95th percentile	%>260	%>540	
Turanganui	Turanganui River	1992 – 2014 (22 years) of modelling	Modelled data (no monitored site)	NO_3-N	0.16	0.62	-	-	A
				NH_4-N	0.009	0.047	-	-	A
				DIN	0.17	0.66	-	-	N/a
				DRP	0.006	0.022	-	-	
				E. coli	76	580	25%	7%	B
Valley Floor Streams	N/a	No data	No data	N/a	-	-	-	-	-
Otukura Stream	Otukura Stream	1992 – 2014 (22 years) of modelling	Modelled data (no monitored site)	NO_3-N	1.43	1.59	-	-	B
				NH_4-N	0.005	0.097	-	-	B
				DIN	1.43	1.59	-	-	N/a
				DRP	0.004	0.014	-	-	
				E. coli	24	3,592	10%	9%	D
Ruamahanga River Main Stem	Ruamahanga River at Boat Ramp	July 2014 – June 2017 (35 samples)	Observed monitoring point	NO_3-N	0.41	0.99	-	-	A
				NH_4-N	0.015	0.041	-	-	A
				DIN	-	-	-	-	N/a
				DRP	0.013	0.022	-	-	
				E. coli	-	-			-
	Ruamahanga River at Gladstone Bridge	July 2012 – July 2017 (61 samples)	Observed monitoring point	NO_3-N	0.36	0.98	-	-	A
				NH_4-N	0.005	0.134	-	-	B
				DIN	0.39	1.06	-	-	N/a
				DRP	0.011	0.032	-	-	
				E. coli	35	1,110	9%	7%	C
	Ruamahanga River at Pukio	July 2012 – July 2017 (61 samples)	Observed monitoring point	NO_3-N	0.36	0.95	-	-	A
				NH_4-N	0.008	0.055	-	-	B
				DIN	0.38	1.00	-	-	N/a
				DRP	0.014	0.026	-	-	

FMU Name	Monitoring Site Name-Rivers	Data period (no. of samples)	Type	Analyte	Current in-stream concentrations (mg/L and cfu/100 mL)				Current NOF Band
					50th percentile	95th percentile	%>260	%>540	
				E. coli	50	880	13%	7%	B
	Ruamahanga River at Waihenga Bridge	July 2016 – August 2017 (14 samples - No MAS set due to insufficient sample size)	Observed monitoring point	NO_3-N	-	-	-	-	A
				NH_4-N	-	-	-	-	A
				DIN	-	-	-	-	N/a
				DRP	-	-	-	-	
				E. coli	-	-	-	-	A
	Ruamahanga-Wardells	1992 – 2014 (22 years) of modelling	Modelled data (no monitored site)	NO_3-N	0.66	1.27	-	-	A
				NH_4-N	0.017	0.169	-	-	B
				DIN	0.68	1.30			N/a
				DRP	0.021	0.040			
				E.coli	111	1,001	29%	13%	C
South Coast Streams	N/a	No data	No data	N/a	-	-	-	-	-
Lake Wairarapa	Lake Wairarapa Middle	January 2014 – June 2017 (39 samples)	Observed Lake monitoring data	TN	540	-	-	-	C
				TP	64.0	-	-	-	D
				NH_4-N	0.01	0.03	-	-	A
				E. coli	-	-	-	-	-
Lake Wairarapa	Lake Wairarapa Site 2	March 2012 – June 2017 (55 samples)	Observed Lake monitoring data	TN	530	-	-	-	C
				TP	61.0	-	-	-	D
				NH_4-N	0.005	0.023	-	-	A
				E. coli	-	-	-	-	-
Lake Onoke	Lake Onoke 1	July 2012 – June 2017 (60 samples)	Observed Lake monitoring data	TN	500	-	-	-	B
				TP	33.0	-	-	-	C
				NH_4-N	0.011	0.040	-	-	A
				E. coli	-	-	-	--	-

Appendix C. In-stream concentrations Minimum Acceptable States (MAS) and Targets

FMU Name	Monitoring Site Name-Rivers	Analyte	Overall recommended scenario	In-stream MAS (mg/L or cfu/100ml)				In-stream FWO (mg/L or cfu/100ml)			
				50th	95th or max	%>260	%>540	50th	95th or max	%>260	%>540
Whangaehu	Whangaehu River at 250m from Confluence	NO_3-N	Silver 2040 + extra mitigations required	0.59	2.35	-	-	0.47	1.50	-	-
		NH_4-N		0.005	0.059	-	-	0.005	0.050	-	-
		DIN		0.60	2.40	-	-	0.48	1.55	-	-
		DRP		0.030	0.093	-	-	0.023	0.045	-	-
		E. coli		185	4,800	36%	14%	130	1,200	33%	13%
Kopuaranga	Kopuaranga River at Stuarts	NO_3-N	Silver 2040 + extra mitigations required	0.99	1.39	-	-	0.82	1.17	-	-
		NH_4-N		0.005	0.026	-	-	0.005	0.024	-	-
		DIN		0.99	1.42	-	-	0.82	1.20	-	-
		DRP		0.014	0.033	-	-	0.011	0.018	-	-
		E. coli		170	1,800	31%	19%	130	1,200	29%	17%
Upper Ruamahanga	Ruamahanga River at McLays	NO_3-N	BAU 2040	0.02	0.05	-	-	0.02	0.05	-	-
		NH_4-N		0.005	0.005	-	-	0.005	0.005	-	-
		DIN		0.03	0.05	-	-	0.03	0.05	-	-
		DRP		0.004	0.004	-	-	0.004	0.004	-	-
		E. coli		7	44	0%	0%	7	44	0%	0%
Upper Ruamahanga	Ruamahanga River at Double Bridges	NO_3-N	BAU 2040	0.09	0.43	-	-	0.09	0.43	-	-
		NH_4-N		0.005	0.019	-	-	0.005	0.019	-	-
		DIN		0.10	0.45	-	-	0.10	0.45	-	-
		DRP		0.005	0.009	-	-	0.005	0.009	-	-
		E. coli		-	-	-	-	13	183	0%	0%
Waipoua	Waipoua River at Colombo Rd Bridge	NO_3-N	Silver 2040 + extra mitigations required	0.82	1.51	-	-	0.63	1.41	-	-
		NH_4-N		0.005	0.008	-	-	0.005	0.008	-	-
		DIN		0.83	1.52	-	-	0.63	1.42	-	-
		DRP		0.004	0.009	-	-	0.003	0.004	-	-

		E. coli		44	1,100	12%	10%	34	540	10%	5%
Waingawa	Waingawa River at South Rd	**NO_3-N**	BAU 2040	0.06	0.22	-	-	0.06	0.22	-	-
		NH_4-N		0.005	0.023	-	-	0.005	0.023	-	-
		DIN		0.07	0.24	-	-	0.07	0.24	-	-
		DRP		0.004	0.006	-	-	0.004	0.006	-	-
		E. coli		14	184	3%	1%	13	183	3%	1%
Mangatarere	Mangatarere River at State Highway 2	**NO_3-N**	Silver 2040 + extra mitigations required	1.06	2.07	-	-	0.99	1.50	-	-
		NH_4-N		0.067	0.295	-	-	0.028	0.128	-	-
		DIN		1.19	2.24	-	-	1.02	1.63	-	-
		DRP		0.048	0.284	-	-	0.018	0.076	-	-
		E. coli		140	840	19%	9%	48	218	8%	2%
Waiohine	Waiohine River at Gorge	**NO_3-N**	BAU 2040	0.03	0.06	-	-	0.03	0.06	-	-
		NH_4-N		0.005	0.010	-	-	0.005	0.010	-	-
		DIN		0.03	0.06	-	-	0.03	0.06	-	-
		DRP		0.004	0.005	-	-	0.004	0.005	-	-
		E. coli		8	82	0%	0%	8	82	0%	0%
Waiohine	Waiohine River at Bicknells	**NO_3-N**	BAU 2040	0.37	0.88	-	-	0.34	0.85	-	-
		NH_4-N		0.005	0.043	-	-	0.005	0.015	-	-
		DIN		0.38	0.91	-	-	0.35	0.87	-	-
		DRP		0.011	0.029	-	-	0.006	0.023	-	-
		E. coli		44	234	4%	0%	15	129	2%	0%
Parkvale	Parkvale Stream at Renalls Weir	**NO_3-N**	Silver 2040 + extra mitigations required	1.74	3.90	-	-	1.00	1.50	-	-
		NH_4-N		0.012	0.100	-	-	0.012	0.050	-	-
		DIN		1.75	3.95	-	-	1.01	1.55	-	-
		DRP		0.025	0.076	-	-	0.019	0.051	-	-
		E. coli		350	2,205	64%	28%	130	1,200	34%	20%
Tauherenikau	Tauherenikau River at Websters	**NO_3-N**	BAU 2040	0.04	0.14	-	-	0.04	0.14	-	-
		NH_4-N		0.005	0.009	-	-	0.005	0.009	-	-
		DIN		0.04	0.15	-	-	0.04	0.15	-	-

		DRP		0.004	0.005	-	-	0.004	0.005	-	-
		E. coli		19	210	5%	3%	19	210	5%	3%
Western Lake Streams	N/a (proxy)	**NO_3-N**	BAU 2040	-	-	-	-	0.04	0.14	-	-
		NH_4-N		-	-	-	-	0.005	0.009	-	-
		DIN		-	-	-	-	0.04	0.15	-	-
		DRP		-	-	-	-	0.004	0.005	-	-
		E. coli		-	-	-	-	19	210	5%	3%
Taueru	Taueru River at Gladstone	**NO_3-N**	Silver 2040	0.78	1.53	-	-	0.71	1.41	-	-
		NH_4-N		0.006	0.048	-	-	0.005	0.044	-	-
		DIN		0.81	1.56	-	-	0.71	1.45	-	-
		DRP		0.015	0.051	-	-	0.009	0.021	-	-
		E. coli		120	1,375	19%	10%	99	1,171	15%	7%
Huangarua	Huangarua River at Ponatahi Bridge	**NO_3-N**	BAU 2040	0.23	0.66	-	-	0.22	0.66	-	-
		NH_4-N		0.005	0.014	-	-	0.005	0.014	-	-
		DIN		0.24	0.67	-	-	0.23	0.67	-	-
		DRP		0.006	0.029	-	-	0.006	0.029	-	-
		E. coli		80	921	15%	7%	68	921	15%	7%
Makahakaha	N/a (modelled location)	**NO_3-N**	Silver 2040 + extra mitigations required	0.78	1.69	-	-	0.73	1.50	-	-
		NH_4-N		0.006	0.020	-	-	0.006	0.019	-	-
		DIN		0.78	1.71	-	-	0.74	1.52	-	-
		DRP		0.017	0.033	-	-	0.011	0.017	-	-
		E. coli		74	122	0%	0%	51	100	0%	0%
Eastern hill streams	N/a (Proxy)	**NO_3-N**	BAU 2040	-	-	-	-	0.22	0.66	-	-
		NH_4-N		-	-	-	-	0.01	0.01	-	-
		DIN		-	-	-	-	0.23	0.67	-	-
		DRP		-	-	-	-	0.01	0.03	-	-
		E. coli		-	-	-	-	68	921	15%	7%
Tauanui	N/a (modelled location)	**NO_3-N**	Silver 2025	0.13	0.34	-	-	0.13	0.33	-	-
		NH_4-N		0.006	0.044	-	-	0.006	0.043	-	-

		DIN		0.13	0.35	-	-	0.13	0.35	-	-
		DRP		0.004	0.009	-	-	0.004	0.007	-	-
		E. coli		138	525	19%	5%	127	505	17%	4%
Turanganui	N/a (modelled location)	**NO_3-N**	BAU 2040	0.16	0.62	-	-	0.15	0.61	-	-
		NH_4-N		0.009	0.047	-	-	0.009	0.046	-	-
		DIN		0.17	0.66	-	-	0.16	0.65	-	-
		DRP		0.006	0.022	-	-	0.005	0.021	-	-
		E. coli		76	580	25%	7%	66	565	24%	6%
Valley Floor Streams - draining to Ruamahanga River	N/a (Proxy)	**NO_3-N**	Silver 2040 + extra mitigations required	-	-	-	-	1.00	1.30	-	-
		NH_4-N		-	-	-	-	0.005	0.050	-	-
		DIN		-	-	-	-	1.01	1.35	-	-
		DRP		-	-	-	-	0.004	0.008	-	-
		E. coli		-	-	-	-	20	1,200	9%	8%
Valley Floor Streams - draining to Lake Wairarapa	N/a (Proxy)	**NO_3-N**	Silver 2040 + extra mitigations required	-	-	-	-	1.00	1.30	-	-
		NH_4-N		-	-	-	-	0.005	0.050	-	-
		DIN		-	-	-	-	1.005	1.348	-	-
		DRP		-	-	-	-	0.004	0.008	-	-
		E. coli		-	-	-	-	20	1,200	9%	8%
Otukura Stream	N/a (modelled location)	**NO_3-N**	Silver 2040 + extra mitigations required	1.43	1.59	-	-	1.00	1.30	-	-
		NH_4-N		0.005	0.097	-	-	0.005	0.050	-	-
		DIN		1.43	1.59	-	-	1.01	1.35	-	-
		DRP		0.004	0.014	-	-	0.004	0.008	-	-
		E. coli		24	3,592	10%	9%	20	1,200	9%	8%
Ruamahanga River Main Stem	Ruamahanga River at Boat Ramp	**NO_3-N**	BAU 2040	0.41	0.99	-	-	0.39	0.98	-	-
		NH_4-N		0.015	0.041	-	-	0.009	0.035	-	-
		DIN		-	-	-	-	0.40	1.01	-	-
		DRP		0.013	0.022	-	-	0.007	0.020	-	-
		E. coli		-	-	-	-	130	900	27%	8%
		NO_3-N		0.36	0.98	-	-	0.31	0.96	-	-

	Ruamahanga River at Gladstone Bridge	**NH_4-N**	BAU 2040 + extra mitigations required	0.005	0.134	-	-	0.005	0.050	-	-
		DIN		0.39	1.06	-	-	0.32	1.01	-	-
		DRP		0.011	0.032	-	-	0.006	0.024	-	-
		E. coli		35	1,110	9%	7%	33	1,098	9%	7%
	Ruamahanga River at Pukio	**NO_3-N**	BAU 2040	0.36	0.95	-	-	0.33	0.94	-	-
		NH_4-N		0.008	0.055	-	-	0.005	0.030	-	-
		DIN		0.38	1.00	-	-	0.33	0.97	-	-
		DRP		0.014	0.026	-	-	0.007	0.021	-	-
		E. coli		50	880	13%	7%	40	875	12%	7%
	Ruamahanga River at Waihenga Bridge	**NO_3-N**	BAU 2040	-	-	-	-	0.50	0.84	-	-
		NH_4-N		-	-	-	-	0.005	0.040	-	-
		DIN		-	-	-	-	0.50	0.88	-	-
		DRP		-	-	-	-	0.006	0.019	-	-
		E. coli		-	-	-	-	33	375	6%	3%
	Ruamahanga-Wardells (modelled)	**NO_3-N**	BAU 2040 + extra mitigations required	0.66	1.27	-	-	0.54	1.24	-	-
		NH_4-N		0.017	0.169	-	-	0.011	0.050	-	-
		DIN		0.68	1.30	-	-	0.55	1.29	-	-
		DRP		0.021	0.040	-	-	0.009	0.021	-	-
		E. coli		111	1,001	29%	13%	105	994	29%	13%
South Coast Streams	N/a (Proxy)	**NO_3-N**	BAU 2040	-	-	-	-	0.04	0.14	-	-
		NH_4-N		-	-	-	-	0.005	0.009	-	-
		DIN		-	-	-	-	0.04	0.15	-	-
		DRP		-	-	-	-	0.004	0.005	-	-
		E. coli		-	-	-	-	19	210	5%	3%
Lake Wairarapa	Lake Wairarapa Middle	**TN**	Silver 2040 + extra mitigations required	540	-	-	-	469	-	-	-
		TP		64.0	-	-	-	49.0	-	-	-
		NH_4-N		0.01	0.03	-	-	0.01	0.03	-	-
		E. coli		-	-	-	-	65	300	10%	3%
		TN		530	-	-	-	469	-	-	-

Lake Wairarapa	Lake Wairarapa Site 2	**TP**	Silver 2040 + extra mitigations required	61.0	-	-	-	49.0	-	-	-
		NH_4-N		0.005	0.023	-	-	0.005	0.023	-	-
		E. coli		-	-	-	-	65	300	10%	3%
Lake Onoke	Lake Onoke 1	**TN**	BAU 2040	500	-	-	-	476	-	-	-
		TP		33.0	-	-	-	19.7	-	-	-
		NH_4-N		0.011	0.040	-	-	0.010	0.040	-	-
		E. coli		-	-	-	-	130	540	20%	5%

Appendix D. Target generated loads (NO_3-N and TP) in t/yr

FMU	FMU derived Baseline Loads						MAS Loads				Target Loads							
	FMU leaching		FMU WWTP		FMU total		FMU Leaching		Nested MAS		FMU leaching		FMU WWTP		FMU total		Nested target	
	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP
Huangarua	405.8	26.6	-	-	405.8	26.6	405.8	26.6	405.8	26.6	403.0	24.7	-	-	403.0	24.7	403.0	24.7
Kopuaranga	338.9	38.2	-	-	338.9	38.2	338.9	38.2	338.9	38.2	297.6	9.5	-	-	297.6	9.5	297.6	9.5
Mangatarere	324.0	17.8	0.1	4.3	324.2	22.1	324.2	22.1	324.2	22.1	288.7	11.5	0.04	0.16	288.7	11.7	288.7	11.7
Parkvale	251.0	9.2	-	-	251.0	9.2	251.0	9.2	251.0	9.2	217.4	6.2	-	-	217.4	6.2	217.4	6.2
Valley floor streams (Ruamahanga River)	379.3	15.1	1.2	8.3	380.4	23.4	380.4	23.4	380.4	23.4	333.9	11.5	0.30	0.54	334.2	12.0	334.2	12.0
Upper Ruamahanga	100.9	8.2	-	-	100.9	8.2	100.9	8.2	100.9	8.2	100.9	8.0	-	-	100.9	8.0	100.9	8.0
Taueru	442.6	18.5	-	-	442.6	18.5	442.6	18.5	442.6	18.5	392.5	8.2	-	-	392.5	8.2	392.5	8.2
Tauherenikau	101.6	5.4	-	-	101.6	5.4	101.6	5.4	101.6	5.4	101.3	5.3	-	-	101.3	5.3	101.3	5.3
Waingawa	124.4	8.1	-	-	124.4	8.1	124.4	8.1	124.4	8.1	123.7	8.0	-	-	123.7	8.0	123.8	8.0
Waiohine	122.4	9.0	-	-	122.4	9.0	122.4	9.0	446.5	31.1	121.1	8.6	-	-	121.1	8.6	409.8	20.2
Waipoua	348.0	25.5	-	-	348.0	25.5	348.0	25.5	348.0	25.5	316.5	9.3	-	-	316.5	9.3	316.5	9.3
Whangaehu	241.7	10.7	-	-	241.7	10.7	241.7	10.7	241.7	10.7	212.4	4.4	-	-	212.4	4.4	212.4	4.4
Tauanui	66.5	2.3	-	-	66.5	2.3	66.5	2.3	66.5	2.3	63.1	1.5	-	-	63.1	1.5	63.1	1.5
Turanganui	84.5	3.1	-	-	84.5	3.1	84.5	3.1	84.5	3.1	82.6	2.8	-	-	82.6	2.8	82.6	2.8
Makahakaha	79.6	3.5	-	-	79.6	3.5	79.6	3.5	79.6	3.5	71.2	1.9	-	-	71.2	1.9	71.2	1.9
Eastern hill streams	483.8	18.6	0.2	1.6	484.0	20.2	484.0	20.2	484.0	20.2	478.8	16.4	0.05	0.11	478.8	16.6	478.8	16.6
Otukura Stream	267.3	6.7	-	-	267.3	6.7	267.3	6.7	267.3	6.7	215.8	4.2	-	-	215.8	4.2	215.8	4.2
Valley floor streams (Lake Wairarapa)	275.3	11.4	-	-	275.3	11.4	275.3	11.4	275.3	11.4	205.0	5.0	-	-	205.0	5.0	205.0	5.0
Western Lake Streams	227.4	26.1	0.7	2.0	228.1	28.1	228.1	28.1	228.1	28.1	223.8	25.4	0.09	0.00	223.9	25.4	223.9	25.4
South coast streams	202.4	8.4	-	-	202.4	8.4	202.4	8.4	202.4	8.4	201.2	7.9	-	-	201.2	7.9	201.2	7.9
Lake Wairarapa	6.0	2.1	-	-	6.0	2.1			872.3	51.5	0.0	0.0	-	-	0.0	0.0	746.1	39.9
Lake Onoke	0.2	0.2	-	-	0.2	0.2			4667.2	280.2	0.0	0.0	-	-	0.0	0.0	4250.0	173.2

Appendix E. Attenuated nutrient loads (tonnes/year) derived off Table 14

FMU	FMU derived baseline load						FMU derived target attenuated load						FMU "Nested" upstream Target Load (attenuated + WWTP)	
	FMU Generated Load		FMU Attenuated Load		Total FMU load (attenuated + WWTP)		FMU Generated Load		FMU Attenuated Load		Total FMU load (attenuated + WWTP)			
	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP	NO_3-N	TP
Huangarua	405.8	26.6	82.8	20.0	82.8	20.0	403.0	24.7	82.2	18.6	82.2	18.6	82.2	18.6
Kopuaranga	338.9	38.2	114.9	23.4	114.9	23.4	297.6	9.5	100.9	5.8	100.9	5.8	100.9	5.8
Mangatarere	324.0	17.8	226.2	8.5	226.3	12.7	288.7	11.5	201.5	5.5	201.5	5.6	201.5	5.6
Parkvale	251.0	9.2	104.7	7.8	104.7	7.8	217.4	6.2	90.6	5.2	90.6	5.2	90.6	5.2
Valley floor streams (Ruamahanga River)	379.3	15.1	104.7	11.4	105.8	19.8	333.9	11.5	92.2	8.7	92.4	9.2	92.4	9.2
Upper Ruamahanga	100.9	8.2	27.3	6.1	27.3	6.1	100.9	8.0	27.3	6.0	27.3	6.0	27.3	6.0
Taueru	442.6	18.5	180.6	13.8	180.6	13.8	392.5	8.2	160.2	6.1	160.2	6.1	160.2	6.1
Tauherenikau	101.6	5.4	20.4	4.8	20.4	4.8	101.3	5.3	20.4	4.7	20.4	4.7	20.4	4.7
Waingawa	124.4	8.1	25.3	6.1	25.3	6.1	123.7	8.0	25.1	6.0	25.1	6.0	25.1	6.0
Waiohine	122.4	9.0	48.5	6.8	48.5	6.8	121.1	8.6	48.0	6.4	48.0	6.4	249.5	12.1
Waipoua	348.0	25.5	130.5	13.1	130.5	13.1	316.5	9.3	118.7	4.8	118.7	4.8	118.7	4.8
Whangaehu	241.7	10.7	60.7	8.0	60.7	8.0	212.4	4.4	53.3	3.3	53.3	3.3	53.3	3.3
Tauanui	66.5	2.3	16.6	1.7	16.6	1.7	63.1	1.5	15.8	1.1	15.8	1.1	15.8	1.1
Turanganui	84.5	3.1	21.1	2.3	21.1	2.3	82.6	2.8	20.7	2.1	20.7	2.1	20.7	2.1
Makahakaha	79.6	3.5	30.2	2.7	30.2	2.7	71.2	1.9	27.0	1.4	27.0	1.4	27.0	1.4
Eastern hill streams	483.8	18.6	136.4	13.9	136.6	15.5	478.8	16.4	135.0	12.3	135.1	12.4	135.1	12.4
Otukura Stream	267.3	6.7	67.1	5.0	67.1	5.0	215.8	4.2	54.2	3.1	54.2	3.1	54.2	3.1
Valley floor streams (Lake Wairarapa)	275.3	11.4	76.0	8.6	76.0	8.6	205.0	5.0	56.6	3.8	56.6	3.8	56.6	3.8
Western Lake Streams	227.4	26.1	60.0	19.6	60.7	21.6	223.8	25.4	59.1	19.1	59.2	19.1	59.2	19.1
South coast streams	202.4	8.4	50.6	6.3	50.6	6.3	201.2	7.9	50.3	5.9	50.3	5.9	50.3	5.9
Lake Wairarapa	-	-	-	-	-	-	-	-	-	-	-	-	190.3	30.7
Lake Onoke	-	-	-	-	-	-	-	-	-	-	-	-	1389.1	124.8

Appendix F. Native and non-native nutrient loads (baseline and targets)

Table F.1: FMU derived NO_3-N baseline and "target" native and non-native loads

FMU	FMU derived Baseline NO_3-N Loads				FMU derived Target NO_3-N Loads							
	Total leaching	"Native" leaching	"Non-native" leaching	Total (Leaching + WWTP)	Total leaching		"Native" leaching		"Non-native" leaching		Total (Leaching + WWTP)	
					Load	% reduction	Load	% reduction	Load	% reduction	Load	% reduction
Huangarua	405.8	0.67	405.1	405.8	403.0	0.7%	0.67	0.0%	402.3	0.7%	403.0	0.7%
Kopuaranga	338.9	0.15	338.7	338.9	297.6	12.2%	0.15	0.0%	297.5	12.2%	297.6	12.2%
Mangatarere	324.0	4.78	319.3	324.2	288.7	10.9%	4.78	0.0%	283.9	11.1%	288.7	10.9%
Parkvale	251.0	0.0	251.0	251.0	217.4	13.4%	0.04	0.0%	217.3	13.4%	217.4	13.4%
Valley floor streams (Ruamahanga River)	379.3	0.03	379.2	380.4	333.9	12.0%	0.03	0.0%	333.9	12.0%	334.2	12.1%
Upper Ruamahanga	100.9	7.65	93.2	100.9	99.5	1.3%	7.65	0.0%	91.9	1.5%	99.5	1.3%
Taueru	442.6	0.41	442.2	442.6	392.5	11.3%	0.41	0.0%	392.1	11.3%	392.5	11.3%
Tauherenikau	101.6	11.23	90.4	101.6	101.3	0.3%	11.23	0.0%	90.1	0.3%	101.3	0.3%
Waingawa	124.4	9.87	114.6	124.4	123.8	0.5%	9.87	0.0%	113.9	0.5%	123.8	0.5%
Waiohine	122.4	18.71	103.6	122.4	121.1	1.0%	18.71	0.0%	102.4	1.2%	121.1	1.0%
Waipoua	348.0	2.79	345.2	348.0	316.5	9.1%	2.79	0.0%	313.7	9.1%	316.5	9.1%
Whangaehu	241.7	0.00	241.7	241.7	212.4	12.1%	0.00	0.0%	212.4	12.1%	212.4	12.1%
Tauanui	66.5	2.51	64.0	66.5	63.1	5.1%	2.51	0.0%	60.6	5.3%	63.1	5.1%
Turanganui	84.5	3.50	81.0	84.5	82.6	2.3%	3.50	0.0%	79.1	2.4%	82.6	2.3%
Makahakaha	79.6	0.00	79.6	79.6	71.2	10.6%	0.00	0.0%	71.2	10.6%	71.2	10.6%
Eastern hill streams	483.8	2.99	480.8	484.0	478.8	1.0%	2.99	0.0%	475.8	1.0%	478.8	1.1%
Otukura Stream	267.3	0.00	267.3	267.3	215.8	19.2%	0.00	0.0%	215.8	19.2%	215.8	19.2%
Valley floor streams (Lake Wairarapa)	275.3	0.86	274.4	275.3	205.0	25.5%	0.86	0.0%	204.1	25.6%	205.0	25.5%
Western Lake Streams	227.4	11.10	216.3	228.1	223.8	1.6%	11.10	0.0%	212.7	1.7%	223.9	1.8%
South coast streams	202.4	6.44	195.9	202.4	201.2	0.6%	6.44	0.0%	194.7	0.6%	201.2	0.6%
Lake Wairarapa	-	-	-	-	-	-	-	-	-	-	-	-
Lake Onoke	-	-	-	-	-	-	-	-	-	-	-	-

Table F.2: FMU derived TP baseline and "target" native and non-native loads

FMU	FMU derived Baseline TP Loads				FMU derived Target TP Loads							
	Total leaching	"Native" leaching	"Non-native" leaching	Total (Leaching + WWTP)	Total leaching		"Native" leaching		"Non-native" leaching		Total (Leaching + WWTP)	
					Load	% reduction	Load	% reduction	Load	% reduction	Load	% reduction
Huangarua	26.65	0.12	26.53	26.65	24.74	7.1%	0.12	0.0%	24.62	7.2%	24.74	7.1%
Kopuaranga	38.24	0.03	38.21	38.24	9.45	75.3%	0.03	0.0%	9.43	75.3%	9.45	75.3%
Mangatarere	17.79	0.86	16.93	22.06	11.49	35.4%	0.86	0.0%	10.63	37.2%	11.65	47.2%
Parkvale	9.21	0.01	9.20	9.21	6.15	33.2%	0.01	0.0%	6.14	33.2%	6.15	33.2%
Valley floor streams (Ruamahanga River)	15.07	0.01	15.06	23.41	11.50	23.7%	0.01	0.0%	11.50	23.7%	12.04	48.6%
Upper Ruamahanga	8.17	1.38	6.79	8.17	8.05	1.4%	1.38	0.0%	6.67	1.7%	8.05	1.4%
Taueru	18.45	0.07	18.38	18.45	8.19	55.6%	0.07	0.0%	8.12	55.8%	8.19	55.6%
Tauherenikau	5.39	2.02	3.37	5.39	5.27	2.3%	2.02	0.0%	3.25	3.6%	5.27	2.3%
Waingawa	8.11	1.78	6.33	8.11	8.01	1.3%	1.78	0.0%	6.23	1.7%	8.01	1.3%
Waiohine	9.04	3.37	5.67	9.04	8.59	5.0%	3.37	0.0%	5.22	7.9%	8.59	5.0%
Waipoua	25.50	0.50	25.00	25.50	9.31	63.5%	0.50	0.0%	8.81	64.7%	9.31	63.5%
Whangaehu	10.72	0.00	10.72	10.72	4.41	58.8%	0.00	0.0%	4.41	58.8%	4.41	58.8%
Tauanui	2.27	0.45	1.82	2.27	1.53	32.9%	0.45	0.0%	1.07	41.0%	1.53	32.9%
Turanganui	3.09	0.63	2.46	3.09	2.78	10.0%	0.63	0.0%	2.15	12.6%	2.78	10.0%
Makahakaha	3.55	0.00	3.55	3.55	1.86	47.4%	0.00	0.0%	1.86	47.4%	1.86	47.4%
Eastern hill streams	18.57	0.54	18.03	20.18	16.45	11.4%	0.54	0.0%	15.91	11.8%	16.56	17.9%
Otukura Stream	6.72	0.00	6.72	6.72	4.17	38.0%	0.00	0.0%	4.17	38.0%	4.17	38.0%
Valley floor streams (Lake Wairarapa)	11.36	0.16	11.20	11.36	5.04	55.7%	0.16	0.0%	4.88	56.4%	5.04	55.7%
Western Lake Streams	26.12	2.00	24.13	28.08	25.41	2.7%	2.00	0.0%	23.41	3.0%	25.41	9.5%
South coast streams	8.39	1.16	7.23	8.39	7.90	5.9%	1.16	0.0%	6.74	6.8%	7.90	5.9%
Lake Wairarapa	-	-	-	-	-	-	-	-	-	-	-	-
Lake Onoke	-	-	-	-	-	-	-	-	-	-	-	-

Appendix G. Sediment Target Loads

FMU Name	Baseline sediment load (Hillslope + Netbank) (tonnes/year)				"Target" sediment load (Hillslope + Netbank) (tonnes/year)						
	Total FMU derived	Nested upstream	"Native" load		Scenario applied	Total FMU derived		Nested upstream		"Native" load	
			Load	% total		Load	%reduction	Load	%reduction	Load	%total
Eastern hill streams	93,040	93,040	7,871	8%	BAU+20% Silver 2080	58,757	37%	58,757	37%	7,318	7%
Huangarua	155,174	155,174	11,037	7%	BAU+20% Silver 2080	97,689	37%	97,689	37%	9,679	12%
Kopuaranga	67,822	67,822	673	1%	BAU+20% Silver 2080	55,567	18%	55,567	18%	670	0.4%
Lake Onoke	4,901	1,248,974	0	0%	BAU 2080	990	80%	884,597	29%	0	0%
Lake Wairarapa	10,034	113,467	0	0%	BAU 2080	2,011	80%	81,480	28%	0	0%
Makahakaha	20,367	20,367	0	0%	BAU 2080	17,211	15%	17,211	15%	0	0%
Mangatarere	38,255	38,255	20,468	54%	BAU 2080	26,797	30%	26,797	30%	17401	65%
Otukura Stream	4,694	4,694	0	0%	BAU 2080	1,215	74%	1,215	74%	0	0%
Parkvale Stream	7,060	7,060	0	0%	BAU 2080	2,389	66%	2,389	66%	0	0%
South coast streams	75,088	75,088	37,048	49%	BAU 2080	61,772	18%	61,772	18%	35752	58%
Western Lake Streams	38,203	38,203	30,762	81%	BAU 2080	28,159	26%	28,159	26%	25140	89%
Tauanui	9,061	9,061	5,476	60%	BAU 2080	6,497	28%	6,497	28%	5394	83%
Taueru	231,273	231,273	1,343	1%	BAU+20% Silver 2080	131,490	43%	131,490	43%	1,175	13%
Tauherenikau	51,370	51,370	41,366	81%	BAU 2080	47,453	8%	47,453	8%	41065	87%
Turanganui	18,071	18,071	7,728	43%	BAU 2080	10,603	41%	10,603	41%	7489	71%
Upper Ruamahanga	80,491	80,491	49,514	62%	BAU 2080	74,162	8%	74,162	8%	49074	66%
Valley floor streams (Lake Wairarapa)	9,166	9,166	0	0%	BAU 2080	2,643	71%	2,643	71%	0	0%
Valley floor streams (Ruamahanga River)	45,641	45,641	0	0%	BAU 2080	13,506	70%	13,506	70%	0	0%
Waingawa	99,177	99,177	80,867	82%	BAU 2080	89,001	10%	89,001	10%	80272	90%
Waiohine	137,234	175,488	115,050	84%	BAU 2080	130,841	5%	157,638	10%	114407	87%
Waipoua	56,431	56,431	13,241	23%	BAU 2080	42,447	25%	42,447	25%	12219	29%
Whangaehu	71,510	71,510	0	0%	BAU+20% Silver 2080	45,170	37%	45,170	37%	0	0%