BEFORE THE ENVIRONMENT COURT

In the matter of	appeals under clause 14 of the First Schedule to the Resource Management Act 1991 concerning proposed One Plan for the Manawatu-Wanganui region.
between	**FEDERATED FARMERS OF NEW ZEALAND** **ENV-2010-WLG-000148**
and	**MINISTER OF CONSERVATION** **ENV-2010-WLG-000150**
and	**DAY, MR ANDREW** **ENV-2010-WLG-000158**
and	**HORTICULTURE NEW ZEALAND** **ENV 2010-WLG-000155**
and	**WELLINGTON FISH & GAME COUNCIL** **ENV-2010-WLG-000157**
	Appellants
and	**MANAWATU-WANGANUI REGIONAL COUNCIL** *Respondent*

SUPPLEMENTARY STATEMENT BY JON ROYGARD AND MAREE CLARK ON NUTRIENT LOAD SCENARIOS AND METHODOLOGY

Dated: 24th February 2012

horizons regional council

Solicitor: John W Maassen/Nicholas Jessen

Administrator: Sharon Belk

Address: 11-15 Victoria Avenue
Private Bag 11025
Palmerston North 4442

Telephone: (06) 952 2800
Facsimile: (06) 952 2929
Email: sharon.belk@horizons.govt.nz

Terms		
TEB	=	technical evidence/planning and technical bundle
NV	=	notified version of POP
DV	=	decisions version of POP
MV	=	mediated version of POP
MCB	=	mediated compilation bundle

Section 1: Introduction

Overview

1. This evidence is the subsequent report to the joint technical evidence of Dr. Jonathon Kelvin Fletcher Roygard, Kathryn Jane McArthur and Maree Ellen Clark released by Horizons Regional Council on the 14th of February 2012. The evidence has been prepared by Jon Roygard and Maree Clark. Questions should be directed as per the note in the earlier evidence (TEB VII. Page 5038) .

2. This report provides the final results from the scenario analysis of instream outcomes for a number of different approaches to managing non-point sourced nitrogen. Further this report also provides the methodologies and assumptions applied to model these scenarios and the results from the scenarios.

3. This report is arranged in 7 sections as outlined below:

   (a) Section 2. The current state of in-river soluble inorganic nitrogen (SIN) and dissolved reactive phosphorus (DRP) loads (Measured Loads);

   (b) Section 3. The translation of the concentration-based SIN and DRP targets (from Schedule D DV POP) into annual loads (Target Loads);

   (c) Section 4. The point source SIN and DRP loads;

   (d) Section 5. The non-point source SIN and DRP loads;

   (e) Section 6. The relative contributions of different land use types to the non-point sourced SIN and DRP loads; and

(f) Section 7. Scenario modelling methodology and results.

Why manage nutrients in river and how do loads fit into this?

4. Primarily, nutrients are managed to reduce in-river contaminant concentrations, and their resultant impacts on periphyton (including cyanobacteria) and aquatic health (Roygard et al 2012 *in press*[1]). Nutrients themselves can be toxic to aquatic life at high concentrations. Known toxicity effects from ammonia and nitrate in surface waters can be avoided by keeping within the proposed targets in Schedule D of the DV POP.

5. Non-point sources of contaminants (e.g. on-farm inputs) tend to be expressed as loads (e.g. kg of nitrogen/ha/yr). To interpret policy scenarios that manage load inputs and the affect this may have on in-stream water quality, it is necessary to think of in-river contaminants as loads instead of as concentrations. In-river nutrient loads are a product of nutrient flux (concentration multiplied by flow) and time. Therefore changes in load translate to changes in concentrations over the long term.

6. Loads are a useful mechanism to relate the target concentrations to the contributions from various sources, including land use, to the concentrations measured in the river. As loads factor in the flow, care need to be taken when considering the effect of a change in load on concentration. For example a 1 tonne reduction in the measured load may produce different concentrations changes depending on the flow at which this occurs.

7. Roygard et al. (2012 *in press*[2]) provides an overview of the purposes of nutrient management, and how calculations of nutrient load can be used to inform management in the context of the Manawatu Catchment and the DV POP nutrient concentration targets.

Purpose of the analysis

8. The purpose of scenario-based analyses is to determine the likely in-river load outcome of various policy approaches to the management of non-point sourced

[1] Appendix 2 TEB v.11 p. 5114-5136

[2] Appendix 2 TEB v.11 p. 5114-5136

nutrients. To do this, this evidence predicts the outcomes from various policy approaches, in several ways including:

(a) The total load that is predicted if the policy approach is implemented in Tonnes SIN/year.

(b) Whether the policy will maintain, improve or degrade water quality, in terms of total SIN load, compared to current state?

(c) How the total load predicted if the policy approach is implemented compares to the target load as determined from the concentration based water quality targets of the DV POP.

Overview of the scenario modelling

9. The scenarios modelled in this project were selected based on a range of potential options considered on the basis they represent an adequate sample of options. Broadly the scenarios modelled are grouped as:

(a) Land Use Capability (LUC) based nitrogen loss limit approaches applied to dairy farming, either conversions only or all dairy farming.

(b) Single number based nitrogen loss limit approaches applied to dairy farming, either conversions only or all dairy farming.

(c) The 'Do nothing' approach, where no loss limits are applied to any land use.

10. Sites identified as target catchments in the DV POP were selected for the scenario analysis. Sites in the lake catchments of the Northern Manawatu Lakes and Lake Horowhenua were not modelled as the methodology applied to river systems. Sites in the Rangitikei were included as these were identified as being in dispute during the mediation. The Rangitikei zone that was in dispute (water management zone (WMZ) Rang_4) is modelled in the scenarios in two ways. These were 1) excluding this area from the Rule (consistent with the DV POP)

and 2) including the non tidal area of the zone within the Rule (similar to that proposed in the NV POP[3]).

Section 2: Calculating the current SIN and DRP Loads in the target catchments

Introduction

11. The Measured Load provides an important benchmark for the scenario analysis under current land use with no nutrient loss limits.

Methods

12. To determine the current Measured Load in-river requires selection of

    (a) a loading calculation method;

    (b) appropriate sites to complete calculations for;

    (c) a time period of flow information to use; and

    (d) a time period of water quality data to use.

Loading calculation method

13. A flow-stratified loading calculation has been used to complete these calculations. The flow-stratified approach is similar to that used by Roygard et al (2012 *in press*[4]) and Roygard and McArthur (2008).

14. One of the reasons that a flow-stratified load method was selected was because of the ability to separate loads into flow ranges or 'decile bins'. This makes it easier to interpret the loads that occur at the flows that trigger the application of Schedule D concentration based targets (i.e. loads that occur below the 20th flow exceedance percentile). For ease of understanding, this study describes flows

[3] The NVPOP proposed the whole zone be included in the Rule.

[4] Appendix 2 TEB v.11 p. 5114-5136

above the 20th flow exceedance percentile (flows that occur 20 per cent of the time or less) as 'flood flows'. Put simply, the concentration based targets in the DV POP apply at flows that occur 80 per cent of the time and do not apply at flood flows.

15. The nutrient concentration targets do not apply at flood flows because flows within the flood flow category are more likely to remove periphyton from the system, through physical abrasion and scouring of the river bed. Under these conditions periphyton is less likely to be able to uptake nutrients for growth from the water column. For a more detailed explanation refer to evidence of Dr Biggs[5] and Kate McArthur[6]. The 20th flow exceedance percentile is considered an appropriate regional approximation of a bed scouring event (Kilroy et al, 2010).

16. The calculation methods for the Measured Loads are generally consistent with earlier analysis for the One Plan, as presented in the s. 42A report of Dr Jon Roygard[7], and have been accepted for peer-reviewed publication in the *New Zealand Journal of Marine and Freshwater Research.*

17. The key change to the published methods was a variation on the way the load in each flow decile bin was calculated. The published method and the method used here both estimate the nutrient flux (flow multiplied by concentration) for each decile bin and then convert these to a load. In both cases the load is calculated by multiplying the flux for each bin, by the period of time flow is within the range of flows within that decile bin. The methods used in this study use the original method for converting flux to load, but differ in the way the average flux for the bin is calculated.

18. The original method (Roygard and McArthur, 2008; Roygard et al, 2012 *in press*[8]) calculates the average flux for each sampling event by multiplying the flow at the time of sampling by the concentration at the time of sampling. The method used in this study calculates the average flux as the average concentration for all of

---

[5] TEB v. 2 p. 953-1020

[6] TEB v. 2 p. 591-928

[7] TEB v. 1 p. 193-476

[8] Appendix 2 TEB v.11 p. 5114-5136

the samples in the decile bin, multiplied by the statistically determined average flow that occurs in the bin.

19. The change in method was used to remove any bias that may occur due to variations in the sampling strategy for a site over time. The reason for this change is that if the average flow at time of sampling is lower than the average flow in the bin, then the original method will likely bias the average load for that bin low due to the sampling methodology. The same bias is likely to occur for high flows. The new method is not susceptible to this type of bias being introduced by the sampling strategy.

Selection of sites and period of record to model

20. The selection of sites and period of records to model was done on a catchment by catchment basis. The aim is to use a common long term flow record for each site and a shorter, more recent period of water quality data for the concentration data. This is summarised in Table 1.

Sites

21. The sites selected for analysis are shown in relation to the targeted catchments of the NV POP and the DV POP in Map 1. Some sites from water management zones in the NV POP but not included in the DV POP were modelled due these sites being in contention during the mediation process.

22. Several sites not in either the DV POP or the NV POP were modelled, these included the:

    (a) Tiraumea at Ngaturi and Mangahao at Ballance sites, which were modelled to enable scenario analysis to be completed for the Manawatu at Upper Gorge site; and

    (b) The Rangitikei at Mangaweka and Rangitikei at Onepuhi sites, which were modelled to enable scenario analysis to be completed for the Rangitikei at McKelvies site.

23. Several sites were included in the analysis to determine losses from particular land use types these included:

(a) The Tamaki at Reserve site and the Mangatainoka at Putara site to determine losses from the native cover land use type; and

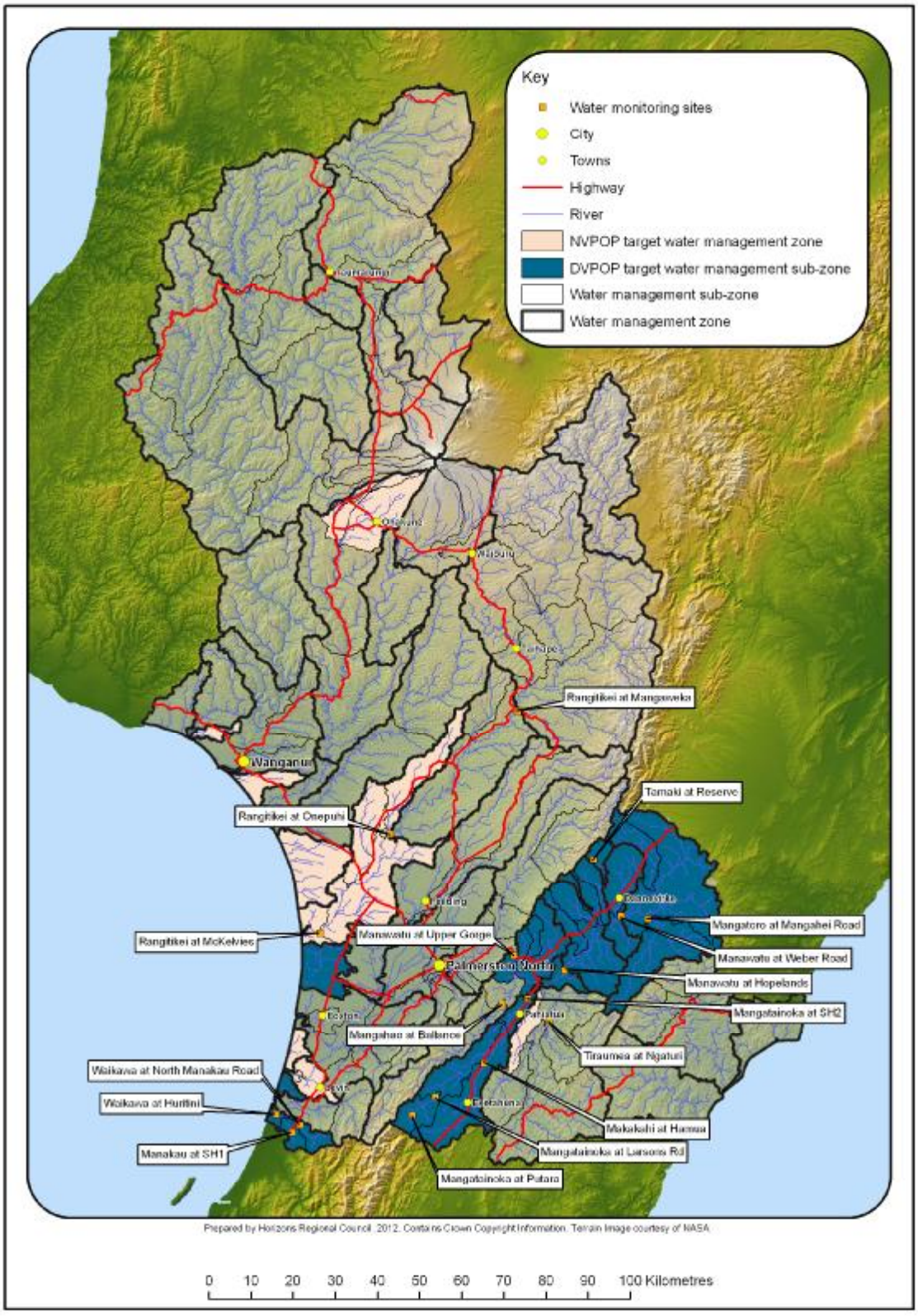
(b) The Mangatoro at Mangahei Road site, which was included to determine losses from the Sheep and/or Beef land use type.

24. Modelling of the Lake Horowhenua subzone has not been undertaken for this study. Instead, a copy of the report from the collaborative work between Horizons and NIWA to gather water quality state and trend information, and to advise options for restoration of the lake is provided. The Lake Horowhenua work was initiated and led by Dr Roygard and the technical work was completed primarily by Max Gibbs of NIWA (Gibbs, 2011).

Table 1: Summary of site, zone, flow and water quality information used for this study

Catchment/Site	Subzone	Sub catchment	Target zone	SIN target conc.	DRP target conc.		Flow period used		Gaps[1]	Water quality data used		SIN	DRP
				(g/m3)	(g/m3)	Flow	To	From		To	From	# of samples	# of samples
Manawatu catchment													
Manawatu at Weber Rd	Mana_1a	Upper- upper Manawatu	DV POP	0.167	0.010	Measured	01-Jul-1993	01-Jul-2010	none	19-Jul-2005	1-Aug-2011	74	74
Manawatu at Hopelands	Mana_5a	Upper Manawatu	DV POP	0.444	0.010	Measured	01-Jul-1993	01-Jul-2010	none	19-Jul-2005	1-Aug-2011	78	78
Tiraumea at Ngaturi	Mana_7a	Tiraumea	No[2]	0.444	0.010	Measured	01-Jul-1993	01-Jul-2010	none	2-Jul-2008	2-Aug-2011	36	36
Mangatainoka at Putara	Mana_8a	Forest park - Managatainoka	DV POP	0.070	0.070	Measured	01-Jul-1993	01-Jul-2010	none	26-Jul-1999	10-May-2011	59	59
Mangatainoka at Larsons Rd	Mana_8a	Upper Managatainoka	DV POP	0.070	0.006	Measured	01-Jul-1993	01-Jul-2010	none	21-Jul-2005	2-Aug-2011	75	75
Makakahi at Hamua	Mana_8d	Makakahi	DV POP	0.444	0.010	Measured	01-Jul-1993	01-Jul-2010	none	17-Aug-2005	5-Jul-2011	73	73
Mangatainoka at SH2 (Pahiatua)	Mana_8c	Mangatainoka	DV POP	0.444	0.010	Measured + Modelled	01-Jul-1993	01-Jul-2010	none	21-Jul-2005	5-Jul-2011	79	79
Mangahao at Ballance	Mana_9d	Mangahao	No[2]	0.167	0.006	Measured	01-Jul-1993	01-Jul-2010	none	21-Jul-2005	2-Aug-2011	60	60
Manawatu at upper Gorge	Mana_9a	Upper Gorge	DV POP	0.444	0.010	Measured	01-Jul-1993	01-Jul-2010	none	19-Jul-2005	3-Aug-2011	73	73
Waikawa Catchment													
Manakau at SH1	West_9b	Manakau	DV POP	0.167	0.010	Measured	19-May-2006	19-May-2010	none	19-Jul-2007	9-Aug-2011	35	35
Waikawa at Nth Manakau Rd	West_9a	Waikawa	DV POP	0.167	0.010	Measured	19-May-2006	19-May-2010	none	23-Aug-2007	9-Aug-2011	46	46
Waikawa at Huritini	West_9a	Waikawa	DV POP	0.167	0.010	Modelled	19-May-2006	19-May-2010	none	19-Jul-2006	9-Aug-2011	61	61
Rangitikei Catchment													
Rangitikei at Mangaweka	Rang_2a	Upper/Middle Rangitikei	NV POP	0.110	0.010	Measured	01-Jul-1993	01-Jul-2010	none	6-Jul-2005	10-08-2011	78	78
Rangitikei at Onepuhi	Rang_3a	Lower Rangitikei	NV POP	0.110	0.010	Measured + Modelled	01-Jul-1993	01-Jul-2010	none	2-Aug-2005	11-Aug-2011	70	70
Rangitikei at McKelvies	Rang_4a	Coastal Rangitikei	NV POP	0.110	0.010	Measured + Modelled	01-Jul-1993	01-Jul-2010	none	1- Aug-2006	11- Aug-2011	61	61
Other sites													
Tamaki at Picnic Reserve[3]	Mana_3	Forest Park Upper Manawatu	DV POP	0.070	0.006		01-Jul-1993	01-Jul-2010	1-Jul-2003 to 1 Jul 2004	18-Jul-2006	5-Jul-2010	38	38
Mangatoro at Mangahei Rd[4]	Mana_1c	Sheep/beef - Upper Manawatu	DV POP	0.110	0.010		1-Jan-04	1-Jan-12		18-Jul-2006	1-Aug-2011	62	62

[1]After gap filling - see text for details. [2]Used to inform analysis for the Upper Gorge site. [3&4]Sites used in determination of relative contributions to non-point source contributions.



Map 1: Location of the sites used in the calculations of the load scenarios in relation to the target catchment zones of the NV POP and DV POP. Note: all DV POP target catchments are also NV POP zones.

Periods of flow record

25. A long period of flow data was sought to accurately include more of the extreme flows that can occur, particularly high flows, as these can significantly alter load estimates. The longest possible common flow period across all sites in each catchment was sought.

26. In some cases provisional flow data was used (i.e. data that had not gone through the full quality assurance process), however all data was checked by an experienced hydrologist (Brent Watson - Senior Data Delivery Coordinator) who manages the processing of flow data for Horizons Regional Council. Some data gaps for the period of record were 'filled' to get a continuous record. Most water quality sampling sites and flow monitoring sites are at the same location. Where this was not the case, standard hydrological methods were used to derive flows for the sites.

27. The selection of a 17 year flow data period from 1993 to 2010 onward in the Manawatu catchment reflects the loss of flow recorders in the 1992/93 water year during a flood event and the availability of up to date quality assured datasets. The length of flow record in the Manawatu is considered long enough to provide accurate estimates of the flow statistics utilised in this study. Flow at Mangatainoka at Putara, Mangatainoka at SH2 and Tamaki at Reserve were modelled from nearby long-term flow measurement sites.

28. Most sites in the Manawatu had 17 years of flow record, however a reduced length of flow record was available for the Mangatoro at Mangahei Road (8 years) and Tamaki at Reserve sites (16 years). As the sites with reduced flow records were not used to specifically report the differences from various policy approaches, this is not considered to have significant bearing on the outcomes of the analysis.

29. The data period used for flow in the Waikawa catchment reflects the recent upgrading of monitoring programmes in this study catchment. The data for the Huritini site is modelled flow data determined using standard hydrological methods. The length of record for the Waikawa sites is comparatively short to that used in the Manawatu and the Rangitikei and it would be preferred to have a longer period of record available for this analysis.

30. Flow statistics for the Rangitikei is from 1993 to 2010 reflecting a 17 year period. Much of the data for the Onepuhi and McKelvies sites was modelled. This reflects the comparatively recently installations of flow recorders at Onepuhi and Mckelvies. The flows used for the Rangitikei as recorded after the abstraction of the Tongariro power development take from the headwaters of the Rangitikei.

31. Flow statistics for the sites can be provided on request.

Periods of water quality information

32. In the Manawatu catchment, water quality data from 1 July 2005 to 31 October 2011 was used to calculate loads. A shorter period of water quality data was used for this analysis to ensure long term changes in water quality that have occurred from land use change in the catchments over the past 10 to 15 years did not bias the data. At the same time, the selected period captures recently introduced water quality management initiatives, including:

- Farm dairy effluent management. As a part of the *Manawatu Catchment Water Quality Regional Plan* (1999) and the *Land and Water Regional Plan* (2003), Horizons introduced stronger regulatory requirements for farm dairy effluent management. As a result, the total number of resource consents for direct discharge of treated dairy farm effluent to water in the Manawatu catchment has reduced from 318 in 1998 to less than five in 2012.

- Upgrades to point sources. As a part of the *Manawatu Catchment Water Quality Regional Plan* (1999), Horizons introduced stronger regulatory policy to manage nutrient from point sources during low flows. An example of point source upgrades in the target catchments since that policy was introduced is the major point source in the Mangatainoka catchment from Pahiatua sewage receiving an upgrade of the sewage treatment pond linings in 2003, at a cost of approximately $1.6 million. The major point source in the upper Manawatu catchment from Dannevirke sewage was upgraded in 2005, with the installation of a new membrane filtration treatment plant at a cost of approximately $3.8 million.

- Increase in numbers of dairy cows as reported by Newman[9] and Neild and Rhodes[10] in their expert evidence to the One Plan.

33. All water quality data utilised was quality assured and quality coded. Standard procedures for samples that had concentrations equal to the detection limits were used i.e. these values were halved. Where there was more than one sample for any day, the median value was utilised.

Results

34. The current loads or Measured loads at the sites in this study are shown for SIN in Table 2 and for DRP in Table 3. in a format that demonstrates the distribution of the loads at the sites in the various decile bins for each site, as total loads and as loads for the period where the schedule D targets apply. Further detail on the proportion of load in each flow decile bin and when the targets do or do not apply is provided in Table 4, and Table 5.

35. In the sites of this study between 48 and 84% of the Measured loads are calculated to occur at flows above the threshold where the water quality targets in Schedule D of the DV POP apply.

[9] TEB v. 8 p. 3811-3826

[10] TEB v. 3 p. 1423-1526

Table 2: Measured soluble inorganic nitrogen (SIN) loads for the Manawatu, Waikawa and Rangitikei catchments, showing the loads in each of the flow decile bins, the loads for all flows and the loads at flows below flood flows (Load 20-100). All units are tonnes SIN/year.

	Decile Bin											
Catchment/ Site	**0-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**80-90**	**90-100**	**Load All Flows**	**Load 20 to 100**
Manawatu Catchment												
Manawatu at Weber Rd	158.3	61.3	26.3	18.7	13.2	8.6	6.8	1.7	1.3	0.3	296.5	76.9
Manawatu at Hopelands	341.3	159.2	96.3	70.7	49.6	34.0	20.8	8.3	4.7	1.6	786.5	286.0
Tiraumea at Ngaturi	118.3	55.7	30.2	19.0	14.8	14.6	9.1	8.6	7.3	5.8	283.5	109.5
Mangatainoka at Putara	0.5	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.4
Mangatainoka at Larsons Road	7.7	2.8	1.9	1.2	0.5	0.2	0.4	0.2	0.1	0.1	15.2	4.7
Makakahi at Hamua	79.2	37.8	20.3	11.3	8.7	7.2	2.3	0.8	0.5	0.1	168.1	51.1
Mangatainoka at SH2	209.1	110.9	62.9	44.9	39.1	33.1	17.8	11.9	8.9	3.7	542.3	222.3
Mangahao at Ballance	43.2	24.9	13.4	8.8	7.6	5.4	2.9	2.3	1.6	0.5	110.6	42.4
Manawatu at upper Gorge	1021.4	390.0	299.0	178.8	153.5	100.7	79.7	33.8	15.6	8.7	2281.2	869.8
Waikawa Catchment												
Manakau at SH1	3.8	0.9	0.4	0.1	0.2	0.1	0.1	0.0	0.0	0.0	5.6	0.9
Waikawa at Nth Manakau Rd	2.3	0.8	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.0	4.5	1.4
Waikawa at Huritini	13.9	7.9	4.0	3.8	3.0	2.6	2.2	2.3	2.1	1.9	43.7	21.9
Rangitikei Catchment												
Rangitikei at Mangaweka	109.3	59.8	28.7	23.0	10.1	5.9	7.8	3.1	2.7	1.2	251.7	82.5
Rangitikei at Onepuhi	158.4	69.5	51.2	31.1	15.3	7.8	2.7	3.5	2.2	0.9	342.5	114.6
Rangitikei at McKelvies	253.9	150.8	68.0	45.9	27.7	10.9	12.5	0.9	1.7	0.7	573.1	168.3
Other sites												
Tamaki at Reserve	0.6	0.4	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1	2.1	1.1
Mangatoro at Mangahei Rd	56.2	18.7	10.3	8.4	5.8	4.1	3.3	1.9	1.7	0.7	111.2	36.3

Table 3: Measured dissolved reactive phosphorus (DRP) loads for the Manawatu, Waikawa and Rangitikei catchments showing the loads in each of the flow decile bins, the loads for all flows and the loads at flows below flood flows (Load 20-100). All units are tonnes DRP/year.

	Decile Bin											
Catchment/ Site	**0-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**80-90**	**90-100**	**Load All Flows**	**Load 20 to 100**
Manawatu Catchment												
Manawatu at Weber Rd	6.679	1.536	0.992	0.661	0.246	0.344	0.326	0.207	0.120	0.072	11.2	3.0
Manawatu at Hopelands	10.993	3.996	2.711	1.722	1.196	0.799	0.884	0.295	0.323	0.220	23.1	8.1
Tiraumea at Ngaturi	3.944	1.642	0.684	0.612	0.299	0.219	0.133	0.080	0.037	0.019	7.7	2.1
Mangatainoka at Putara	0.097	0.062	0.017	0.010	0.008	0.008	0.003	0.004	0.003	0.002	0.214	0.055
Mangatainoka at Larsons Road	0.293	0.117	0.074	0.051	0.046	0.041	0.024	0.015	0.013	0.006	0.7	0.3
Makakahi at Hamua	1.045	0.342	0.232	0.190	0.102	0.080	0.045	0.035	0.021	0.006	2.1	0.7
Mangatainoka at SH2	2.465	1.296	0.742	0.508	0.277	0.348	0.137	0.246	0.065	0.082	6.2	2.4
Mangahao at Ballance	3.144	0.484	0.369	0.262	0.251	0.121	0.056	0.052	0.042	0.023	4.8	1.2
Manawatu at upper Gorge	27.947	9.069	5.910	4.308	3.191	2.155	0.995	0.634	0.348	0.314	54.9	17.9
Waikawa Catchment												
Manakau at SH1	0.081	0.019	0.016	0.011	0.007	0.006	0.004	0.003	0.004	0.002	0.153	0.054
Waikawa at Nth Manakau Rd	0.195	0.080	0.056	0.043	0.029	0.022	0.023	0.015	0.009	0.008	0.5	0.2
Waikawa at Huritini	0.561	0.159	0.147	0.091	0.064	0.050	0.057	0.041	0.036	0.027	1.233	0.513
Rangitikei Catchment												
Rangitikei at Mangaweka	10.443	3.042	2.603	1.538	1.576	1.228	0.406	0.633	0.426	0.153	22.0	8.6
Rangitikei at Onepuhi	12.660	3.981	3.260	2.483	0.992	1.164	1.287	0.664	0.368	0.267	27.126	10.49
Rangitikei at McKelvies	20.787	8.444	4.061	2.536	1.692	1.767	1.205	0.325	0.645	0.262	41.723	12.49
Other sites												
Tamaki at Reserve	0.111	0.038	0.029	0.016	0.018	0.017	0.010	0.014	0.006	0.004	0.264	0.114
Mangatoro at Mangahei Rd	3.745	0.469	0.241	0.177	0.142	0.078	0.087	0.030	0.021	0.021	5.011	0.797

Table 4: Proportion of overall measured SIN load (Load all flows) in each of the decile bins for the sites analysed in this study. The table also shows the percentage of the measured load above flood flows (Load 0-20) and the percentage of measured load below flood flows (Load 20 to 100). All units are percentages.

Catchment/ Site	Decile Bin										Load all flows	Load 20 to 100
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100		
Manawatu Catchment												
Manawatu at Weber Rd	53.4%	20.7%	8.9%	6.3%	4.5%	2.9%	2.3%	0.6%	0.4%	0.1%	74.1%	25.9%
Manawatu at Hopelands	43.4%	20.2%	12.2%	9.0%	6.3%	4.3%	2.6%	1.1%	0.6%	0.2%	63.6%	36.4%
Tiraumea at Ngaturi	41.7%	19.6%	10.7%	6.7%	5.2%	5.1%	3.2%	3.0%	2.6%	2.0%	61.4%	38.6%
Mangatainoka at Putara	42.3%	24.9%	14.6%	6.0%	3.3%	3.7%	2.5%	1.5%	0.8%	0.3%	67.2%	32.8%
Mangatainoka at Larsons	50.8%	18.3%	12.9%	8.2%	3.6%	1.1%	2.7%	1.3%	0.7%	0.4%	69.2%	30.8%
Makakahi at Hamua	47.1%	22.5%	12.1%	6.7%	5.2%	4.3%	1.4%	0.5%	0.3%	0.1%	69.6%	30.4%
Mangatainoka at SH2	38.6%	20.5%	11.6%	8.3%	7.2%	6.1%	3.3%	2.2%	1.6%	0.7%	59.0%	41.0%
Mangahao at Ballance	39.1%	22.5%	12.1%	8.0%	6.9%	4.8%	2.7%	2.0%	1.5%	0.4%	61.6%	38.4%
Manawatu at upper Gorge	44.8%	17.1%	13.1%	7.8%	6.7%	4.4%	3.5%	1.5%	0.7%	0.4%	61.9%	38.1%
Average of Manawatu Sites	44.6%	20.7%	12.0%	7.4%	5.4%	4.1%	2.7%	1.5%	1.0%	0.5%	65.3%	34.7%
Waikawa Catchment												
Manakau at SH1	67.8%	15.4%	7.5%	2.3%	3.0%	1.9%	1.4%	0.2%	0.4%	0.3%	83.1%	16.9%
Waikawa at Nth Manakau Rd	51.4%	17.6%	9.7%	6.0%	4.9%	3.5%	2.9%	1.6%	1.5%	0.9%	68.9%	31.1%
Waikawa at Huritini	31.8%	18.0%	9.1%	8.6%	6.9%	5.9%	5.1%	5.3%	4.8%	4.4%	49.9%	50.1%
Rangitikei Catchment												
Rangitikei at Mangaweka	43.4%	23.8%	11.4%	9.1%	4.0%	2.3%	3.1%	1.2%	1.1%	0.5%	67.2%	32.8%
Rangitikei at Onepuhi	46.2%	20.3%	15.0%	9.1%	4.5%	2.3%	0.8%	1.0%	0.6%	0.3%	66.5%	33.5%
Rangitikei at McKelvies	44.3%	26.3%	11.9%	8.0%	4.8%	1.9%	2.2%	0.2%	0.3%	0.1%	70.6%	29.4%
Other sites												
Tamaki at Reserve	27.5%	17.8%	10.6%	9.8%	11.5%	5.4%	4.0%	7.8%	3.0%	2.7%	45.3%	54.7%
Mangatoro at Mangahei Rd	50.5%	16.8%	9.3%	7.5%	5.2%	3.7%	3.0%	1.7%	1.5%	0.7%	67.4%	32.6%

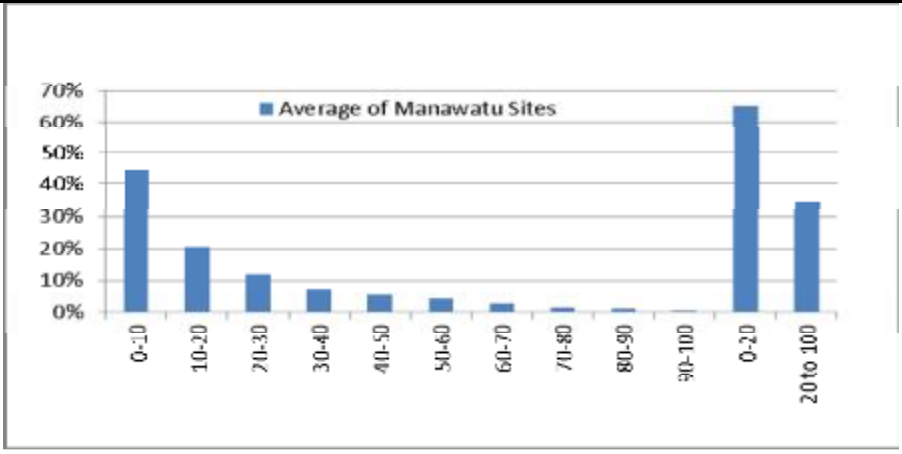


Figure 1: Proportion of overall measured SIN load (vertical axis) in each of the decile bins (horizontal axis) for the average of the Manawatu sites. The table also shows the percentage of the load above flood flows (0-20) and below flood flows (Load 20-100).

Table 5: Measured SIN and DRP loads for the sites used in this study, showing the overall loads for all flows (Load All Flows), the loads at flows below flood flows (Load 20-100) and the proportion (percentage) of each of these loads above and below flood flows.

	SIN				DRP			
Site	SIN Measured Load All Flows Tonnes/ year	SIN Measured Load 20-100 Tonnes/ year	Percentage of Measured Load Above Flood Flows %	Percentage of Measured Load Below Flood Flows %	Measured Load All Flows Tonnes/ year	Measured Load 20-100 Tonnes/ year	Percentage of Measured Load Above Flood Flows %	Percentage of Measured Load Below Flood Flows %
Manawatu Catchment								
Manawatu at Weber Rd	296.5	76.9	74%	26%	11.2	3.0	73%	27%
Manawatu at Hopelands	786.5	286.0	64%	36%	23.1	8.1	65%	35%
Tiraumea at Ngaturi	283.5	109.5	61%	39%	7.7	2.1	73%	27%
Mangatainoka at Putara	1.3	0.4	69%	31%	0.2	0.1	74%	26%
Mangatainoka at Larsons	15.2	4.7	69%	31%	0.7	0.3	60%	40%
Makakahi at Hamua	168.1	51.1	70%	30%	2.1	0.7	66%	34%
Mangatainoka at SH2	542.3	222.3	59%	41%	6.2	2.4	61%	39%
Mangahao at Ballance	110.6	42.4	62%	38%	4.8	1.2	76%	24%
Manawatu at upper Gorge	2281.2	869.8	62%	38%	54.9	17.9	67%	33%
Waikawa Catchment								
Manakau at SH1	5.6	0.9	84%	16%	0.2	0.1	65%	35%
Waikawa at Nth Manakau	4.5	1.4	69%	31%	0.5	0.2	57%	43%
Waikawa at Huritini	43.7	21.9	50%	50%	1.2	0.5	58%	42%
Rangitikei catchment								
Rangitikei at Mangaweka	251.7	82.5	67%	33%	22.0	8.6	61%	39%
Rangitikei at Onepuhi	343	114.6	67%	33%	27.1	10.5	61%	39%
Rangitikei at McKelvies	573.1	168.3	71%	29%	41.7	12.5	70%	30%
Other sites								
Tamaki at Reserve	2.1	1.1	48%	52%	0.3	0.1	57%	43%
Mangatoro at Mangahei Rd	111.2	36.3	67%	33%	5.0	0.8	84%	16%

Section 3: Translating the concentration based targets to annual target loads

Introduction

36. The water quality targets in Schedule D of the DV POP provide an important benchmark to test the outcomes of potential policy approaches. The targets in Schedule D are concentration based. To make comparisons with the management of non-point sources, these targets have been converted to long term average annual loads. This conversion makes the targets comparable to long term average annual losses from farming systems as calculated by the Overseer model.

Methods

37. The method used in this study for calculating the concentration based water quality targets to annual loads involved multiplying the flow volume for each 15 minute interval of a flow series of a site by the concentration of the water quality target for that site, then assigning each 15 minute load interval to the appropriate flow decile bin and adding the loads within each of the decile bins. This calculation yields the total load for the decile bin. The process was repeated for each year of flow record, and the annual totals for each year were reported for each decile bin, all flows, and flows below flood flows. This enables assessment of target loads for the flow periods where the concentration based targets apply. The method also allows the variation in the annual Target load totals (which result from annual variations in river flow) to be assessed. The Target Load calculations were completed for the same sites and flow periods as the Measured Load calculations.

Results

38. The Target loads at the sites in this study are shown for SIN in Table 6 and for DRP in Table 7 in a format that demonstrates the distribution of the target loads at the sites in the individual decile bins for each site, as total loads and as loads for the period where the Schedule D targets apply. Further detail on the

proportion of the Target load in each flow decile bin and when the targets do or do not apply is provided in Table 8, Table 9 and Figure 2.

39. In the sites of this study between 49 and 70% of the Target loads are calculated to occur at flows above the threshold where the water quality targets in Schedule D of the DV POP apply.

Table 6: Target soluble inorganic nitrogen (SIN) loads for the Manawatu, Waikawa and Rangitikei catchments, showing the loads in each of the flow decile bins, the loads for all flows and the loads at flows below flood flows (Load 20 to 100). All units are tonnes SIN/year.

	Decile Bin											
Catchment/ Site	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	Load All Flows	Load 20 to 100
Manawatu Catchment												
Manawatu at Weber Rd	34.6	10.0	6.6	5.0	3.9	3.0	2.4	1.8	1.4	1.0	69.6	25.0
Manawatu at Hopelands	155.7	57.9	40.2	30.2	23.6	18.7	14.5	10.9	7.8	5.0	364.3	150.7
Tiraumea at Ngaturi	107.2	36.4	22.5	15.8	11.7	8.9	6.8	5.3	4.3	3.4	222.4	78.7
Mangatainoka at Putara	1.7	0.5	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0	3.2	1.0
Mangatainoka at Larsons Road	6.3	1.7	1.0	0.7	0.5	0.4	0.3	0.2	0.2	0.1	11.6	3.5
Makakahi at Hamua	43.0	15.7	10.2	7.3	5.3	3.8	2.6	1.7	1.0	0.5	91.1	32.5
Mangatainoka at SH2	118.9	45.1	29.8	21.3	15.9	11.9	8.8	6.3	4.1	2.2	264.3	100.2
Mangahao at Ballance	43.4	10.9	6.9	5.0	3.9	3.0	2.4	1.8	1.4	0.8	79.5	25.2
Manawatu at upper Gorge	474.2	207.7	141.8	105.5	80.3	61.7	46.9	34.7	24.5	16.1	1193.5	511.6
Waikawa Catchment												
Manakau at SH1	1.0	0.3	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	2.0	0.6
Waikawa at Nth Manakau Rd	3.3	1.3	0.9	0.7	0.5	0.4	0.3	0.3	0.2	0.2	8.1	3.5
Waikawa at Huritini	4.3	1.6	1.1	0.8	0.6	0.5	0.4	0.3	0.2	0.2	10.0	4.1
Rangitikei Catchment												
Rangitikei at Mangaweka	72.2	36.3	27.1	21.4	17.2	13.9	11.2	8.8	7.0	5.0	220.0	111.5
Rangitikei at Onepuhi	76.9	38.1	28.0	22.0	17.7	14.2	11.5	9.1	7.1	5.3	230.1	115.1
Rangitikei at McKelvies	84.7	41.4	30.4	23.6	18.8	15.0	12.0	9.5	7.4	5.5	248.3	122.2
Other sites												
Tamaki at Reserve	0.6	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	1.6	0.7
Mangatoro at Mangahei Rd	10.5	2.3	1.5	1.2	0.9	0.7	0.6	0.5	0.4	0.3	18.8	6.0

Table 7: Target dissolved reactive phosphorus (DRP) loads for the Manawatu, Waikawa and Rangitikei catchments showing the Target loads in each of the flow decile bins, the loads for all flows and the loads at flows below flood flows (Load 20 to 100). All units are tonnes DRP/year.

	Decile Bin											
Catchment/ Site	**0-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**80-90**	**90-100**	**Load All Flows**	**Load 20 to 100**
Manawatu Catchment												
Manawatu at Weber Rd	2.072	0.597	0.398	0.297	0.231	0.182	0.144	0.109	0.082	0.057	4.169	1.500
Manawatu at Hopelands	3.506	1.305	0.905	0.680	0.532	0.420	0.326	0.246	0.175	0.112	8.205	3.395
Tiraumea at Ngaturi	2.415	0.821	0.507	0.357	0.264	0.199	0.154	0.119	0.097	0.076	5.008	1.772
Mangatainoka at Putara	0.149	0.041	0.024	0.017	0.013	0.009	0.007	0.005	0.004	0.002	0.272	0.083
Mangatainoka at Larsons Road	0.542	0.148	0.089	0.062	0.046	0.035	0.026	0.020	0.014	0.009	0.990	0.301
Makakahi at Hamua	0.968	0.352	0.230	0.164	0.119	0.087	0.060	0.039	0.023	0.010	2.053	0.732
Mangatainoka at SH2	2.679	1.017	0.671	0.479	0.358	0.267	0.199	0.143	0.092	0.049	5.954	2.258
Mangahao at Ballance	1.559	0.392	0.248	0.181	0.140	0.109	0.085	0.065	0.049	0.030	2.857	0.906
Manawatu at upper Gorge	10.681	4.677	3.195	2.377	1.808	1.390	1.057	0.783	0.551	0.362	26.880	11.522
Waikawa Catchment												
Manakau at SH1	0.062	0.017	0.011	0.008	0.006	0.004	0.003	0.003	0.002	0.001	0.117	0.038
Waikawa at Nth Manakau Rd	0.195	0.080	0.055	0.040	0.031	0.024	0.019	0.015	0.013	0.009	0.482	0.208
Waikawa at Huritini	0.255	0.097	0.066	0.049	0.037	0.029	0.023	0.018	0.015	0.011	0.60	0.25
Rangitikei Catchment												
Rangitikei at Mangaweka	6.564	3.301	2.467	1.941	1.560	1.259	1.016	0.803	0.634	0.454	20.00	10.14
Rangitikei at Onepuhi	6.994	3.462	2.550	2.002	1.609	1.293	1.044	0.830	0.649	0.486	20.92	10.46
Rangitikei at McKelvies	7.699	3.765	2.760	2.149	1.706	1.360	1.095	0.865	0.675	0.503	22.58	11.11
Other sites												
Tamaki at Reserve	0.049	0.022	0.016	0.012	0.010	0.008	0.007	0.005	0.004	0.002	0.13	0.06
Mangatoro at Mangahei Rd	0.955	0.209	0.139	0.107	0.083	0.067	0.052	0.041	0.033	0.026	1.71	0.55

Table 8: Proportion of overall Target SIN load (Load all flows) in each of the decile bins for the sites analysed in this study. The table also shows the percentage of the measured load above flood flows (Load 0-20) and the percentage of measured load below flood flows (Load 20 to 100). All units are percentages.

Catchment/ Site	Decile Bin										Load all flows	Load 20 to 100
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100		
Manawatu Catchment												
Manawatu at Weber Rd	50%	14%	10%	7%	6%	4%	3%	3%	2%	1%	64%	36%
Manawatu at Hopelands	43%	16%	11%	8%	6%	5%	4%	3%	2%	1%	59%	41%
Tiraumea at Ngaturi	48%	16%	10%	7%	5%	4%	3%	2%	2%	2%	65%	35%
Mangatainoka at Putara	55%	15%	9%	6%	5%	3%	3%	2%	1%	1%	70%	30%
Mangatainoka at Larsons	55%	15%	9%	6%	5%	4%	3%	2%	1%	1%	70%	30%
Makakahi at Hamua	47%	17%	11%	8%	6%	4%	3%	2%	1%	1%	64%	36%
Mangatainoka at SH2	45%	17%	11%	8%	6%	4%	3%	2%	2%	1%	62%	38%
Mangahao at Ballance	55%	14%	9%	6%	5%	4%	3%	2%	2%	1%	68%	32%
Manawatu at upper Gorge	40%	17%	12%	9%	7%	5%	4%	3%	2%	1%	57%	43%
Average of Manawatu Sites	*48%*	*16%*	*10%*	*7%*	*6%*	*4%*	*3%*	*2%*	*2%*	*1%*	*64%*	*36%*
Waikawa Catchment												
Manakau at SH1	53%	14%	9%	6%	5%	4%	3%	2%	2%	1%	68%	32%
Waikawa at Nth Manakau Rd	40%	17%	11%	8%	7%	5%	4%	3%	3%	2%	57%	43%
Waikawa at Huritini	43%	16%	11%	8%	6%	5%	4%	3%	2%	2%	59%	41%
Rangitikei Catchment												
Rangitikei at Mangaweka	33%	17%	12%	10%	8%	6%	5%	4%	3%	2%	49%	51%
Rangitikei at Onepuhi	33%	17%	12%	10%	8%	6%	5%	4%	3%	2%	50%	50%
Rangitikei at McKelvies	34%	17%	12%	10%	8%	6%	5%	4%	3%	2%	51%	49%
Other sites												
Tamaki at Reserve	37%	16%	12%	9%	7%	6%	5%	4%	3%	2%	53%	47%
Mangatoro at Mangahei Rd	56%	12%	8%	6%	5%	4%	3%	2%	2%	2%	68%	32%

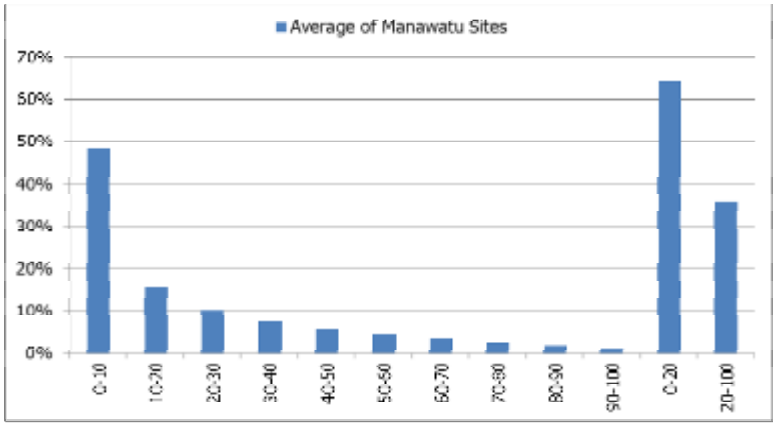


Figure 2: Proportion of overall measured SIN load (vertical axis) in each of the decile bins (horizontal axis) for the average of the Manawatu sites. The table also shows the percentage of the load above flood flows (0-20) and below flood flows (Load 20-100).

Table 9: Average annual target SIN and DRP loads for the sites used in this study showing the loads the overall loads for all flows (Load All flows) and the loads at flows below flood flows (Load 20-100) and the proportion (percentage) of each of these loads above and below flood flows. This table also quantifies the annual variability in average annual target loads for both SIN and DRP.

	SIN				DRP				SIN and DRP			
Period 1 July 1993 to 1 July 2010	SIN Target Conc.	Average annual Target Load All Flows	Average annual Target Load 20-100	Percentage of Target Load Below Flood Flows	DRP Target Conc.	Average Annual Target Load All Flows	Average Aannual Target Load 20-100	Percentage of Target Load Below Flood Flows	Annual Variability in Target Loads All Flows		Annual Variability in Target Loads 20-100	
Site	(g/m3)	Tonnes/ year	Tonnes/ year	%	(g/m3)	Tonnes/ year	Tonnes/ year	%	min.	max.	min	max
Manawatu Catchment												
Manawatu at Weber Rd	0.167	69.6	25.0	36%	0.010	4.2	1.5	36%	-44%	70%	-17%	12%
Manawatu at Hopelands	0.444	364.3	150.7	41%	0.010	8.2	3.4	41%	-46%	52%	-20%	13%
Tiraumea at Ngaturi	0.444	222.4	78.7	35%	0.010	5.0	1.8	35%	-37%	59%	-13%	19%
Mangatainoka at Putara	0.070	3.17	0.96	30%	0.060	0.272	0.083	30%	-21%	26%	-19%	15%
Mangatainoka at Larsons	0.070	11.6	3.5	30%	0.006	1.0	0.3	30%	-21%	26%	-19%	14%
Makakahi at Hamua	0.444	91.1	32.5	36%	0.010	2.1	0.7	36%	-29%	46%	-20%	14%
Mangatainoka at SH2	0.444	264.3	100.3	38%	0.010	6.0	2.3	38%	-30%	40%	-23%	19%
Mangahao at Ballance	0.167	79.5	25.2	32%	0.006	2.9	0.9	32%	-29%	23%	-21%	14%
Manawatu at upper Gorge	0.444	1193.5	511.6	43%	0.010	26.9	11.5	43%	-33%	40%	-14%	13%
Manawatu Maximum									-21%	70%	-13%	19%
Manawatu Minimum									-46%	23%	-23%	12%
Waikawa Catchment												
Manakau at SH1	0.167	8.1	3.5	43%	0.010	0.5	0.2	43%	-25%	36%	-11%	14%
Waikawa at Nth Manakau Rd	0.167	2.0	0.6	32%	0.010	0.1	0.0	32%	-16%	14%	-16%	19%
Waikawa at Huritini	0.167	10.0	4.1	41%	0.010	0.6	0.2	41%	-23%	31%	-12%	16%
Rangitikei Catchment												
Rangitikei at Mangaweka	0.110	220.0	111.5	51%	0.010	20.0	11.1	56%	-28%	22%	-17%	22%
Rangitikei at Onepuhi	0.110	230.1	115.1	50%	0.010	20.9	10.5	50%	-28%	29%	-20%	18%
Rangitikei at McKelvies	0.110	248.3	122.2	49%	0.010	22.6	11.1	49%	-28%	31%	-19%	20%
Other Sites												
Tamaki at Reserve	0.070	1.575	0.74	47%	0.06	0.14	0.06	47%	-41%	33%	-21%	22%
Mangatoro at Mangahei Rd	0.110	18.8	6.0	32%	0.010	1.71	0.55	32%	-55%	76%	-37%	74%

Section 4: Calculating the point source contributions of SIN and DRP to in-river nutrient loads.

Introduction

40. To model the load outcomes of policy approaches to management of non-point sources, it is necessary to subtract the point source components of the load from the measured loads. This section deals with the calculations of the point source contribution of loads.

Methods

41. Due to limitations in the monitoring data for the volume of point-source discharged in relation to the flow decile bins, the method to calculate the point source load simply estimates the flux from the point source using the average concentration of the discharge in each decile bin, multiplied by the average volume of the discharge (for all flows). It is recognised that, in contrast to the method employed for the measured load calculations, this method has its limitations. The method is likely to underestimate point source contributions at high flows and overestimate them at low flows through the use of the average flow in all categories.

42. As a result, inputs from point sources at the point of discharge are likely to be underestimated. However, the methodology for calculating non-point source inputs does not account for any in-river attenuation and assimilation of the nutrients from point source discharges which may be some considerable distance upstream of the water quality recorder site. As Roygard et al (2012 *in press*[11]) notes, the method assumes is that there is no uptake of soluble nutrients between the point of discharge and the water quality recorder site, and no transformation of total nitrogen or organic nitrogen to soluble inorganic nitrogen (SIN). The estimated point source contribution therefore potentially has a degree of over-estimation at the point of measurement at the water quality recorder sites where the Measured Loads are calculated for.

[11] Appendix 2 TEB v. 11 p. 5114-5136

43. The nutrient load estimates for point sources of nitrogen are typically a very small percentage of the overall Measured load for upper Manawatu and Mangatainoka sites when the same method that was used to calculate the measured load is applied to point source data (Roygard et al 2012 *in press*[12]). Given the relatively small component of the overall loads that point sources are estimated to comprise, the methodology is considered fit for purpose (particularly given the limitations in the data available).

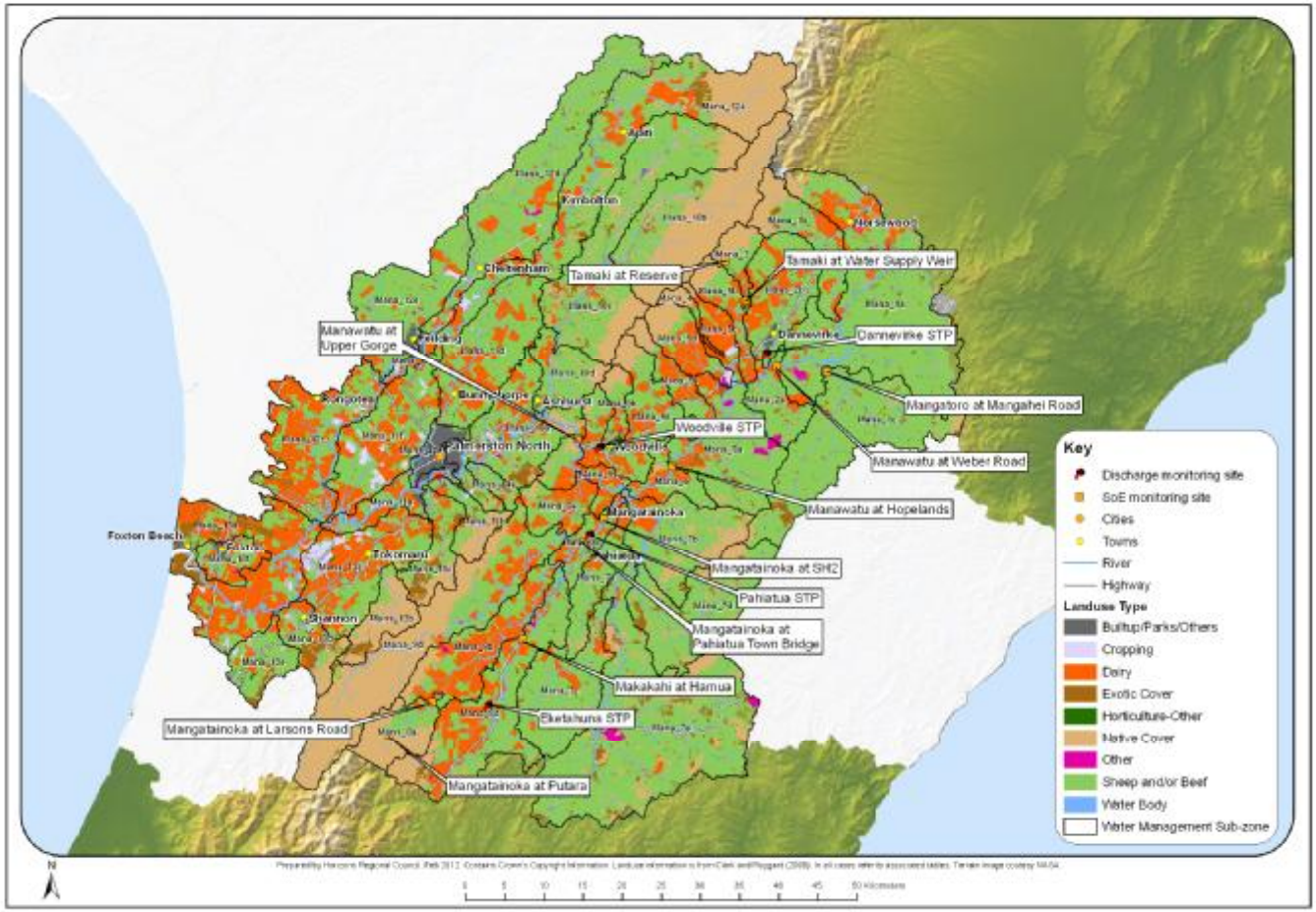
44. The decisions on which point sources to calculate was based on previous analyses (e.g. McArthur and Clark, 2007, Roygard and McArthur 2008, and Roygard et al. 2012 *in press)* and knowledge obtained through the State of the Environment and discharge monitoring programmes.

45. In the Manawatu scenarios, four major point sources are considered large enough to complete a calculation of nitrogen for this analysis (Map 2). Further detailed mapping for the upper Manawatu and Mangatainoka catchments is provided in Map 5 and Map 6.

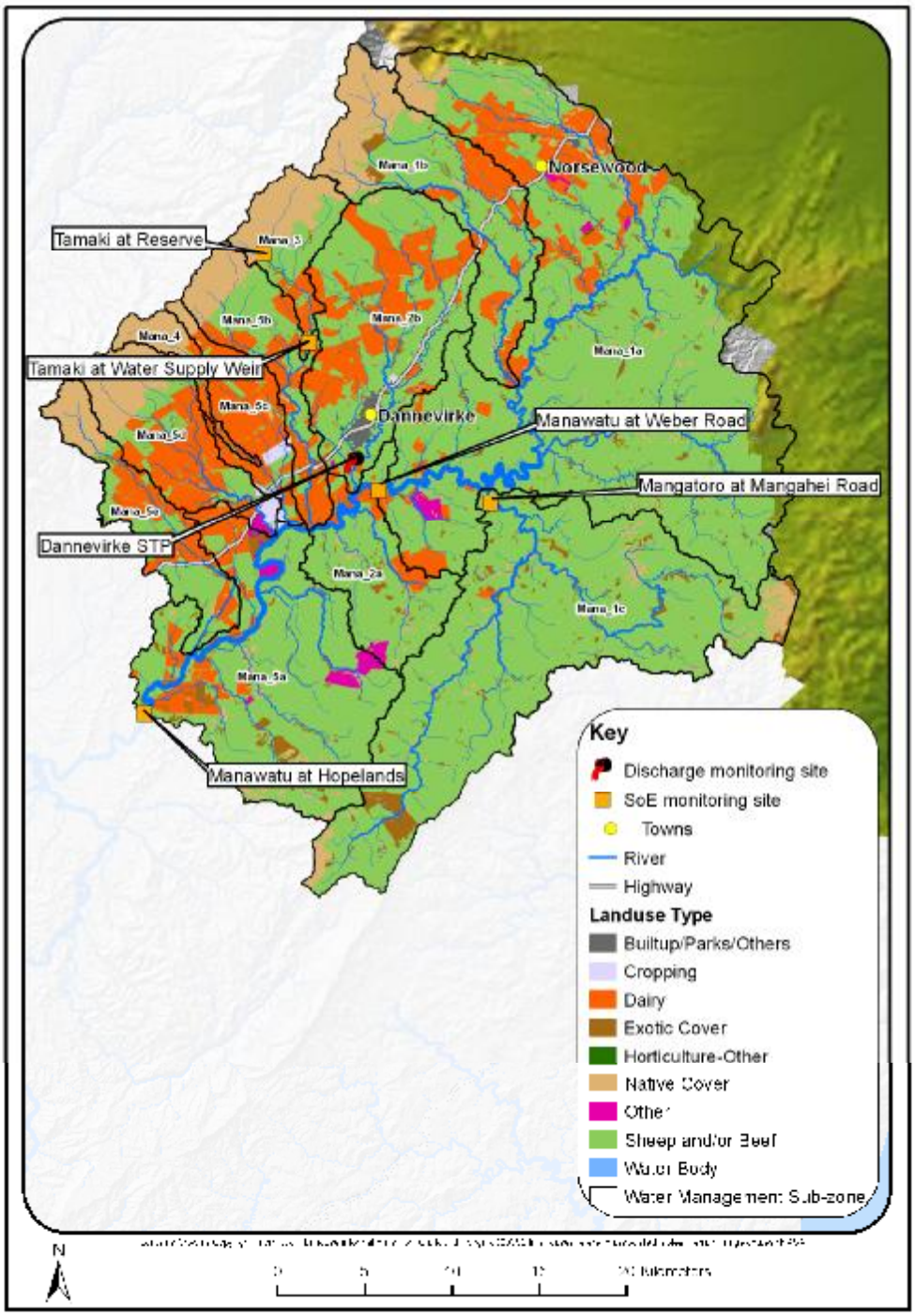
46. In the Waikawa (Map 5) there are no point source discharges considered of a sufficient scale to model.

47. In the Rangitikei scenarios, eight major point sources (Map 6) are considered large enough to complete a calculation of nitrogen for this analysis.

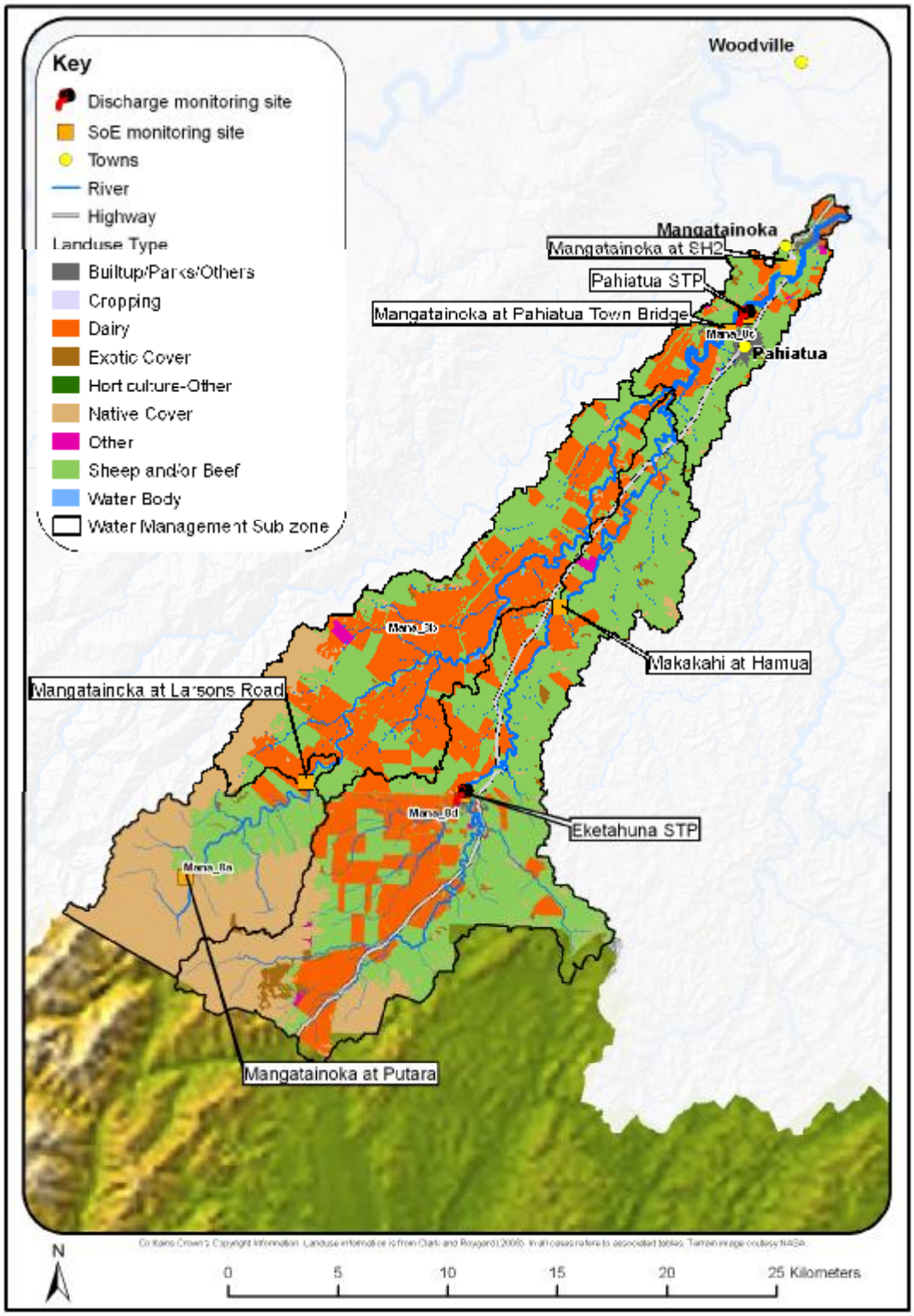
[12] Appendix 2 TEB v. 11 p. 5114-5136



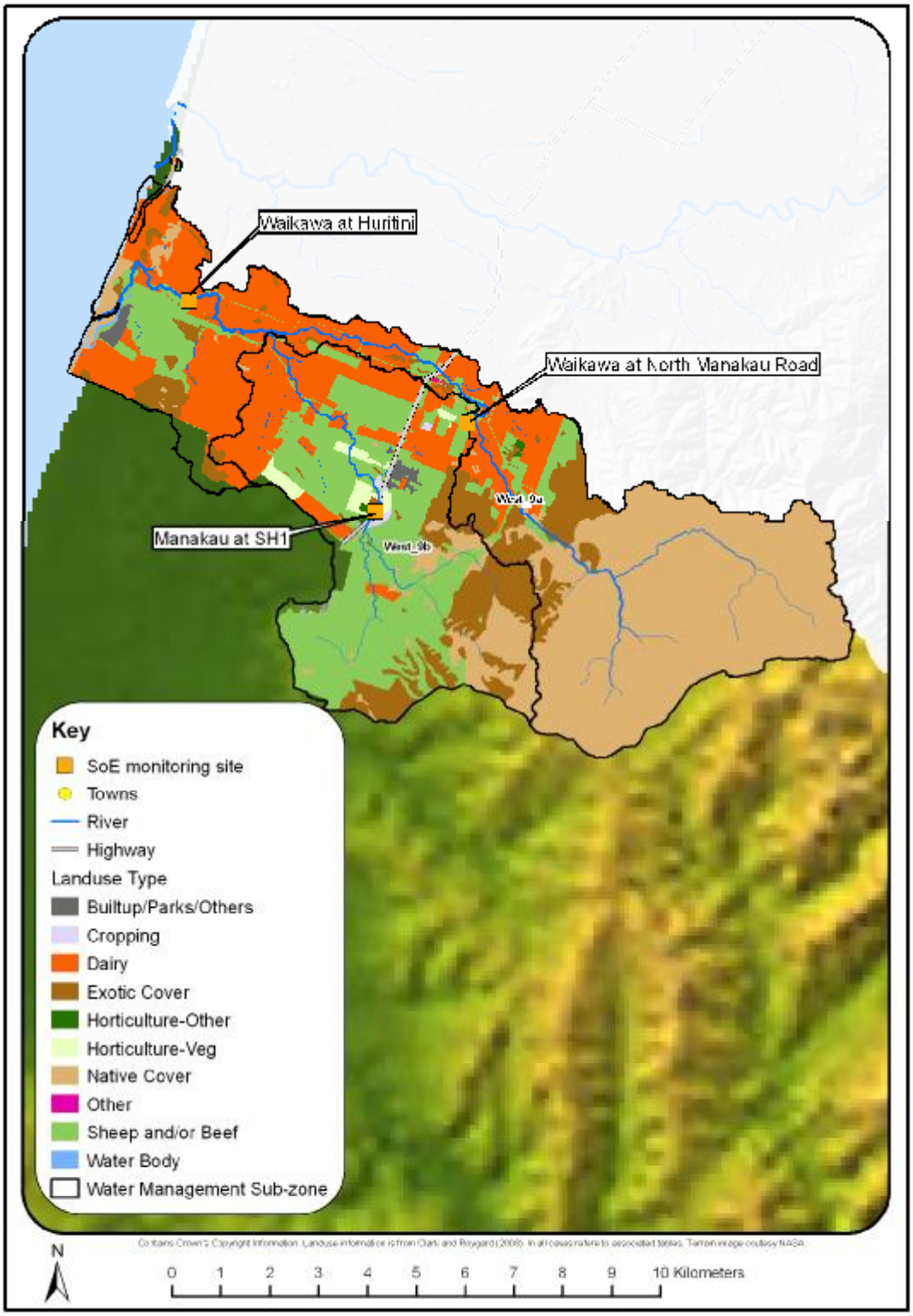
Map 2: Land use in the Manawatu catchment showing the locations of the monitoring sites modelled in this study, including point source monitoring sites.



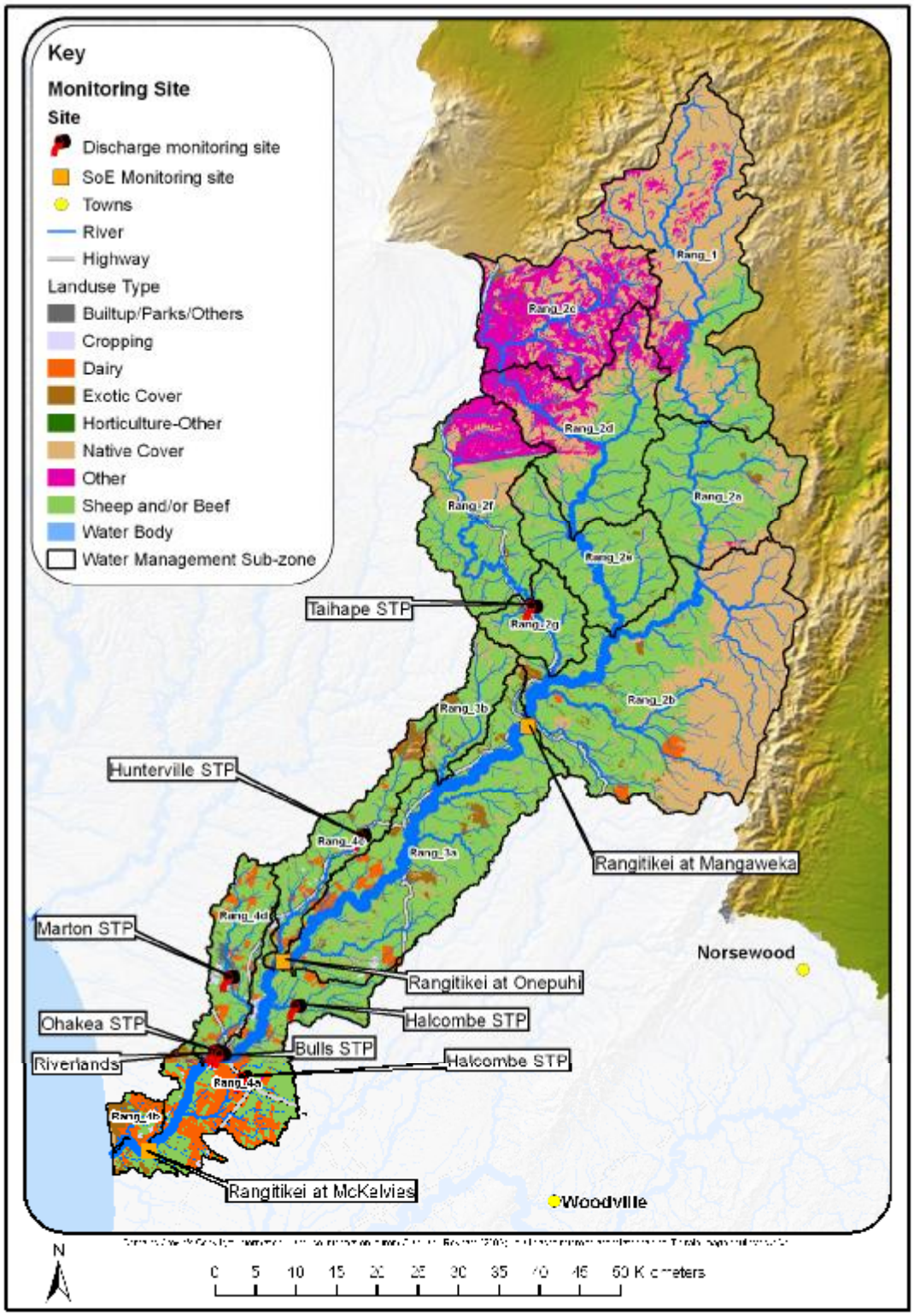
Map 3: Land use in the upper Manawatu catchment showing the locations of the monitoring sites modelled in this study, and their catchment areas, the location of point source monitoring sites are also shown. The Tamaki at Water Supply and weir site is included as flow information from this site was used for the Tamaki at Picnic reserve site.



Map 4: Land use in the Mangatainoka catchment showing the locations of the monitoring sites modelled in this study, and their catchment areas, the location of point source monitoring sites are also shown.



Map 5: Land use in the Waikawa catchment showing the locations of the monitoring sites modelled in this study.



Map 6: Land use in the Rangitikei catchment showing the locations of the monitoring sites modelled in this study, including point source monitoring sites.

Results

48. The point source SIN contributions are shown in Table 10 and Table 11, including the detail of the proportion of the loads for each point source in each flow decile bin. Table 12 shows the proportion of the load above and below flood flows for each of the point sources.

Table 10: Measured SIN loads for the point sources analysed in this study, showing the loads in each of the decile bins, the loads for all flow (Load All Flows) and the loads at flows below flood flows (Load 20-100). All units tonnes SIN/year. STP is short for Sewage Treatment Plant.

	Flow decile bin											
Site	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	All Flows	20-100
Manawatu Catchment												
Dannevirke STP	3.15	2.45	2.54	1.26	2.89	2.15	2.65	2.75	2.37	1.93	24.15	18.54
Eketahuna STP	0.04	0.03	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.47	0.40
Pahiatua STP	0.34	0.45	0.53	0.27	0.22	0.44	0.15	0.54	0.32	0.31	3.57	2.77
SH2	0.38	0.48	0.58	0.32	0.27	0.49	0.19	0.58	0.37	0.36	4.04	3.18
Woodville STP	0.18	0.15	0.14	0.15	0.15	0.18	0.14	0.15	0.12	0.20	1.57	1.24
Gorge	3.72	3.09	3.27	1.73	3.32	2.82	2.99	3.48	2.86	2.49	29.76	22.96
Waikawa catchment												
No significant point source discharges												
Rangitikei Catchment												
Taihape STP	0.22	0.27	0.30	0.40	0.20	0.26	0.32	0.04	0.33	0.28	2.63	2.13
Hunterville STP	0.04	0.05	0.07	0.04	0.04	0.05	0.06	0.05	0.03	0.03	0.48	0.38
Halcombe STP	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.18	0.14
Sanson STP	0.08	0.09	0.09	0.11	0.09	0.07	0.09	0.07	0.06	0.10	0.85	0.69
Bulls STP	0.07	0.09	0.06	0.03	0.02	0.01	0.04	0.10	0.03	0.02	0.48	0.32
Riverlands	0.37	0.52	0.41	0.75	0.73	0.71	0.72	0.38	0.50	0.56	5.64	4.76
Ohakea STP	0.11	0.14	0.18	0.19	0.20	0.20	0.27	0.25	0.22	0.22	1.98	1.73
Marton STP	2.12	1.87	2.06	1.82	1.64	1.46	1.87	2.42	1.22	1.27	17.76	13.76
Rangitikei All	3.03	3.04	3.19	3.36	2.94	2.78	3.40	3.33	2.41	2.50	30.00	23.92
Other sites used												
No significant point source discharges												

Table 11: Measured DRP loads for the point sources analysed in this study, showing the loads in each of the decile bins, the loads for all flow (Load All Flows) and the loads at flows below flood flows (Load 20-100). All units tonnes SIN/year. STP is short for Sewage Treatment Plant.

Site	Flow decile bin											
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	All Flows	20-100
Manawatu Catchment												
Dannevirke STP	0.65	0.55	0.51	0.35	0.58	0.62	0.54	0.63	0.71	0.70	5.84	4.64
Eketahuna STP	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.16	0.13
Pahiatua STP	0.12	0.07	0.12	0.10	0.10	0.06	0.04	0.12	0.09	0.13	0.96	0.77
SH2	0.14	0.08	0.14	0.12	0.12	0.08	0.06	0.14	0.11	0.14	1.12	0.90
Woodville STP	0.02	0.02	0.02	0.02	0.02	0.04	0.02	0.03	0.01	0.04	0.25	0.20
Gorge	0.81	0.64	0.68	0.49	0.72	0.74	0.62	0.79	0.83	0.88	7.20	5.74
Waikawa catchment												
No significant point source discharges												
Rangitikei Catchment												
Taihape STP	0.06	0.07	0.09	0.09	0.03	0.12	0.10	0.08	0.11	0.11	0.86	0.73
Hunterville STP	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.14	0.12
Halcombe STP	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.05	0.04
Sanson STP	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.21	0.18
Bulls STP	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.30	0.24
Riverlands	0.07	0.12	0.10	0.18	0.20	0.22	0.19	0.11	0.11	0.17	1.47	1.29
Ohakea STP	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.26	0.22
Marton STP	0.29	0.29	0.32	0.22	0.35	0.48	0.54	0.43	0.52	0.53	3.98	3.39
Rangitikei All	0.50	0.57	0.60	0.58	0.68	0.92	0.93	0.73	0.85	0.92	7.28	6.21
Other sites used												
No significant point source discharges	0.65	0.55	0.51	0.35	0.58	0.62	0.54	0.63	0.71	0.70	5.84	

Table 12: Measured SIN and DRP loads for the point sources analysed in this study showing the overall loads for all flows (Point Source Load All Flows) and the loads at flows below flood flows (Point Source Load 20-100), and the proportion (%) of each of these loads above and below flood flows.

	SIN				DRP			
Site	Point Source Load All Flows	Point Source Load 20-100	Per cent of Point Source Load Above Flood Flows	Per cent of Point Source Load Below Flood Flows	Point Source Load All Flows	Point Source Load 20-100	Per cent of Point Source Load Above Flood Flows	Per cent of Point Source Load Below Flood Flows
	Tonnes/ year	Tonnes/ year	%	%	Tonnes/ year	Tonnes/ year	%	%
Manawatu Catchment								
Dannevirke STP	24.1	18.5	23%	77%	5.84	4.64	20%	80%
Eketahuna STP	0.5	0.4	15%	85%	0.16	0.13	19%	81%
Pahiatua STP	3.6	2.8	22%	78%	0.96	0.77	20%	80%
Eketahuna STP + Pahiatua STP	4	3.2	21%	79%	1.12	0.90	19%	81%
Woodville STP	1.6	1.2	21%	79%	0.25	0.20	19%	81%
Sum(Dannevirke STP+ Eketahuna STP+ Pahiatua +Woodville STP)	29.8	23	23%	77%	7.20	5.74	20%	80%
Waikawa catchment								
No significant point source discharges								
Rangitikei Catchment								
Taihape STP	2.63	2.13	19%	81%	0.86	0.73	15%	85%
Hunterville STP	0.48	0.38	20%	80%	0.14	0.12	15%	85%
Halcombe STP	0.18	0.14	20%	80%	0.05	0.04	15%	85%
Sanson STP	0.85	0.69	19%	81%	0.21	0.18	17%	83%
Bulls STP	0.48	0.32	33%	67%	0.30	0.24	21%	79%
Riverlands	5.64	4.76	16%	84%	1.47	1.29	13%	87%
Ohakea STP	1.98	1.73	12%	88%	0.26	0.22	14%	86%
Marton STP	17.76	13.76	23%	77%	3.98	3.39	15%	85%
Sum Rangitikei	30.00	23.92	1.62	6.38	7.28	6.21	15%	85%
Other sites used								
No significant point source discharges								

Section 6: Calculating the non-point source contributions of SIN and DRP to in-river nutrient loads.

Introduction

49. The non-point source contribution to the Measured SIN and DRP loads are the component that the scenarios for policy approaches are to model. To start this process, this Section outlines the derivation of the total non-point source contribution to Measured loads at for the sites in this study.

Methods

50. Non-point source loads were calculated by subtracting the point source loads (calculated in the previous section) from the Measured Loads set out in Section 2.

Results

51. The non-point source SIN and DRP contributions are shown in Table 13, Table 14, Table 15 and Table 16, along with the detail of the proportion of the loads for each point source in each decile bin. The results in Table 13 show that for some decile bins the point source loads exceeds the Measured loads for the bins. This is likely as a result of in-river attenuation between the point source discharge and the downstream site where the Measured Loads are calculated.

52. The proportion of the load above and below flood flows for each of the point sources is shown in Table 17. The results show that between 45% and 83% of the non-point source is recorded above flood flows for the sites analysed in this study.

53. The relative contributions of point sources and non-point sources to overall loads are shown for SIN and DRP in Table 18. The results for show that :

    (i) Non point sources contribute 97 to 100% of the SIN loads for the sites in the Manawatu.

    (ii) Non point sources contribute 100% of the SIN loads for the sites in the Waikawa.

(iii) Non point sources contribute 97 to 100% of the SIN loads in the Rangitikei.

(iv) Non point sources contribute 75 to 100% of the DRP loads for the sites in the Manawatu.

(v) Non point sources contribute 100% of the DRP loads for the sites in the Waikawa.

(vi) Non point sources contribute 83 to 97% of the DRP loads in the Rangitikei.

54. A summary of total loads, point source loads, non point source loads and target loads for the sites analysed in this study is presented in Table 19.

Table 13: Non-point source SIN loads for the Manawatu, Waikawa and Rangitikei catchments showing the loads in each of the decile bins, the loads for all flow (Load All Flows) and the loads at flows below flood flows (Load 20-100). All units tonnes SIN/year**.** Figures in bold and italics indicate situations where point source load exceeds measured load.

	Flow decile bin											
Catchment/ Site	**0-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**80-90**	**90-100**	**Load All flows**	**Load 20 to 100**
Manawatu Catchment												
Manawatu at Weber Road	158.3	61.3	26.3	18.7	13.2	8.6	6.8	1.7	1.3	0.3	296.5	76.9
Manawatu at Hopelands	338.1	156.8	93.7	69.5	46.7	31.8	18.2	5.6	2.3	***0.0***	762.4	267.4
Tiraumea at Ngaturi	118.3	55.7	30.2	19.0	14.8	14.6	9.1	8.6	7.3	5.8	283.5	109.5
Mangatainoka at Putara	0.5	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.4
Mangatainoka at Larsons Road	7.7	2.8	1.9	1.2	0.5	0.2	0.4	0.2	0.1	0.1	15.2	4.7
Makakahi at Hamua	79.1	37.8	20.2	11.2	8.7	7.1	2.3	0.8	0.4	0.0	167.6	50.7
Mangatainoka at SH2	208.7	110.4	62.3	44.5	38.8	32.6	17.6	11.3	8.5	3.4	538.3	219.1
Mangahao at Ballance	43.2	24.9	13.4	8.8	7.6	5.4	2.9	2.3	1.6	0.5	110.6	42.4
Manawatu at Upper Gorge	1017.7	386.9	295.7	177.1	150.2	97.8	76.7	30.3	12.8	6.2	2251.5	846.9
Waikawa Catchment												
Manakau at S.H.1 Bridge	3.8	0.9	0.4	0.1	0.2	0.1	0.1	0.0	0.0	0.0	5.6	0.9
Waikawa at North Manakau Road	2.3	0.8	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.0	4.5	1.4
Waikawa at Huritini	13.9	7.9	4.0	3.8	3.0	2.6	2.2	2.3	2.1	1.9	43.7	21.9
Rangitikei Catchment												
Rangitikei at Mangaweka	109.1	59.6	28.4	22.6	9.9	5.6	7.5	3.1	2.4	0.9	249.1	80.4
Rangitikei at Onepuhi	158.2	69.2	50.9	30.7	15.1	7.5	2.4	3.5	1.8	0.6	339.9	112.5
Rangitikei at McKelvies	250.9	147.8	64.8	42.5	24.8	8.2	9.1	***0.0***	***0.0***	***0.0***	543.1	144.4
Other sites used												
Tamaki at Picnic Reserve	0.6	0.4	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1	2.1	1.1
Mangatoro at Mangahei Road	56.2	18.7	10.3	8.4	5.8	4.1	3.3	1.9	1.7	0.7	111.2	36.3

Table 14: Non-point source DRP loads for the Manawatu, Waikawa and Rangitikei catchments showing the loads in each of the decile bins, the loads for all flow (Load All Flows) and the loads at flows below flood flows (Load 20-100). All units tonnes SIN/year. Figures in bold and italics indicate situations where point source load exceeds measured load.

	Flow decile bin											
Catchment/ Site	**0-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**80-90**	**90-100**	**Load All flows**	**Load 20 to 100**
Manawatu Catchment												
Manawatu at Weber Road	6.68	1.54	0.99	0.66	0.25	0.34	0.33	0.21	0.12	0.07	11.18	2.97
Manawatu at Hopelands	10.34	3.45	2.20	1.37	0.61	0.18	0.34	***0.00***	***0.00***	***0.00***	17.30	3.51
Tiraumea at Ngaturi	3.94	1.64	0.68	0.61	0.30	0.22	0.13	0.08	0.04	0.02	7.67	2.08
Mangatainoka at Putara	0.10	0.06	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.21	0.05
Mangatainoka at Larsons Road	0.29	0.12	0.07	0.05	0.05	0.04	0.02	0.01	0.01	0.01	0.68	0.27
Makakahi at Hamua	1.02	0.33	0.22	0.18	0.08	0.06	0.03	0.02	0.01	0.00	1.94	0.58
Mangatainoka at SH2	2.32	1.22	0.60	0.39	0.16	0.27	0.08	0.11	***0.00***	***0.00***	5.05	1.50
Mangahao at Ballance	3.14	0.48	0.37	0.26	0.25	0.12	0.06	0.05	0.04	0.02	4.80	1.18
Manawatu at Upper Gorge	27.13	8.42	5.23	3.82	2.47	1.42	0.37	***0.00***	***0.00***	***0.00***	47.67	12.11
Waikawa Catchment												
Manakau at S.H.1 Bridge	0.08	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.15	0.05
Waikawa at North Manakau Road	0.20	0.08	0.06	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.48	0.20
Waikawa at Huritini	0.56	0.16	0.15	0.09	0.06	0.05	0.06	0.04	0.04	0.03	1.23	0.51
Rangitikei Catchment												
Rangitikei at Mangaweka	10.39	2.97	2.52	1.45	1.54	1.11	0.31	0.55	0.31	0.04	21.19	7.84
Rangitikei at Onepuhi	12.60	3.91	3.17	2.39	0.96	1.04	1.19	0.59	0.26	0.16	26.27	9.76
Rangitikei at McKelvies	20.29	7.88	3.46	1.95	1.01	0.85	0.27	***0.0***	***0.0***	***0.0***	34.45	6.28
Other sites used												
Tamaki at Picnic Reserve	0.11	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.26	0.11
Mangatoro at Mangahei Road	3.75	0.47	0.24	0.18	0.14	0.08	0.09	0.03	0.02	0.02	5.01	0.80

Table 15: Proportion of non-point source SIN load (NPS Load All Flows) in each of the decile bins for the sites analysed in this study. The table also shows the percentage of the non-point source load above and below flood flows (Load 0-20). All units are percentages.

	Flow decile bin											
Catchment/ Site	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	Load 0-20	Load 20 to 100
Manawatu Catchment												
Manawatu at Weber Road	53%	21%	9%	6%	4%	3%	2%	1%	0%	0%	74%	26%
Manawatu at Hopelands	44%	21%	12%	9%	6%	4%	2%	1%	0%	0%	65%	35%
Tiraumea at Ngaturi	42%	20%	11%	7%	5%	5%	3%	3%	3%	2%	61%	39%
Mangatainoka at Putara	42%	25%	15%	6%	3%	4%	3%	2%	1%	0%	67%	33%
Mangatainoka at Larsons Road	51%	18%	13%	8%	4%	1%	3%	1%	1%	0%	69%	31%
Makakahi at Hamua	47%	23%	12%	7%	5%	4%	1%	0%	0%	0%	70%	30%
Mangatainoka at SH2	39%	21%	12%	8%	7%	6%	3%	2%	2%	1%	59%	41%
Mangahao at Ballance	39%	23%	12%	8%	7%	5%	3%	2%	1%	0%	62%	38%
Manawatu at Upper Gorge	45%	17%	13%	8%	7%	4%	3%	1%	1%	0%	62%	38%
Average of Manawatu Sites	45%	21%	12%	7%	5%	4%	3%	1%	1%	0%	66%	34%
Waikawa Catchment												
Manakau at S.H.1 Bridge	68%	15%	7%	2%	3%	2%	1%	0%	0%	0%	83%	17%
Waikawa at North Manakau Road	51%	18%	10%	6%	5%	3%	3%	2%	2%	1%	69%	31%
Waikawa at Huritini	51%	18%	10%	6%	5%	3%	3%	2%	2%	1%	69%	31%
Rangitikei Catchment												
Rangitikei at Mangaweka	44%	24%	11%	9%	4%	2%	3%	1%	1%	0%	68%	32%
Rangitikei at Onepuhi	47%	20%	15%	9%	4%	2%	1%	1%	1%	0%	67%	33%
Rangitikei at McKelvies	46%	27%	12%	8%	5%	2%	2%	0%	0%	0%	73%	27%
Other sites used												
Tamaki at Picnic Reserve	27%	18%	11%	10%	11%	5%	4%	8%	3%	3%	45%	55%
Mangatoro at Mangahei Road	51%	17%	9%	8%	5%	4%	3%	2%	1%	1%	67%	33%

Table 16: Proportion of non-point source DRP load (NPS Load All Flows) in each of the decile bins for the sites analysed in this study. The table also shows the percentage of the non-point source load above and below flood flows (Load 0-20). All units are percentages.

Catchment/ Site	Flow decile bin										Load 0-20	Load 20 to 100
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100		
Manawatu Catchment												
Manawatu at Weber Road	60%	14%	9%	6%	2%	3%	3%	2%	1%	1%	73%	27%
Manawatu at Hopelands	60%	20%	13%	8%	4%	1%	2%	0%	0%	0%	80%	20%
Tiraumea at Ngaturi	51%	21%	9%	8%	4%	3%	2%	1%	0%	0%	73%	27%
Mangatainoka at Putara	45%	29%	8%	4%	4%	4%	2%	2%	1%	1%	74%	26%
Mangatainoka at Larsons Road	43%	17%	11%	7%	7%	6%	4%	2%	2%	1%	60%	40%
Makakahi at Hamua	53%	17%	11%	9%	4%	3%	1%	1%	0%	0%	70%	30%
Mangatainoka at SH2	46%	24%	12%	8%	3%	5%	2%	2%	0%	0%	70%	30%
Mangahao at Ballance	65%	10%	8%	5%	5%	3%	1%	1%	1%	0%	76%	24%
Manawatu at Upper Gorge	57%	18%	11%	8%	5%	3%	1%	0%	0%	0%	75%	25%
Average of Manawatu Sites	53%	19%	10%	7%	4%	3%	2%	1%	1%	0%	72%	28%
Waikawa Catchment												
Manakau at S.H.1 Bridge	53%	12%	11%	7%	4%	4%	3%	2%	2%	2%	65%	35%
Waikawa at North Manakau Road	41%	17%	12%	9%	6%	5%	5%	3%	2%	2%	57%	43%
Waikawa at Huritini	45%	13%	12%	7%	5%	4%	5%	3%	3%	2%	58%	42%
Rangitikei Catchment												
Rangitikei at Mangaweka	49%	14%	12%	7%	7%	5%	1%	3%	1%	0%	63%	37%
Rangitikei at Onepuhi	48%	15%	12%	9%	4%	4%	5%	2%	1%	1%	63%	37%
Rangitikei at McKelvies	59%	23%	10%	6%	3%	2%	1%	0%	0%	0%	82%	18%
Other sites used												
Tamaki at Picnic Reserve	42%	14%	11%	6%	7%	6%	4%	5%	2%	2%	57%	43%
Mangatoro at Mangahei Road	75%	9%	5%	4%	3%	2%	2%	1%	0%	0%	84%	16%

Table 17: Percentage of non-point source loads of SIN and DRP loads for the sites used in this study showing the loads the overall non-point source load for all flows (Load All Flows) and the loads at flows below flood flows (Load 20-100), and the proportion (percentage) of each of these non-point source loads above and below flood flows.

	SIN				DRP			
	Measured Load All Flows	Measured Load 20-100	Percentage of Measured Load Above Flood Flows	Percentage of Measured Load Below Flood Flows	Measured Load All Flows	Measured Load 20-100	Percentage of Measured Load Above Flood Flows	Percentage of Measured Load Below Flood Flows
Site	Tonnes/ year	Tonnes/ year	%	%	Tonnes/ year	Tonnes/ year	%	%
Manawatu Catchment								
Manawatu at Weber Road	296.5	76.9	74%	26%	11.2	3.0	73%	27%
Manawatu at Hopelands	762.4	267.4	65%	35%	17.3	3.5	80%	20%
Tiraumea at Ngaturi	283.5	109.5	61%	39%	7.7	2.1	73%	27%
Mangatainoka at Putara	1.3	0.4	67%	33%	0.2	0.1	74%	26%
Mangatainoka at Larsons Road	15.2	4.7	69%	31%	0.7	0.3	60%	40%
Makakahi at Hamua	167.6	50.7	70%	30%	1.9	0.6	70%	30%
Mangatainoka at SH2	538.3	219.1	59%	41%	5.0	1.5	70%	30%
Mangahao at Ballance	110.6	42.4	62%	38%	4.8	1.2	76%	24%
Manawatu at Upper Gorge	2251.5	846.9	62%	38%	47.7	12.1	75%	25%
Waikawa Catchment								
Waikawa at North Manakau	4.5	1.4	69%	31%	0.5	0.2	57%	43%
Manakau at SH1	5.6	0.9	83%	17%	0.2	0.1	65%	35%
Waikawa at Huritini	43.7	21.9	50%	50%	1.2	0.5	58%	42%
Rangitikei catchment								
Rangitikei at Mangaweka	249.1	80.4	68%	32%	21.2	7.8	63%	37%
Rangitikei at Onepuhi	339.9	112.5	67%	33%	26.3	9.8	63%	37%
Rangitikei at McKelvies	543.1	144.4	73%	27%	34.4	6.3	82%	18%
Other sites used								
Tamaki at Picnic Reserve	2.1	1.1	45%	55%	0.3	0.1	57%	43%
Mangatoro at Mangahei Road	111.2	36.3	67%	33%	5.0	0.8	84%	16%

Table 18: Relative contributions of point sources and non-point sources to overall loads (All Flows) for SIN and DRP for the sites analysed in this study.

	SIN					DRP				
Catchment/ Site	Measured Load All Flows	Point Source Load All Flows	Non-point Source Load All Flows	Point Source Load All Flows	Non-point Source Load All Flows	Measured Load All Flows	Point Source Load All Flows	Non-point Source Load All Flows	Point Source Load All Flows	Non-point Source Load All Flows
	Tonnes/ year	Tonnes/ year	Tonnes/ year	%	%	Tonnes/ year	Tonnes/ year	%	%	%
Manawatu Catchment										
Manawatu at Weber Road	296.51	0.00	296.51	0%	100%	11.18	0.00	11.18	0%	100%
Manawatu at Hopelands	786.51	24.15	762.36	3%	97%	23.14	5.84	17.30	25%	75%
Tiraumea at Ngaturi	283.47	0.00	283.47	0%	100%	7.67	0.00	7.67	0%	100%
Mangatainoka at Putara	1.26	0.00	1.26	0%	100%	0.21	0.00	0.21	0%	100%
Mangatainoka at Larsons Road	15.16	0.00	15.16	0%	100%	0.68	0.00	0.68	0%	100%
Makakahi at Hamua	168.05	0.47	167.58	0%	100%	2.10	0.16	1.94	7%	93%
Mangatainoka at SH2	542.33	4.04	538.29	1%	99%	6.17	1.12	5.05	18%	82%
Mangahao at Balance	110.55	0.00	110.55	0%	100%	4.80	0.00	4.80	0%	100%
Manawatu at Upper Gorge	2281.24	29.76	2251.48	1%	99%	54.87	7.20	47.67	13%	87%
Waikawa Catchment										
Manakau at S.H.1 Bridge	5.57	0.00	5.57	0%	100%	0.15	0.00	0.15	0%	100%
Waikawa at North Manakau Road	4.48	0.00	4.48	0%	100%	0.48	0.00	0.48	0%	100%
Waikawa at Huritini	43.68	0.00	43.68	0%	100%	1.23	0.00	1.23	0%	100%
Rangitikei Catchment										
Rangitikei at Mangaweka	251.69	2.63	249.07	1%	99%	22.05	0.86	21.19	4%	96%
Rangitikei at Onepuhi	342.5	2.6	339.9	1%	99%	27.13	0.86	26.27	3%	97%
Rangitikei at McKelvies	573.06	30.00	543.07	5%	95%	41.72	7.28	34.45	17%	83%
Other sites used										
Tamaki at Picnic Reserve[3]	2.08	0.00	2.08	0%	100%	0.26	0.00	0.26	0%	100%
Mangatoro at Mangahei Road[4]	111.16	0.00	111.16	0%	100%	5.01	0.00	5.01	0%	100%

Table 19: A summary of total loads, point source loads, non point source loads and target loads for the sites analysed in this study.

	SIN All Flows				SIN Below 20th				DRP All Flows				DRP Below 20th			
Catchment/ Site	Measured Load	Point Source (PS) Load	Non Point Source (NPS) Load	Target Load	Measured Load	Point Source (PS) Load	Non Point Source (NPS) Load	Target Load	Measured Load	Point Source (PS) Load	Non Point Source (NPS) Load	Target Load	Measured Load	Point Source (PS) Load	Non Point Source (NPS) Load	Targ Loa
	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonnes/yr	Tonne
Manawatu Catchment																
Manawatu at Weber Road	296.51	0.00	296.51	69.6	77	0.00	76.86	25.05	11.18	0.00	11.18	4.2	3	0.00	2.97	
Manawatu at Hopelands	786.51	24.15	762.36	364.3	286	18.54	267.44	150.74	0.00	5.84	17.30	8.2	8	4.64	3.51	
Tiraumea at Ngaturi	283.47	0.00	283.47	222.4	109	0.00	109.45	78.69	0.00	0.00	7.67	5.0	2	0.00	2.08	
Mangatainoka at Putara	1.26	0.00	1.26	3.2	0	0.00	0.41	0.96	0.00	0.00	0.21	0.3	0	0.00	0.05	
Mangatainoka at Larsons Road	15.16	0.00	15.16	11.6	5	0.00	4.67	3.51	0.00	0.00	0.68	1.0	0	0.00	0.27	
Makakahi at Hamua	168.05	0.47	167.58	91.1	51	0.40	50.69	32.51	0.00	0.16	1.94	2.1	1	0.13	0.58	
Mangatainoka at SH2	542.33	4.04	538.29	264.3	222	3.18	219.13	100.25	0.00	1.12	5.05	6.0	2	0.90	1.50	
Mangahao at Ballance	110.55	0.00	110.55	79.5	42	0.00	42.42	25.23	0.00	0.00	4.80	2.9	1	0.00	1.18	
Manawatu at Upper Gorge	2281.24	29.76	2251.48	1193.5	870	22.96	846.87	511.57	0.00	7.20	47.67	26.9	18	5.74	12.11	1
Waikawa Catchment																
Manakau at S.H.1 Bridge	5.57	0.00	5.57	2.0	1	0.00	0.94	0.63	0.00	0.00	0.15	0.1	0	0.00	0.05	
Waikawa at North Manakau Road	4.48	0.00	4.48	8.1	1	0.00	1.39	3.47	0.00	0.00	0.48	0.5	0	0.00	0.20	

	SIN All Flows				SIN Below 20th				DRP All Flows				DRP Below 20th			
Catchment/ Site	Measured Load	Point Source (PS) Load	Non Point Source (NPS) Load	Target Load	Measured Load	Point Source (PS) Load	Non Point Source (NPS) Load	Target Load	Measured Load	Point Source (PS) Load	Non Point Source (NPS) Load	Target Load	Measured Load	Point Source (PS) Load	Non Point Source (NPS) Load	Targ Loa
Waikawa at Huritini	43.68	0.00	43.68	10.0	22	0.00	21.90	4.14	1.23	0.00	1.23	0.6	1	0.00	0.51	
Rangitikei Catchment																
Rangitikei at Mangaweka	251.69	2.63	249.07	220.0	83	2.13	80.40	111.49	0.00	0.86	21.19	20.0	9	0.73	7.84	1
Rangitikei at Onepuhi	342.5	2.6	339.9	230.1	115	2.13	112.49	115.09	0.00	0.86	26.27	20.9	10	0.73	9.76	1
Rangitikei at McKelvies	573.06	30.00	543.07	248.3	168	23.92	144.42	122.24	0.00	7.28	34.45	22.6	12	6.21	6.28	1
Other sites used																
Tamaki at Picnic Reserve[3]	2.08	0.00	2.08	1.6	1	0.00	1.14	0.74	0.00	0.00	0.26	0.1	0	0.00	0.11	
Mangatoro at Mangahei Road[4]	111.16	0.00	111.16	18.8	36	0.00	36.29	6.04	0.00	0.00	5.01	1.7	1	0.00	0.80	

Section 5: Determining the relative contributions to the non-point source SIN loads.

Introduction

55. This study is to determine how various policy approaches to manage loss limits from various land use types will influence nutrient loads at monitoring sites. To do this, it is necessary to estimate the relative contributions from various land use types to the non-point source loads at these sites. This section shows the methodologies and results for determining these relative contributions from various land use type to the measured non-point source loads determined in the previous section.

56. The previous analyses to inform the One Plan process are overviewed in Roygard[13] and discussed in Clothier[14].

57. The previous methods all used a 'screening' type method. Such methods estimated or assume values of nutrient loss for particular land types. In general, the number of hectares of each land use type is multiplied by the rate of nutrient loss per hectare for that particular land use type. The result is a total load in tonnes per year for each land use type. The losses for the various land use types are then summed to estimate the total non-point source contribution from all of the land use types.

58. The losses from the land use types can be expressed as direct loss rates of nutrient per hectare i.e. the rate at which nutrient is lost from the rootzone and farm boundary. Another way to express these is as a rate of in-river contribution, in kg/ha/year. Both types of loss can also be expressed as total rates of load contribution for the entire area of the land use. These are typically expressed in tonnes/year. The relationship between the direct losses and in-river contributions is known as an attenuation factor, which accounts for the proportion of nutrient

[13] TEB v. 1 p. 193-410

[14] TEB v. 3 p. 1527-1592

that is 'lost' as the nutrient travels between the farm boundary/rootzone and the water quality site.

59. There are many mechanisms by which some of the direct losses of nutrient may not transport to the water quality monitoring site. Examples include some nutrient converting to a gaseous form of nitrogen, some nutrient being stored in the subsoil, and uptake of nutrient occurring by riparian plantings or in the river (including uptake by periphyton). The relationship between the total losses from the land area and the load measured in-river is called the attenuation factor.

60. In this study the direct losses of nitrogen are expressed as total nitrogen and the in-river loads are expressed as the in-river load of soluble inorganic nitrogen (SIN). In this case, some of the attenuation factor is simply due to the SIN being a subset of total nitrogen. Total nitrogen is more relevant to direct losses, and software like the Overseer model predicts losses from farming systems in total nitrogen. Aquatic plant growth in-river responds primarily to soluble forms of nitrogen and phosphorus. It is also noted that total nitrogen lost from farms can transform to SIN. The situation is similar for total phosphorus and dissolved reactive phosphorus (DRP).

61. In this study, the attenuation factors have been assumed to be 0.5 based on earlier studies presented to the One Plan hearings. These studies included literature reviews and calculations for a catchment in this Region. The literature reviews reported attenuation factors in New Zealand varying from 0.3 to 0.7 and noted these can be catchment specific. Further information on attenuation factors is provided in Roygard (2009)[15], Clothier (2009)[16] and Clothier et al. (2007).

[15] TEB v. 1 p. 193-410

[16] TEB v. 3 p. 1527-1592

Approach used to inform one plan NVPOP and DVPOP about relative contributions of various land use types to overall non-point source loads – Clothier et al. 2007

62. The primary technical analysis to inform the One Plan policy development about the relative contributions of various non point sources to nutrient loads in rivers was completed by Clothier et al (2007), a report commissioned by Horizons Regional Council. The study first carried out a literature review of the typical losses from various land use types.

63. Further to this, Clothier et al. (2007) were asked by Horizons to 'ground-truth' the loss rates from various land use types reported in the literature, by determining the loss rates for areas of the Manawatu-Wanganui Region, specifically one of the catchments targeted through the approach proposed through the One. To do this, Clothier et al. (2007) as overviewed in Clothier (2009)[17], used a screening method combined with estimates of non point source in-river nutrient loads to calculate losses from sheep/beef farming and dairy farming. The method was applied in the upper Manawatu catchment, upstream of the Manawatu at Hopelands water quality monitoring site.

64. The work modelling outcomes of various policy approaches on non point source nutrient loads presented here builds on the earlier work of Clothier et al. (2007) and uses a modified version of their methodology. The modification to the approach is considered to improve the estimates of relative contributions from different land use types to nonpoint source loads. Given the importance of the Clothier et al study to the development of the methodology used in this evidence, a broad overview of that study is provided in the next few paragraphs.

65. Broadly, Clothier et al. (2007) used the in-river loading information from an early draft of Roygard and McArthur (2008) that defined the average annual non point source SIN loads for Manawatu at Weber Road (343 tonnes SIN/year) and Manawatu at Hopelands (744 tonnes SIN/year) to derive the load for the area

[17] TEB v. 3 p. 1527-1592

between Weber Road and Hopelands (744-343 = 401 tonnes/year). They then used land area information to calculate the relative contributions from dairy farming; sheep and/or beef farming (sheep/beef farming); cropping (including horticulture); and forestry (including native forest/cover).

66. Clothier et al. (2007) then used literature values of the rate of nutrient contributed (loss rate) to in-river loads on a per hectare basis for both cropping and forestry, combined with the information of the area of these land use types in the catchment, to determine the contribution from these sources to overall non-point source loads. The literature values for loss rates used were:

    (a) 2 kg SIN/ha/year contribution to in-river loads for forestry. This implies that the forestry areas had direct losses of 4 kg SIN/ha/year when the attenuation factor of 0.5 used by Clothier et al. (2007) was accounted for; and

    (b) 40 kg SIN/ha/year contribution to in-river loads for cropping implying direct losses of 80 kg SIN/ha/year from the boundary/rootzone when the attenuation factor of 0.5 was accounted for.

67. Clothier et al. (2007) subtracted the calculated loads for forestry and cropping from the non point source loads for each of the study areas. The remaining load in each of the zones was then attributable to the remaining land use types (dairy and sheep/beef). The differing proportions of land use in sheep/beef and dairying between these two zones and the known loads for zones enabled the in-river contributions from sheep/beef and dairy to be by solving the simultaneous equations where:

    (a) The area of sheep/beef in the Weber Road catchment multiplied by the loss rate of sheep/beef, plus the area of dairy in the Weber Road catchment multiplied by the loss rate of dairy farms, equals the load at Manawatu at Weber Road; and

    (b) The area of sheep/beef in the Weber Road to Hopelands catchment multiplied by the loss rate of sheep/beef, plus the area of dairy in the

Weber Road to Hopelands catchment multiplied by the loss rate of dairy farms, equals the load at Manawatu at Weber Road.

68. Clothier et al. (2007) reported that based on these calculations, the in-river loads contributions from sheep/beef farms were 3.75kg/ha and in-river load contributions from dairy farms were 15.4 kg SIN/ha/year.

69. To determine the direct loss rates per hectare from these farming types, Clothier et al. (2007) in consultation with local farm management consultants, constructed Overseer budgets for a 'typical' sheep/beef farm and a 'typical' dairy farm in the catchment area they had modelled. These Overseer budgets estimated losses from the typical sheep/beef farm to be 7 kg/ha/year and a typical dairy farm to be 31 kg/ha/year. Based on these results Clothier et al. (2007) concluded the attenuation factor was 0.5. This attenuation factor is used throughout the calculations of the modelling completed in the sections below.

Approach used in this study to determine relative contributions to overall non point source loads from various land use types

Overview

70. This study set out to build on the methodology used by Clothier et al. (2007) to determine the relative contributions of various land use types to overall loads, and to improve the method by:

(a) improving the estimates of the non point source loads (see the section above);

(b) applying the methods to more sites and different catchments to see the variability in estimates of proportional contributions to loads with differing land use mixes;

(c) using alternate methods and new information to estimate losses from some land use types in different ways, particularly those that make up the larger proportions of the load calculations;

(d) testing the assumptions made to see how variation of some of the assumptions impact on the percentage of overall non point source load from various land use types; and

(e) using a greater range of land use categories to provide greater detail on which land use types have a major or minor contribution to overall loads at the various sites tested.

Land use information

71. Land use type and Land Use Capability (LUC) information was sourced from Clark and Roygard (2008) who analysed and presented land use type and LUC information for the Manawatu-Wanganui Region, and the catchments, water management zones and water management subzones in that Region. The intersection of the land use type information with LUC information by water management subzone in Clark and Roygard (2008) provided the data in a directly usable format where sites were located on the boundary of a water management zone or subzone. Where this was not the case, the information required was obtained through analysis of the data sets that informed this report.

72. Clark and Roygard (2008) derived land use type information from various data sets. The core data set was Agribase, and LCDB2 was used to improve accuracy of the data set in terms of forested blocks on farms. In some cases, areas of catchments were not able to have land use information filled from either of these databases, and a further attempt to fill gaps was completed using mapping information of dairy farm locations based on consent information held by Horizons. Where an area was not able to be classified using any of the databases, it was assigned to the 'other' category. The amount of this information was relatively low compared to overall land area. Given the small amounts of information in this 'other' category, it was merged with two other small categories, 'built up area' and 'water body', to create a single category of 'built up/other'. Overall, in the Manawatu catchment this category included a maximum of 1.2% of the total land area upstream of any site and 1% for the

area upstream of the Manawatu at Gorge site. This site is the most downstream point of the Manawatu analysis and encompasses all of the area modelled in this study for the Manawatu. For detailed information on how the land use layer was derived refer to Clark and Roygard (2008).

73. The categories of land use type used by Clark and Roygard (2008) were simplified from the original databases as described in that report. These categories have been further simplified for use in this study as shown in Table 20.

Table 20: Table of the simplification of the categories used in Clark and Roygard (2008) to the categories used in this study**.**

Count	Category used in this study	Category used in Clark and Roygard 2008	Detailed description[1]
1	Horticulture	Horticulure-Veg & Horticulture-other	Vegetable Growing, Flowers, Fruit growing, Nursery, Orchard/Crop, other planted, viticulture
2	Cropping	Cropping	Arable cropping and seed production, short rotation cropping and seed production
3	Built up/ other	Built up, other and water body	includes build up areas, transport infrastructure, urban parkland/open space/dump,tourism and surface mine. Areas classified as water bodies and areas that could not be classified
4	Exotic Cover	Exotic cover	Exotic forest, major shelterbelts,other exotic cover (includes gorse and broom), forest harvested
5	Dairy	Dairy	Dairy
6	Native Cover	Native Cover	Native forest areas, other native covers, alpine grass/herbfield, alpine gravel and Rock, Coastal sand and Gravel, Landslide, permanent Snow and Ice, Tall tussock grassland
7	Sheep and/or Beef	Sheep and/or beef	Sheep/and or beef, depleted tussock grassland, low-producing grassland, High producing Grassland, and Other Dry stock

[1]The detailed descriptions are from Table 10 in Clark and Roygard 2008. See the original document for the full detailed descriptions.

74. The areas and percentages of the land use types upstream of each of the sites modelled in this study are shown in Table 21 and Table 22. Maps of land use information are shown in the points source section above (Section 3D).

75. The area upstream of the Upper Gorge site contains all of the area modelled for the Manawatu in this study and comprises 54% of the whole Manawatu catchment. Upstream of the Upper Gorge site, the predominant land use is sheep/beef farming (64%), followed by native cover (17%) and dairy farming at 15% (Table 30). The area of the categories horticulture, cropping and built

up/other, when summed together, is less than 5% of the catchment area upstream of the Upper Gorge site.

76. The Waikawa catchment is different to the two other catchments studied, being much smaller and having higher proportions of native cover and exotic forestry (Map 5). The most downstream monitoring site in the Waikawa (Table 21 and Table 22) is predominately in native cover (37.4%) followed by sheep/beef (26%), dairy (22%) and exotic forest (22%)

77. The Rangitikei catchment is overall smaller than the Manawatu catchment, but contains the site with the largest catchment area in this study (Rangitikei at McKelvies). Land use in the Rangitikei (Table 21 and Table 22) is predominately sheep/beef farming (54%), followed by native cover (29%) and the built up/other category (10%). Dairy farming comprises around 4% of the Rangitikei Catchment.

78. It is noted that the data used does have its limitations as is outlined in Clark and Roygard (2008). One limitation of this study is the age of the data, which was compiled in 2008. The land use mix may have changed since the data was compiled. This assumption is based on the projections by Newman[18] and Neilds and Rhodes[19], who in expert witness statements to the One Plan forecast the growth of the sector to 2030. To some extent the modelling below accounts for this, by calculating outcomes based on the forecast land use changes predicted by Newman[20], expert witness for Fonterra who predicted a growth scenario from 2010 to 2030. For comparison Neild and Rhodes[21], expert witnesses for Horizons, predicted higher levels of growth based on scenario from 2008/09 to 2030.

79. The methodologies for determining the loss co-efficient for these land use types are explained in detail in the following sections.

---

[18] TEB v. 8 p. 3811-3826

[19] TEB v. 3 p. 1423-1526

[20] TEB v. 8 p. 3811-3826

[21] TEB v. 3 p. 1423-1526

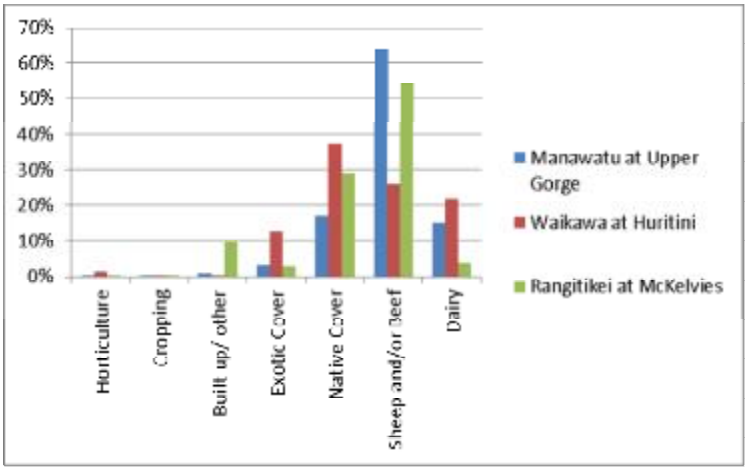


Figure 4: Percentage of each land use type category upstream of the sites at the most down stream monitoring site in each of the catchments studied.

Table 21: Total area of each the various land use types upstream of the sites modelled in this study.

Area (ha)	Horticulture	Cropping	Built up/ other	Exotic Cover	Native Cover	Sheep / Beef	Dairy	Total
Manawatu Catchment	1,622	4,772	10,025	23,397	101,628	346,363	102,068	589,876
Manawatu at Weber Road	17	1	347	2,324	5,285	55,398	5,470	68,842
Manawatu at Hopelands	21	479	1,481	3,792	12,757	85,677	20,139	124,345
Tiraumea at Ngaturi	0	0	646	3,908	8,248	60,155	1,260	74,217
Mangatainoka at Putara	0	0	0	7	1,857	3	0	1,867
Mangatainoka at Larsons Road	0	0	13	64	4,510	1,953	268	6,808
Makakahi at Hamua	0	0	76	408	2,763	8,280	5,010	16,537
Mangatainoka at SH2	0	0	512	667	8,789	19,958	12,883	42,809
Mangahao at Ballance	0	0	109	254	18,204	6,590	2,579	27,736
Manawatu at Upper Gorge	88	491	3,082	9,822	54,455	203,014	48,377	319,330
Waikawa Catchment	100	21	42	1,009	2,815	2,100	1,883	7,970
Manakau at SH1	5	0	0	316	2,382	108	170	2,981
Waikawa at North Manakau	9	7	0	384	295	770	15	1,480
Waikawa at Huritini	100	21	28	924	2,725	1,893	1,594	7,286
Rangitikei catchment	13	1,629	37,817	12,888	112,420	213,496	16,550	394,811
Rangitikei at Mangaweka	0	3	35,855	4,129	106,644	120,722	1,015	268,367
Rangitikei at Onepuhi	2	195	36,372	7,762	110,976	168,862	3,336	327,504
Rangitikei at McKelvies	13	1,547	37,665	11,270	112,216	211,167	14,940	388,816
Other sites used								
Tamaki at Picnic Reserve	0	0	13	0	1,141	2	0	1,156
Mangatoro at Mangahei Road	0	0	6	1,133	1,293	20,323	40	22,795

Table 22: The percentage of the area upstream of the monitoring site for each land use type.

Percentage of area upstream of the site (%)	Horticulture	Cropping	Built up/ other	Exotic Cover	Native Cover	Sheep / Beef	Dairy
Manawatu Catchment	0.275%	0.8%	1.7%	4.0%	17.2%	58.7%	17.3%
Manawatu at Weber Road	0.0%	0.0%	0.5%	3.4%	7.7%	80.5%	7.9%
Manawatu at Hopelands	0.0%	0.4%	1.2%	3.0%	10.3%	68.9%	16.2%
Tiraumea at Ngaturi	0.0%	0.0%	0.9%	5.3%	11.1%	81.1%	1.7%
Mangatainoka at Putara	0.0%	0.0%	0.0%	0.4%	99.5%	0.2%	0.0%
Mangatainoka at Larsons Road	0.0%	0.0%	0.2%	0.9%	66.2%	28.7%	3.9%
Makakahi at Hamua	0.0%	0.0%	0.5%	2.5%	16.7%	50.1%	30.3%
Mangatainoka at SH2	0.0%	0.0%	1.2%	1.6%	20.5%	46.6%	30.1%
Mangahao at Ballance	0.0%	0.0%	0.4%	0.9%	65.6%	23.8%	9.3%
Manawatu at Upper Gorge	0.0%	0.2%	1.0%	3.1%	17.1%	63.6%	15.1%
Waikawa Catchment	1.3%	0.3%	0.5%	12.7%	35.3%	26.4%	23.6%
Manakau at SH1	0.6%	0.5%	0.0%	25.9%	19.9%	52.0%	1.0%
Waikawa at North Manakau	0.2%	0.0%	0.0%	10.6%	79.9%	3.6%	5.7%
Waikawa at Huritini	1.4%	0.3%	0.4%	12.7%	37.4%	26.0%	21.9%
Rangitikei catchment	0.003%	0.4%	9.6%	3.3%	28.5%	54.1%	4.2%
Rangitikei at Mangaweka	0.0%	0.0%	13.4%	1.5%	39.7%	45.0%	0.4%
Rangitikei at Onepuhi	0.0%	0.1%	11.1%	2.4%	33.9%	51.6%	1.0%
Rangitikei at McKelvies	0.0%	0.4%	9.7%	2.9%	28.9%	54.3%	3.8%
Other sites used							
Tamaki at Picnic Reserve	0.0%	0.0%	1.2%	0.0%	98.7%	0.2%	0.0%
Mangatoro at Mangahei Road	0.0%	0.0%	0.0%	5.0%	5.7%	89.2%	0.2%

Determining the nutrient loss rates for the 'Horticulture' land use type

Area of horticulture upstream of the study sites

80. The horticulture land use type includes a range of different activities (Table 20) including flowers, vegetable production, orchids etc. Overall, horticulture is shown to be one of the minor land use types for all sites in the analysis, being less than 0.1% of any of the Manawatu sites, less than 1.5% for the Waikawa sites and less than 0.005% for the Rangitikei sites in the analysis (Table 21 and Table 22). One reason for the low rates of horticulture may be due to the low rate of recording of horticulture. Primarily this is due to horticulture being transient in some cases and the small areas of horticulture not being reported on larger farm blocks that are predominately of another land use e.g. sheep/beef or dairy. This analysis is may have identified a greater proportion of the more permanent areas in horticulture although it is difficult to test this.

Effect of amalgamating the range of activities in the single category of the horticulture land use type

81. It is recognised that the land uses that have been amalgamated into the horticulture land use type have a wide range of different nutrient loss rates. For the purpose of this analysis the horticultural activities have all been merged into one category due to the very small area they comprise in the target catchment areas being modelled.

82. Clothier et al. (2007) amalgamated horticulture and cropping into a single category (called cropping). This study chose to separate the land use types, as horticulture and cropping are considered quite different activities and both occur in the areas modelled in this study. It is also noted the NV POP separated these activities.

83. Loss rates from horticultural activities were overviewed briefly in the Horizons End of Hearing report[22] and by Clothier[23]. Clothier et al (2007; Table 8) reported market gardening to have loss rates in the order of 100-300kg/ha/year. One study from near Levin in the Horowhenua area of the Manawatu-Wanganui Region reported loss rates in the order of 330 kg/ha/year over two years (Snow et al. 2004). Results from the fictitious test farm strategy and the Pencoed farm strategy 'Test Farm' showed nitrogen loss from potatoes to be about 58 and 56 kg N/ha/year direct losses, from root crops (carrots, parsnips) to be 18-19 kg N/ha/year and Brussel sprouts to be 30 kg N/ha/year.

84. Using these numbers as a guide for potential leaching rates, an analysis to test different loss rate assumptions for horticulture was completed to determine the contribution from horticulture to overall loads (Table 23). The results show that, if the rates are as high as was assumed by Clothier et al. (2007), that is 80 kg/ha/year direct losses, the contribution from horticulture may be in the order

[22] TEB v. 9 p. 4250 and 4252

[23] TEB v. 3 p. 1547, 1548, 1564-1567

of 10% of the overall load at the Waikawa at Huritini site, where horticulture makes up 1.3% of the sites' catchment area.

85. This finding demonstrates that a small area of land use with a high loss rate can have a significant impact on catchment loads. In the case of the Waikawa, doubling the area of horticulture (adding a further 100 ha) may increase the catchment load by 10% (when the loss rate of Clothier et al. 2007 is assumed, i.e. 80 kg N/ha/year direct losses).

86. Some experiments in Levin, near the Waikawa catchment, have reported estimates of over 200 kg N/ha/year direct losses over a period of 2 years (Snow et al. 2004). If this rate of loss is assumed in the Waikawa then the 1.3% area in horticulture is predicted to contribute 22.9% of the overall the load. Doubling the area at this rate is calculated to result in horticulture contributing in the order of 40% of the load from an area of about 3% of the catchment.

87. Both higher and lower rates of leaching from horticulture were shown in the evidence. Some experiments in Levin have reported estimates that were in the order of 200kg N/ha/year direct losses, with the contribution from horticulture reaching 24% of the load. It is noted that 200 kg N/ha/year is less than was shown by Snow et al. (2004) in the Horowhenua area not far from the Waikawa.

88. In the Manawatu and Rangitikei catchments, in the areas of horticulture identified, the rate of loss from horticulture has little bearing on the overall load outcomes for any of the sites in the catchment. In the Manawatu, contributions from horticulture were predicted to be less than 1.2 % for all sites modelled at the highest tested in Table 20, while in the Rangitikei, contributions from horticulture were predicted to be less than 0.5 %.

89. It is concluded that the assumed rate for horticulture has only a small influence on the overall estimates of the relative contributions from other land use types in the Manawatu and Rangitikei. However, the rate in the Waikawa can have significant bearing on the catchment load calculation. Both higher and lower rates of leaching from horticulture were shown in the evidence. The estimate

used in this study for the modelling below is from the Clothier et al. (2007) study. These rates are 80 kg N/ha/year direct losses and 40 kg SIN/ha in-river contribution.

Table 23: Percentage contribution to overall loads at the sites with different assumptions of SIN loss rates for the area of horticulture in each study area. The shaded cells indicate the rate of loss assumed throughout the modelling in this study (see text for details).

Site	Total catchment area upstream of the site	Total area of Horticulture upstream of the site	% of site catchment area in Horticulture	Total non point source load	Direct losses from Horticulture (kg SIN/ha/year)								
					2	10	20	40	60	80	100	200	400
					In river losses from Horticulture (kg SIN/ha/year)								
					1	5	10	20	30	40	50	100	200
					Percentage of overall non point source load at the loss rate identified above (%)								
	Ha	Ha	%	Tonnes /year									
Manawatu Catchment													
Manawatu at Weber Road	68,842	17.0	0.025%	296.5	0.01%	0.03%	0.06%	0.11%	0.17%	0.23%	0.29%	0.57%	1.14%
Manawatu at Hopelands	124,345	20.9	0.017%	786.5	0.00%	0.01%	0.03%	0.05%	0.08%	0.11%	0.13%	0.27%	0.53%
Tiraumea at Ngaturi	74,217	0.0	0.000%	283.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mangatainoka at Putara	1,867	0.0	0.000%	1.3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mangatainoka at Larsons Road	6,808	0.0	0.000%	15.2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Makakahi at Hamua	16,537	0.0	0.000%	168.1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mangatainoka at SH2	42,808	0.0	0.000%	542.3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mangahao at Ballance	27,736	0.0	0.000%	110.6	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Manawatu at Upper Gorge	319,329	88.3	0.028%	2281.2	0.00%	0.02%	0.04%	0.08%	0.12%	0.15%	0.19%	0.39%	0.77%
Waikawa Catchment													
Waikawa at North Manakau	2,981	5.0	0.168%	4.5	0.11%	0.56%	1.11%	2.22%	3.33%	4.44%	5.56%	11.11%	22.22%
Manakau at SH1	1,480	8.8	0.594%	5.6	0.16%	0.79%	1.57%	3.14%	4.71%	6.29%	7.86%	15.71%	31.43%
Waikawa at Huritini	7,286	100.3	1.377%	43.68	0.23%	1.15%	2.30%	4.59%	6.89%	9.19%	11.49%	22.97%	45.94%
Rangitikei catchment													
Rangitikei at Mangaweka	268,367	0.1	0.000%	249.1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
Rangitikei at Onepuhi	327,504	1.9	0.001%	501.8	0.00%	0.00%	0.00%	0.01%	0.01%	0.02%	0.02%	0.04%	0.08%
Rangitikei at McKelvies	388,816	12.9	0.003%	543.1	0.00%	0.01%	0.02%	0.05%	0.07%	0.10%	0.12%	0.24%	0.48%
Other sites used													
Tamaki at Picnic Reserve	1,156	0.0	0.000%	2.1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mangatoro at Mangahei Road	22,795	0.0	0.000%	111.2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Determining the nutrient loss rates for the 'Cropping' land use type

Area of cropping upstream of the study sites

90. The cropping land use class includes a range of different crop types (Table 20) including wheat, maize, fodder crops etc. Overall cropping is one of the minor land use types in the analysis (Table 21 and Table 22), comprising 0.5% or less of the land use in catchment area of the sites modelled in this study.

91. It is noted that the area of cropping may be underestimated as farms may have been listed in Agribase under their predominant land use (sheep/beef or dairy) although the farm may contain some level of cropping. This can result in areas of cropping being omitted from the land use type estimates. The losses of these 'missed' areas of cropping losses will be picked up in the scenarios for the sheep/beef farming and dairy farming categories. As these cropping areas are on dairy farms and sheep/beef farms, the losses from these cropping areas will be assigned to the losses within these categories and will simply reflect the mixed enterprises that occur in these farming types.

Effect of amalgamating the range of activities in the single cropping category

92. The range of land use types that have been amalgamated into the cropping land use category are recognised to have a wide range of different nutrient loss rates. However, for the purpose of this analysis the activities have all been merged into one category due to the small area they comprise in the target catchment areas being modelled, and the lack of detailed knowledge of the individual areas and locations of the more specific categories that make up cropping land use. To put this in perspective, the total area of cropping is less than 0.5 %, of any of the study sites in the Manawatu, Waikawa and Rangitikei sites modelled in this study (Table 21 and Table 22).

Loss rates for cropping presented in Horizons' evidence to the One Plan hearings

93. Loss rates from cropping activities presented in Horizons' evidence showed rates of nitrogen loss from cropping are variable depending on the crop type. Clothier

et al. (2007) identified likely losses from cropping to be 100 to 140 kg N/ha/yr. Data from the Pencoed FARM Strategy test farm shows winter wheat, spring wheat and maize leaches nitrogen at 67, 8, and 29 kg/ha/yr respectively. Maize grown for maize silage on a number of the FARM strategy test farms showed nitrogen leaching losses of 99, 132, 46, and 85 kg/ha/yr. This data shows cropping can leach a significant amount of nitrogen and the amount will depend on crop type, time of year it is grown and its occurrence in rotation.

New information on cropping loss rates from dairy farm nutrient budgets

94. Loss rates from cropping activities have been able to be estimated from nutrient budgets for dairy farms provided to Horizons as a part of regulatory processes or on a voluntary basis. All of the budgets used in this analysis have been provided to Horizons Consents or Environmental Protection teams.

95. Out of a total of 950 dairy farms in the Region, 325 farms (34%) have provided nutrient budgets. Of these, 48 farms have cropping blocks included and some nutrient budgets include multiple cropping blocks. Sixty cropping blocks were identified within these 48 farms (Table 24). The cropping block information provided by these budgets shows an average direct leaching rate of 50.5 kg N/ha/year, which translates to 25.25 kg SIN/ha/year (Table 25).

Table 24: Number of Dairy Farm nutrient budgets provided by consent applicants and consent holders (or their agents) to Horizons Regional Council.

Number of dairy farms in the region	950
Number of farms that have supplied nutrient budgets	325
Number of Nutrient budgets with usable cropping block information	48
Number of cropping blocks used in the analysis	60

Table 25: Loss rates for cropping as estimated from nutrient budget cropping block information provided by consent applicants and consent holders (or their agents) to Horizons Regional Council.

Number of samples = 60	Min	Lower quartile	Average	Upper Quartile	Maximum
Direct losses Kg N/year	12	35	50.5	55.25	147
In river contribution kg SIN/ha/year	6	17.5	25.25	27.625	73.5

Analysis of different loss rates for cropping and the effect on overall loads

96. Using these numbers above as a guide for rates of potential losses from cropping, an analysis to test different loss rate assumptions for cropping was completed to determine the contribution from cropping to overall loads (Table 26).

97. The results show, that if the rates are as high as was assumed by Clothier et al (2007; 80 kg/ha/year direct losses), the contribution from cropping may be up to 2.5, 5.3 and 1.4% of the load at sites in the Manawatu, Waikawa and Rangitikei respectively (Table 26).

98. If the rates are as predicted by the dairy farm nutrient budget information from 48 farms (50.5 kg/ha/year direct losses), the contribution from horticulture may be in up to 1.5, 3.3 and 7.2% of the load at sites in the Manawatu, Waikawa and Rangitikei respectively (Table 26).

Direct loss rates and in-river contribution rates used for cropping in this study

99. It is concluded that the assumed rate for cropping has only a small influence on the overall estimates of the relative contributions from other land use types. In many cases the contribution from cropping will be incorporated into land use types that incorporate some cropping, for example sheep/beef farming and dairy farming. The preference is to use an estimate that is derived from data from the Region, rather than the more generic estimates from the literature of Clothier et al. (2007) that had a combined category for horticulture and cropping. For cropping, this study uses the rate from the 60 cropping blocks provided from 48 dairy farm nutrient budget from the Region. The average loss is therefore assumed to be 50.5 kg N/ha/year direct loss, which, assuming an attenuation factor of 0.5, translates to an in-river contribution of 20.25 kg SIN/ha/year.

Table 26: Percentage contribution to overall loads at the sites with different assumptions of 'SIN loss rates' for the area of cropping in each study area. The shaded area shows the rate of loss assumed throughout the modelling in this study (see text for details).

Site	Total catchment area	Total area of Cropping upstream of the site	Percent of site catchment area in cropping	Total non point source load	Direct losses from cropping (kg SIN/ha/year								
					2	10	20	40	50.5	60	80	100	200
					In river losses from cropping (kg SIN/ha/year)								
					1	5	10	20	25.25	30	40	50	100
	hectares	hectares	%	Tonnes/year	Percentage of overall non point source load at the loss rate identified above (%)								
Manawatu Catchment													
Manawatu at Weber Road	68,842	0.6	0.001%	296.5	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.02%
Manawatu at Hopelands	124,345	478.9	0.385%	786.5	0.06%	0.30%	0.61%	1.22%	1.54%	1.83%	2.44%	3.04%	6.09%
Tiraumea at Ngaturi	74,217	0.0	0.000%	283.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mangatainoka at Putara	1,867	0.0	0.000%	1.3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mangatainoka at Larsons Road	6,808	0.0	0.000%	15.2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Makakahi at Hamua	16,537	0.0	0.000%	168.1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mangatainoka at SH2	42,808	0.0	0.000%	542.3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mangahao at Ballance	27,736	0.0	0.000%	110.6	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Manawatu at Upper Gorge	319,329	491.2	0.154%	2281.2	0.02%	0.11%	0.22%	0.43%	0.54%	0.65%	0.86%	1.08%	2.15%
Waikawa Catchment													
Waikawa at North Manakau	2,981	0.0	0.000%	4.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Manakau at SH1	1,480	7.4	0.500%	5.6	0.13%	0.66%	1.32%	2.64%	3.34%	3.96%	5.29%	6.61%	13.21%
Waikawa at Huritini	7,286	20.6	0.283%	43.68	0.05%	0.24%	0.47%	0.95%	1.19%	1.42%	1.89%	2.36%	4.73%
Rangitikei catchment													
Rangitikei at Mangaweka	268,367	2.5	0.001%	249.1	0.00%	0.01%	0.01%	0.02%	0.03%	0.03%	0.04%	0.05%	0.10%
Rangitikei at Onepuhi	327,504	194.8	0.059%	501.8	0.04%	0.19%	0.39%	0.78%	0.98%	1.16%	1.55%	1.94%	3.88%
Rangitikei at McKelvies	388,816	1546.7	0.398%	543.1	0.28%	1.42%	2.85%	5.70%	7.19%	8.54%	11.39%	14.24%	28.48%
Other sites used													
Tamaki at Picnic Reserve	1,156	0.0	0.000%	2.1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Mangatoro at Mangahei Road	22,795	0.0	0.000%	111.2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Determining the nutrient loss rates for the 'Built up/other' land use type

100. The built up/other land use type includes a range of different activities (Table 20) including built up areas, roads, water bodies and areas that could not be classified. Overall, the built up area is one of the minor land use types in the analysis (Table 21 and Table 22), comprising less than 1.5 %, of the catchment area modelled in the Manawatu and Waikawa. In contrast, in the Rangitikei it totals 9.7 to 13.7 % of the area which is largely due to the defence force land contribution in the area associated with the Waiouru Army facility in the upper catchment (Table 22).

Effect of amalgamating the range of activities in the single category of the built up/other land use type

101. The range of land use types that have been amalgamated into the built up area / other land use type category may well have a wide range of different nutrient loss rates. For example, the water body category will have no loss rate, and the built up area may differ from the loss rates of dumps, for example. However, for the purpose of this analysis the land use types have been merged into one category due to the very small area they comprise when combined. The percentage of the overall catchment that each of the individual components of this category comprise for each site is shown in (Table 27).

102. No loss rate was defined for this category in Clothier et al. (2007). The loss rate used by Clothier et al. 2007 for the forestry area is considered the most applicable, given the low expected nitrogen losses from built up areas/road and the defence area in the vicinity if the Desert Road. The area that has not been able to be categorised may be farm land and this may bring up the average loss for this area. The loss rate used by Clothier et al. (2007) for forestry was 4 kg/ha/year direct loss from the boundary/rootzone and 2kg/ha/year in-river contribution.

103. The results show that, if Clothier et al. (2007) rates for forestry (4 kg/ha/year direct losses) are assumed for the built up/other area, the contribution from built

up area/other may be up to 0.5, 1.0 and 29% of the load at sites in the Manawatu, Waikawa and Rangitikei respectively (Table 30).

104. The analysis below for native cover predicts direct losses of 2.5kg N/ha/year on average based on two sites. The approach taken in this study to the built up area/other category is to use the native cover estimates as a basis and to increase this slightly to account for some farmland being included in this category. Using a direct loss rate of 3 kg/ha/year direct losses, the contribution from built up/other is calculated to be up to 0.3, 0.8 and 21.5% of the load at sites in the Manawatu, Waikawa and Rangitikei respectively (Table 28).

Direct loss rates and in-river contribution rates used for built up/other in this study

105. It is concluded that the assumed rate for built-up/other has only a very small influence on the overall estimates of the relative contributions from other land use types for the Manawatu and Waikawa sites. However, in the Rangitikei the rate can have significant bearing on the catchment load calculation, in part due to the inclusion of Defence Force area in this category. Although both higher and lower rates of leaching from the built up/other area could be considered for the analysis, the approach used in this modelling builds on the rates estimated from native cover in the sections below and increases the rate to account for some of the area in this category being farm area that has not been separately identified in the classification process. The estimate used in this study for the modelling below is 3 kg N/ha/year direct losses and 1.5 kg SIN/ha in-river contribution.

Table 27: Proportions of the various categories grouped into the built up/other category used in the analysis of this report.

Site	Built up	Other	Waterbody	Built up + Other + Waterbody	Site Catchment Area	Built up	Other	Waterbody	Built up + Other + Waterbody
Percentage of area upstream of the site	ha	ha	ha	ha	ha	%	% of Catchment	% of Catchment	% of Catchment
Manawatu Catchment	132	67	136	10025	589876	0.0%	0.0%	0.0%	1.7%
Manawatu at Weber Road	38	287	22	347	68842	0.0%	0.0%	0.0%	0.1%
Manawatu at Hopelands	457	922	103	1481	124345	0.1%	0.2%	0.0%	0.3%
Tiraumea at Ngaturi	2	639	6	646	74217	0.0%	0.1%	0.0%	0.1%
Mangatainoka at Putara	0	0	1	1	1867	0.0%	0.0%	0.0%	0.0%
Mangatainoka at Larsons Road	0	0	12	13	6808	0.0%	0.0%	0.0%	0.0%
Makakahi at Hamua	38	40	3	76	16537	0.0%	0.0%	0.0%	0.0%
Mangatainoka at SH2	235	157	120	512	42809	0.0%	0.0%	0.0%	0.1%
Mangahao at Ballance	0	8	101	109	27736	0.0%	0.0%	0.0%	0.0%
Manawatu at Upper Gorge	848	1781	453	3082	319330	0.1%	0.3%	0.1%	0.5%
Waikawa Catchment	50	1	9	42	7970	0.0%	0.0%	0.0%	0.0%
Waikawa at North Manakau	0	0	0	0	2981	0.0%	0.0%	0.0%	0.0%
Manakau at SH1	0	0	0	0	1480	0.0%	0.0%	0.0%	0.0%
Waikawa at Huritini	27	1	0	28	7286	0.0%	0.0%	0.0%	0.0%
Rangitikei catchment	1015	35484	1319	37817	394811	0.2%	6.0%	0.2%	6.4%
Rangitikei at Mangaweka	355	35141	360	35855	268367	0.1%	6.0%	0.1%	6.1%
Rangitikei at Onepuhi	384	35216	771	36372	327504	0.1%	6.0%	0.1%	6.2%
Rangitikei at McKelvies	980	35462	1223	37665	388816	0.2%	6.0%	0.2%	6.4%
Other sites used						0.0%	0.0%	0.0%	0.0%
Tamaki at Picnic Reserve	0	0	13	13	1156	0.0%	0.0%	0.0%	0.0%
Mangatoro at Mangahei Road	0	6	0	6	22795	0.0%	0.0%	0.0%	0.0%

Table 28: Percentage contribution to overall loads at the sites with different assumptions of 'SIN loss rates' for the area of built up area/other in each study area. The shaded cells indicate the rate of loss assumed throughout the modelling in this study (see text for details).

Site	Total catchment area	Total area of built/ other upstream of the site	% of site catchment area in built up/ other	Total non point source load	Direct losses from Built up/other(kg SIN/ha/year)								
					1	2	3	4	5	7	8	10	15
					In river losses from Built up/other (kg SIN/ha/year)								
					0.5	1.0	1.5	2.0	2.5	3.5	4	5	7.5
	hectares	hectares	%	Tonnes /year	Percentage of overall non point source load at the loss rate identified above. (%)								
Manawatu Catchment													
Manawatu at Weber Road	68,842	347.0	0.504%	296.5	0.06%	0.12%	0.18%	0.23%	0.29%	0.41%	0.47%	0.59%	0.88%
Manawatu at Hopelands	124,345	1481.0	1.191%	786.5	0.09%	0.19%	0.28%	0.38%	0.47%	0.66%	0.75%	0.94%	1.41%
Tiraumea at Ngaturi	74,217	645.9	0.870%	283.5	0.11%	0.23%	0.34%	0.46%	0.57%	0.80%	0.91%	1.14%	1.71%
Mangatainoka at Putara	1,867	0.4	0.021%	1.3	0.02%	0.03%	0.05%	0.06%	0.08%	0.11%	0.13%	0.16%	0.24%
Mangatainoka at Larsons Road	6,808	12.5	0.184%	15.2	0.04%	0.08%	0.12%	0.16%	0.21%	0.29%	0.33%	0.41%	0.62%
Makakahi at Hamua	16,537	75.5	0.457%	168.1	0.02%	0.04%	0.07%	0.09%	0.11%	0.16%	0.18%	0.22%	0.34%
Mangatainoka at SH2	42,808	511.6	1.195%	542.3	0.05%	0.09%	0.14%	0.19%	0.24%	0.33%	0.38%	0.47%	0.71%
Mangahao at Ballance	27,736	109.0	0.393%	110.6	0.05%	0.10%	0.15%	0.20%	0.25%	0.35%	0.39%	0.49%	0.74%
Manawatu at Upper Gorge	319,329	3081.7	0.965%	2281.2	0.07%	0.14%	0.20%	0.27%	0.34%	0.47%	0.54%	0.68%	1.01%
Waikawa Catchment													
Waikawa at North Manakau	2,981	0.0	0.000%	4.5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Manakau at SH1	1,480	0.0	0.000%	5.6	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Waikawa at Huritini	7,286	28.2	0.387%	5.6	0.25%	0.50%	0.76%	1.01%	1.26%	1.76%	2.01%	2.52%	3.78%
Rangitikei catchment													
Rangitikei at Mangaweka	268,367	35855.2	13.360%	249.1	7.20%	14.39%	21.59%	28.79%	35.98%	50.38%	57.58%	71.97%	107.95%
Rangitikei at Onepuhi	327,504	36371.7	11.106%	501.8	3.62%	7.25%	10.87%	14.50%	18.12%	25.37%	28.99%	36.24%	54.36%
Rangitikei at McKelvies	388,816	37664.6	9.687%	543.1	3.47%	6.94%	10.40%	13.87%	17.34%	24.27%	27.74%	34.68%	52.01%
Other sites used													
Tamaki at Picnic Reserve	1,156	13.4	1.159%	2.1	0.32%	0.65%	0.97%	1.29%	1.61%	2.26%	2.58%	3.23%	4.84%
Mangatoro at Mangahei Road	22,795	6.2	0.027%	111.2	0.00%	0.01%	0.01%	0.01%	0.01%	0.02%	0.02%	0.03%	0.04%

Determining the nutrient loss rates for the 'Exotic Cover' land use type

106. The exotic cover land use type includes a range of different activities (Table 20) including exotic forest, shelterbelts, gorse etc. Overall' exotic cover comprises up to 5.3, 25.9 and 9.7% of the sites in the Manawatu, Waikawa and Rangitikei respectively (Table 21 and Table 22).

Effect of amalgamating the range of activities in the single category of the exotic cover land use type

107. The range of land uses that have been amalgamated into the exotic cover land use type category are recognised to have a wide range of different nutrient loss rates. For example, loss rates from pine plantations are likely to be different to areas of gorse. However, for the purpose of this analysis the land use types have been merged into one category due to the small area they comprise when combined. To put the area of this category into perspective, the total area of this exotic cover category is less than 5.5% of the catchment area modelled in the Manawatu and Rangitikei. In contrast, in the Waikawa it totals to 10 to 25% of the area (Table 22). This is largely due to the large pine plantations that have been established in this catchment.

108. The loss rate used for forestry (which included the native forest area) used by Clothier et al. (2007) was 4 kg/ha/year direct loss from the boundary/rootzone and 2kg/ha/year in-river contribution.

109. Analysis of various loss rate assumptions was completed by modelling the changes in overall load contribution from the exotic forest category to overall loads at the water quality monitoring sites, when different rates of loss were assumed (Table 29). The rates trialled were based on rates for forestry from Clothier et al. (2007) and reported gorse losses in the order of 50 kg/N/ha/year have been reported (Male et al. 2011). The loss rates tested range from 1 kg N/ha/year direct loss to 12.5 kg/ha/year losses. The rate of 12.5 kg N/ha/year was included as an example of losses from catchments where the proportion of gorse approached 25% of the exotic cover category (at a direct loss rate of 50

kg N/ha/yr). This is considered to be an overestimate for these catchments. More detailed analysis on the proportion of gorse/broom could be completed by going back to the original databases and determining the proportion of these at each of the sites, and modelling them separately.

Direct loss rates and in-river contribution rates used for exotic forest in this study

110. The analysis below for native cover predicts direct losses of 2.5 kg N/ha/year on average based on two sites. The approach taken in this study to the exotic forest category is to use the native cover estimates as a baseline and to increase this to account for some areas of gorse being included in this category. A loss rate of 4 kg/ha/year direct losses was selected for this study, being higher than the rate for built up/other land use types where an increase to the rate from native cover was used. The increase for exotic forest is higher to account for gorse having higher leaching losses and comprising part of this land use category.

111. Using a direct loss rate of 4 kg N/ha/year direct losses, the contribution from exotic forest is calculated to be up to 2.8, 17.1 and 13.9% of the load at sites in the Manawatu, Waikawa and Rangitikei respectively.

112. We conclude that the assumed rate for exotic forestry has a small influence on the overall estimates of the relative contributions from other land use types for the Manawatu sites. However, the rate in the Waikawa and Rangitikei can have significant bearing on the catchment load calculation. The estimate used in this study for the modelling below for exotic forestry is 4 kg N/ha/year direct losses and 2 kg SIN/ha in-river contribution.

Table 29: Percentage contribution to overall loads at the sites with different assumptions of 'SIN loss rates' for the area of exotic cover in each study area. The shaded cells indicate the rate of loss assumed throughout the modelling in this study (see text for details).

Site	Total catchment area	Total area of exotic cover upstream of the site	% of site catchment area in exotic cover	Total non point source load	Direct losses from Exotic cover (kg SIN/ha/year)								
					1	2	3	4.0	5	7	8	10	15
					In river losses from Exotic cover (kg SIN/ha/year)								
					0.5	1.0	1.5	2.0	2.5	3.5	4	5	7.5
	hectares	hectares	%	Tonnes /year	Percentage of overall non point source load at the loss rate identified above. (%)								
Manawatu Catchment													
Manawatu at Weber Road	68,842	2324	3.4%	296.5	0.4%	0.8%	1.2%	1.6%	2.0%	2.7%	3.1%	3.9%	4.7%
Manawatu at Hopelands	124,345	3792	3.0%	786.5	0.2%	0.5%	0.7%	1.0%	1.2%	1.7%	1.9%	2.4%	2.9%
Tiraumea at Ngaturi	74,217	3908	5.3%	283.5	0.7%	1.4%	2.1%	2.8%	3.4%	4.8%	5.5%	6.9%	8.3%
Mangatainoka at Putara	1,867	7	0.4%	1.3	0.3%	0.5%	0.8%	1.1%	1.4%	1.9%	2.2%	2.7%	3.2%
Mangatainoka at Larsons Road	6,808	64	0.9%	15.2	0.2%	0.4%	0.6%	0.8%	1.1%	1.5%	1.7%	2.1%	2.5%
Makakahi at Hamua	16,537	408	2.5%	168.1	0.1%	0.2%	0.4%	0.5%	0.6%	0.8%	1.0%	1.2%	1.5%
Mangatainoka at SH2	42,808	667	1.6%	542.3	0.1%	0.1%	0.2%	0.2%	0.3%	0.4%	0.5%	0.6%	0.7%
Mangahao at Ballance	27,736	254	0.9%	110.6	0.1%	0.2%	0.3%	0.5%	0.6%	0.8%	0.9%	1.1%	1.4%
Manawatu at Upper Gorge	319,329	9822	3.1%	2281.2	0.2%	0.4%	0.6%	0.9%	1.1%	1.5%	1.7%	2.2%	2.6%
Waikawa Catchment													
Waikawa at North Manakau	2,981	316	10.6%	4.5	3.5%	7.0%	10.5%	14.0%	17.5%	24.5%	28.1%	35.1%	42.1%
Manakau at SH1	1,480	384	25.9%	4.5	4.3%	8.5%	12.8%	17.1%	21.3%	29.9%	34.1%	42.6%	51.2%
Waikawa at Huritini	7,286	924	12.7%	4.5	10.3%	20.5%	30.8%	41.1%	51.4%	71.9%	82.2%	102.7%	123.3%
Rangitikei catchment													
Rangitikei at Mangaweka	268,367	4129	1.5%	249.1	0.8%	1.7%	2.5%	3.3%	4.1%	5.8%	6.6%	8.3%	9.9%
Rangitikei at Onepuhi	327,504	7762	2.4%	501.8	0.8%	1.5%	2.3%	3.1%	3.9%	5.4%	6.2%	7.7%	9.3%
Rangitikei at McKelvies	388,816	37665	9.7%	543.1	3.5%	6.9%	10.4%	13.9%	17.3%	24.3%	27.7%	34.7%	41.6%
Other sites used													
Tamaki at Picnic Reserve	1,156	0	0.0%	2.1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mangatoro at Mangahei Road	22,795	1133	5.0%	111.2	0.5%	1.0%	1.5%	2.0%	2.5%	3.6%	4.1%	5.1%	6.1%

Determining the nutrient loss rates for the 'Native Cover' land use type

113. The native cover land use type includes a range of different activities (Table 20) including native forest areas, other native covers, coastal sands and landslides. The reference sites Putara and Tamaki Reserve both over 98.5% native cover. For the DVPOP target zones (excluding the reference sites, native cover ranges from to 8 to 66% and 20 to 80% in the Manawatu and Waikawa sites. In the Rangitikei native cover ranges from 29 to 40% of the land area of the sites analysed in this study (Table 22).

Effect of amalgamating the range of activities in the single category of the native cover land use type

114. The range of land use types that have been amalgamated into the native cover land use type category are recognised as having low nutrient loss rates (with the possible exception of land slides for particulate phosphorus). As, native cover is a predominant land use type in some areas, this study has calculated the losses from native cover using the two reference sites. The reference sites Mangatainoka at Putara and Tamaki at Reserve represent reference conditions in the upper of the Mangatainoka and upper Manawatu (Map 4, Map 5).

115. This approach differs to that of Clothier et al. (2007) who merged this category of land use with exotic forestry and assumed a direct loss rate of 4 kg N/ha/year (2 kg SIN/ha/year in-river contribution).

116. Calculations of the native cover loss rates required information on the Non point source loads for the sites (Table 30) and assumptions of the loss rate form the other land uses that made up the 1.5% or less of the catchment. The assumptions on loss rates from other land uses were based on the approach of Clothier et al. (2007).

Table 30: Measured SIN loads at Mangatainoka at Putara and Tamaki at Reserve

Site	All Flows				Below 20th			
	Measured Load	Point Source (PS) Load	Non Point Source (NPS) Load	Target Load	Measured Load	Point Source (PS) Load	Non Point Source (NPS) Load	Target Load
Mangatainoka at Putara	1.3	0.0	1.3	3.2	0.4	0.0	0.4	1.0
Tamaki at Reserve	2.1	0.0	2.1	1.6	1.1	0.0	1.1	0.7

Table 31: Predicted in river SIN contribution from native cover at Mangatainoka at Putara. Shaded areas show native cover calculations.

Mangatainoka at Putara	Units	Builtup/ Others	Cropping	Exotic Cover	Horticulture	Native Cover	Sheep and/or Beef	Dairy	Total
Current land area	(Hectares)	0.4	0.0	6.8	0.0	1856.8	2.9	0.0	1866.9
Area	percentage of total	0.0%	0.0%	0.4%	0.0%	99.5%	0.2%	0.0%	
in-river contribution	kg SIN /ha/year (in river)	2	25.25	2	20	0.66	3.75	31	0.67
Source of in river contribution		Assumed	Clothier et al. 2007	Clothier et al. 2007	Clothier et al. 2007	calculated	Clothier et al. 2007	Clothier et al. 2007	Measured Load
Tonnes/year in river	tonnes SIN/year	0.0	0.0	0.0	0.0	1.2	0.0	0.0	1.3
in-river contribution	percentage of total	0.1%	0.0%	1.1%	0.0%	98.0%	0.9%	0.0%	
Attenuation factor		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Direct loss by leaching/runoff	kg SIN/ha /year from land area	4	50.5	4	40	1.3	7.5	62	1.35

Table 32: Predicted in river SIN contribution from native cover at Tamaki at Reserve. Shaded areas show native cover calculations.

Tamaki at Reserve	Units	Builtup/ Others	Cropping	Exotic Cover	Horticulture	Native Cover	Sheep and/or Beef	Dairy	Total
Current land area	(Hectares)	13.4	0.0	0.0	0.0	1140.6	1.8	0.0	1155.8
Area	percentage of total	1.2%	0.0%	0.0%	0.0%	98.7%	0.2%	0.0%	
in-river contribution	kg SIN /ha/year (in river)	2	25.25	2	20	1.79	3.75	31	1.80
Source of in river contribution		Assumed	Clothier et al. 2007	Clothier et al. 2007	Clothier et al. 2007	calculated	Clothier et al. 2007	Clothier et al. 2007	Measured Load
Tonnes/year in river	tonnes SIN/year	0.0	0.0	0.0	0.0	2.0	0.0	0.0	2.1
in-river contribution	percentage of total	1.3%	0.0%	0.0%	0.0%	98.4%	0.3%	0.0%	
Attenuation factor		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Direct loss by leaching/runoff	kg SIN/ha /year from land area	4	50.5	4	40	3.6	7.5	62	3.59

117. The calculations for native cover determined the loads from all of the other land uses within each catchment area and subtracted these from the measured load. The final step was to divide the load attributable to native cover by the land area in Native cover for each catchment to provide an in river SIN contribution rate in kg SIN/ha/year. The calculation of direct losses assumed an attenuation factor of 0.5.

118. The native cover loss in the Mangatainoka at Putara site was almost half that of the Tamaki at Reserve site with in river contributions being 0.66 and 1.79 kg SIN/ha/yr respectively. The direct loss rates calculated were 1.3 and 3.6 kg N/ha/yr. Averaging the two sites provides an estimate of 1.2 kg SIN/ha/year in-river contribution. This converts to 2.4 kg/ha/year direct losses when an attenuation factor of 0.5 is assumed.

119. Using these numbers as a guide for potential leaching rates, an analysis to test different loss rate assumptions for native cover on proportion of loads native cover contributes to the sites in this study was completed (**Table 33**). The results show that at sum of the assumed rates at some sites the proportion from native cover alone exceeds the load at the sites (as shaded yellow in **Table 33**).

120. It is concluded that the average rate from the reference sites analysed above provided most robust estimate of losses from native cover.

Table 33: Percentage contribution to overall loads at the sites with different assumptions of SIN loss rates for the area of native cover in each study area. The blue shaded cells indicate the rate of loss assumed throughout the modelling in this study (see text for details).

Site	Total catchment area	Total area of native cover upstream of the site	% of site catchment area in native cover	Total non point source load	Direct losses from native cover (kg SIN/ha/year)								
					1.3	2.0	2.4	3.0	3.6	4.0	6.0	8.0	16.0
					In river losses from native cover (kg SIN/ha/year)								
					0.66	1	1.2	1.5	1.79	2	3	4	8
	hectares	hectares	%	Tonnes/year	Percentage of overall non point source load at the loss rate identified above. (%)								
Manawatu Catchment													
Manawatu at Weber Road	68,842	5284.7	7.677%	296.5	1%	2%	2%	3%	3%	4%	5%	7%	14%
Manawatu at Hopelands	124,345	12757.0	10.259%	786.5	1%	2%	2%	2%	3%	3%	5%	6%	13%
Tiraumea at Ngaturi	74,217	8248.4	11.114%	283.5	2%	3%	3%	4%	5%	6%	9%	12%	23%
Mangatainoka at Putara	1,867	1856.8	99.5%	1.3	97%	147%	177%	221%	264%	295%	442%	590%	1180%
Mangatainoka at Larsons Road	6,808	4510.0	66.248%	15.2	20%	30%	36%	45%	53%	60%	89%	119%	238%
Makakahi at Hamua	16,537	2762.9	16.707%	168.1	1%	2%	2%	2%	3%	3%	5%	7%	13%
Mangatainoka at Pahiatua	42,808	8789.0	20.531%	542.3	1%	2%	2%	2%	3%	3%	5%	6%	13%
Mangahao at Ballance	27,736	18203.9	65.632%	110.6	11%	16%	20%	25%	29%	33%	49%	66%	132%
Manawatu at Upper Gorge	319,329	54455.2	17.053%	2281.2	2%	2%	3%	4%	4%	5%	7%	10%	19%
Waikawa Catchment													
Waikawa at North Manakau	2,981	2382.0	79.911%	4.5	35%	53%	64%	79%	95%	106%	159%	212%	423%
Manakau at SH1	1,480	294.7	19.907%	5.6	3%	5%	6%	8%	9%	11%	16%	21%	42%
Waikawa at Huritini	7,286	2724.7	37.396%	43.68	4%	6%	7%	9%	11%	12%	19%	25%	50%
Rangitikei catchment													
Rangitikei at Mangaweka	268,367	106643.8	39.738%	249.1	28%	43%	51%	64%	77%	86%	128%	171%	342%
Rangitikei at Onepuhi	327,504	110976.0	33.885%	501.8	15%	22%	27%	33%	40%	44%	66%	88%	177%
Rangitikei at McKelvies	388,816	112215.5	28.861%	543.1	14%	21%	25%	31%	37%	41%	62%	83%	165%
Other sites used													
Tamaki at Picnic Reserve3	1,156	1140.6	98.687%	2.1	36%	55%	66%	82%	98%	110%	165%	220%	439%
Mangatoro at Mangahei Road4	22,795	1292.9	5.672%	111.2	1%	1%	1%	2%	2%	2%	3%	5%	9%

Determining the nutrient loss rates for the dairy-farming land use type

121. The dairy farm land use type includes a range of activities associated with dairy farming including the milking platforms of dairy farms and some runoff of blocks. It is difficult to ascertain from the primarily Agribase sourced data, the level to which runoff blocks or other land areas separate to the milking platforms are incorporated in the dairy farm areas estimated by Clark and Roygard (2008). It is also acknowledged that during the time from the completion of Clark and Roygard (2008), the area associated with dairy farming has likely increased.

122. For the DV POP target zones (excluding the reference sites, dairy farming ranges from to 4 to 30% and 1 to 22% of the land area upstream of the Manawatu and Waikawa sites. In the Rangitikei dairy farming ranges from 0.4 to 4% of the land area upstream of the sites analysed in this study (Table 22)

Effect of amalgamating the range of activities in the single category of the dairy farming category

123. Some of the areas included with the dairy farming activity may have different leaching loss rates than are identified in nutrient budgets for dairy farms. It is difficult to ascertain the amount of nutrient budgets available that include areas other than the milking platform. Other areas may have lower leaching rates, for example any native bush blocks on farms, the land area around the house, or run off blocks. Further some areas of the farms may have higher leaching rates than recorded by nutrient budgets as calculated by Overseer. This is due to assumptions of best practice by Overseer around effluent management, stream fencing etc. While best practice may be the norm for most, compliance statistics for effluent management and reporting on stream fencing indicate a proportion of cases where best practice is not being met.

Loss rates for the dairy farming presented in Horizons' evidence to the One Plan hearings

124. A summary of the loss limits from dairy farming activities was provided in Horizons End of Hearing Report (TB Vol 9 pages 4252). This summary information included that:

(a) Clothier et al. (2007) identified likely direct losses from dairy farming to be 15 to 115 kg N/ha/year; and

(b) Peter Taylor reported summary information from case study farms in the Manawatu-Wanganui Region which were determined to have loss rates from 13 to 35 Kg N/ha/year.

125. Further to this Duncan Smeaton in evidence for Fonterra stated that "the existing N loss from dairy farms in Horizons region appears to be 26 to 27 kg N/ha/year. This is based on aggregated data provided by Ravensdown Fertilizer company from the audited OVERSEER files of their dairy farmer clients"[24]

New information on dairy loss rates from dairy farm nutrient budgets

126. Loss rates from dairy farms have been able to be estimated from nutrient budgets provided to Horizons as a part of regulatory processes or on a voluntary basis. All of the budgets used in this analysis have been provided to Horizons Consents or Environmental Protection teams.

127. Out of a total of 950 dairy farms in the Region, 325 farms (34%) have provided 'usable' nutrient budgets. In summary, the average N leaching loss from the 325 budgets was 22.7 Kg N/ha/year ranging from 4 to 55 Kg N/ha/year (Figure 3). The summary of number of budgets and average leaching losses for the sites analysed in this study is shown in (Table 34)

128. These nutrient budgets were considered the most accurate source of information on nutrient loss from dairy farms available to Horizons Regional Council at the time of writing this evidence. The limitations of the dataset include:

(i) Budgets being unverified (very few budgets contained parameter reports[25]);

(ii) Budgets not necessarily including areas of run-off blocks etc (few farms provided the area to which the budget applied);

[24] TEB v. 8 p. 3877

[25] This is the documentation of inputs to the Overseer Model

(iii) The uncertainty as to whether farm budgets are meeting overseer assumptions of best practice;

(iv) The average number of nutrient management blocks incorporated into these budgets being low (2.48); and

(v) Budgets not being available for all dairy farms for the study sites.

129. While there are limitations of the dataset for the purposes of this study the numbers it provides have been utilised to estimate the relative contributions from dairy farming to the current loads. When utilising the information as a part of the load calculations for sites the individual summary information for the site was used. In the Waikawa catchment there was little information and the value for the single nutrient budget for this catchment was used for all sites. There were no nutrient budgets for the Mangaweka sites in the data set and the average N loss from the downstream monitoring site (Onepuhi) was used.

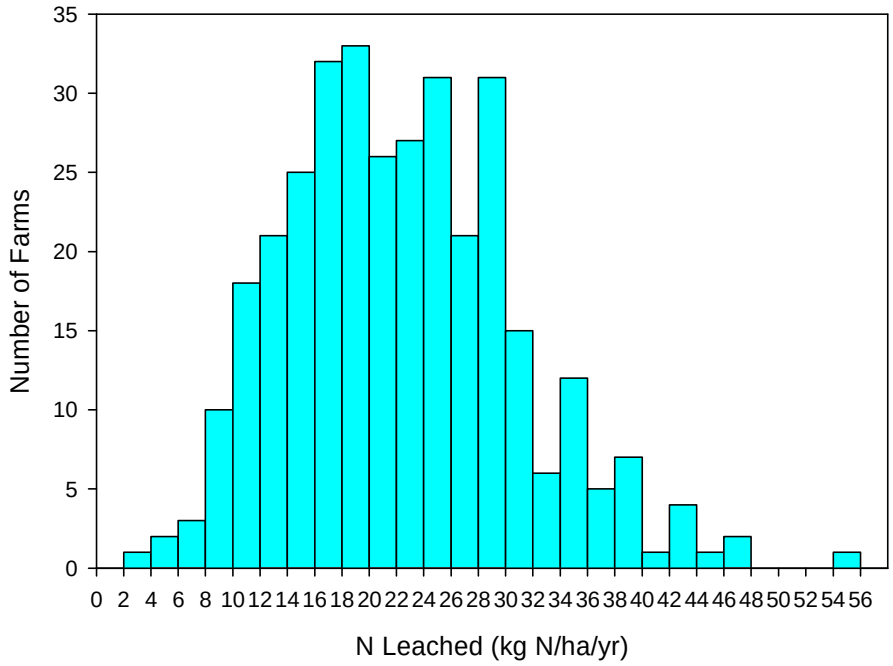


Figure 3: Regional summary of N (nitrogen) leaching from nutrient budgets collected by HRC. n = 325 of 950. Average N Loss is 22.72.[26] kg N/ha/yr. The classes are in 2 kg groups (i.e. >2kg – 4kg is the first blue bar shown).

[26] A value of 190 kg N/ha/yr leached has been removed from this dataset as the number did not make sense when compared to the leaching from the block summary.

Table 34: Summary of dairy nutrient budget information for the sites analysed in this study

Site	Catchment Area (ha)	Area in Dairy	Proportion of catchment in Dairy	Number of farms	Number of budgets with N loss identified	% of farms in zone with budgets	Ave N loss kg/ha /yr
Manawatu Catchment	**589,876.0**	**102,067.8**	**17.3%**	**663**	**246**	**37.10%**	**23.42**
Manawatu at Weber Road	68,841.8	5,470.4	7.9%	39	14	35.90%	26.85
Manawatu at Hopelands	124,345.4	20,138.8	16.2%	147	47	31.97%	26.09
Tiraumea at Ngaturi	74,217.4	1,260.3	1.7%	7	5	71.43%	28.60
Mangatainoka at Putara	1,866.9	0.0	0.0	0			
Mangatainoka at Larsons Road	6,807.8	267.8	3.9%	0			
Makakahi at Hamua	16,537.0	5,010.3	30.3%	34	9	26.47%	24.11
Mangatainoka at Pahiatua	42,808.5	12,883.2	30.1%	90	25	27.78%	24.71
Mangahao at Ballance	27,736.1	2,579.1	9.3%	13	4	30.77%	34.75
Manawatu at Upper Gorge	319,329.6	48,376.7	15.1%	333	120	36.04%	25.29
Waikawa Catchment	**7,988.3**	**1,883.1**	**23.6%**	**7**	**1**	**14.29%**	**16.00**
Waikawa at North Manakau	2,980.8	170.4	5.7%	0			
Manakau at SH1	1,480.4	15.24	1.0%	0			
Rangitikei catchment	**394,811.3**	**16,549.6**	**4.2%**	**112**	**46**	**41.07%**	**21.82**
Rangitikei at Mangaweka	268,367.4	1,014.9	0.4%	1	0	0%	
Rangitikei at Onepuhi	327,504.0	3,335.5	1.0%	17	8	47.06%	26.38
Rangitikei at McKelvies	388,815.9	14,940.0	3.8%	107	45	42.06%	21.95
Regional	**2,229,735**	**149,230.0**	**6.7%**	**950**	**325**	**34.21%**	**22.72**

Determining the nutrient loss rates for the sheep and/or beef land use type

130. The sheep/beef land use type includes a range of farming include extensive and intensive sheep and or beef farming (including the non-irrigated and irrigated farms).

131. For the DV POP target zones (excluding the reference sites, sheep/beef farming ranges from to 29 to 81%, 4 to 52% in the Manawatu and Waikawa sites respectively. In the Rangitikei sheep/ beef ranges from 41 to 54% of the sites analysed here (Table 22).

Effect of amalgamating the range of activities in the single category of the dairy farming category

132. Some of the activities included within the sheep/beef category will have quite different loss rates of nitrogen. For example, intensive bull beef operations are likely to have greater average N loss than extensive sheep farming. For the purpose of this analyse we have followed approach of Clothier et al. (2007) and assumed these activities to all have an single overall average loss rate per hectare.

Loss rates for the sheep and/or beef presented in Horizons' evidence to the One Plan hearings.

133. A summary of the loss limits from sheep and/or beef activities was provided in Horizons End of Hearing Report (TB Vol 9 pages 4250 and 4251). This summary information included that:

(a) Clothier et al. (2007) identified likely direct losses from dairy farming to be 6 to 60 kg N/ha/year;

(b) The Oringi farm (a case study farm for the FARM strategy approach of the NV POP) showed nitrogen losses for two separate nutrient management blocks on the same farm to be 12 Kg N/ha/yr on a non-irrigated block and 15 Kg N/ha/yr on an irrigated block overall this farm had a loss of 19 Kg/N/ha/yr (TEB v. 4 p. 1785); and

(c) The Day farm (another case study farm for the FARM strategy approach of the NVPOP) showed nitrogen losses of 10 Kg N/ha/yr (TEB v. 4 p. 1785);

Calculating losses from sheep/beef farming from a predominately Sheep/Beef catchment

134. One method used to calculate losses from sheep and/or beef farming, loads was to use loads for a monitoring site in a predominantly sheep/beef catchment in the Upper Manawatu. The site for this was Mangatoro at Mangahei Road. This site is located upstream of Manawatu at Weber Road and is 89% sheep/beef farming. The Mangatoro catchment has a geology that differs from the rest of the upper Manawatu Catchment. However, the site did provide an area of the upper Manawatu where loads from sheep/beef contributions could be estimated from loads where nearly 90% of the catchment was in sheep/beef and where there are few dairy farms.

135. The loads for this site were calculated using the data available (Table 1). The method used was similar to that utilised for the native cover estimates in the previous section. The method determined the sheep/beef load by subtracting estimated loads from the other land uses in the catchment from the measured in-river load for the Mangatoro site. The land use information (Table 22) shows that:

(a) There is no horticulture or cropping in the catchment.

(b) Built up areas/other is estimated to be less than 0.0% of the catchment.

(c) Exotic cover and Native cover make up 10.7% of the catchment, with about 5% being Exotic cover.

(d) Dairy is estimated to have been 40ha by this dataset which is about 0.2% of the catchment. Consent information in 2012 suggests a higher proportion of dairy is present in this catchment.

136. To complete the analysis to estimate the contribution from sheep/beef, three scenarios of loss rate from native cover and three scenarios of loss rate from dairy farms were completed. This enabled testing of the sensitivity of the assumptions used for other land use types on the estimate from sheep/beef. An example of the calculations for sheep/beef loss in the Mangatoro catchment is shown in Table 35. In this example the average loss for native cover from the Putara and Tamaki sites was used, the regional average loss from nutrient budgets was used for dairy and an attenuation factor of 0.5 is assumed.

Table 35: Calculations of sheep/beef loss rates in the Mangatoro catchment for one of the scenarios trialled see text for details.

Mangatoro at Mangahei Road	Units	Builtup / Others	Cropping	Exotic Cover	Horticulture	Native Cover	Sheep and/or Beef	Dairy	Total
Current land area	(Ha)	6.2	0.0	1,133.4	0.0	1,292.9	20,322.5	39.8	22794.7
Area	% of total	0.0%	0.0%	5.0%	0.0%	5.7%	89.2%	0.2%	
in-river contribution	kg SIN /ha/year (in river)	2	25.25	2	20	1.23	5.25	13.85	4.88
Source of in river contribution		Assumed	Clothier et al. 2007	Clothier et al. 2007	Clothier et al. 2007	From Tamaki at reserve	Regional Average	Clothier et al. 2007	Measured Load
Tonnes/year in river	tonnes SIN/year	0.0	0.0	2.3	0.0	1.6	106.7	0.6	111.2
in-river contribution	% of total	0.0%	0.0%	2.0%	0.0%	1.4%	96.0%	0.5%	
Attenuation factor		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Direct loss by leaching/runoff	kg SIN/ha /year from land area	4	50.5	4	40	2.5	10.5	27.7	9.75

137. The results for loss rates from sheep/beef farming in the Mangatoro from the scenarios (Table 36) ranged from 5.21 to 5.30 kg SIN/ha/year. The overall

average was 5.25 kg SIN/ha/year which converts to a direct loss of 10.5 kg N/ha/year.

Table 36: Scenarios results for the determination of average in river contributions from Sheep/Beef in the Mangatoro Catchment.

Estimate of native cover losses	Estimate of dairy losses	Scenario	In River Losses kg SIN/ha/yr		
			Native cover	Dairy	Sheep/beef (calculated)
Tamaki	Site nutrient budget	1	1.79	7.00	5.23
Tamaki	Regional nutrient budget	2	1.79	13.85	5.22
Tamaki	Clothier dairy estimate	3	1.79	15.50	5.21
Putara	Site nutrient budget	4	0.66	7.00	5.30
Putara	Regional nutrient budget	5	0.66	13.85	5.29
Putara	Clothier dairy estimate	6	0.66	15.50	5.29
Clothier native cover	Site nutrient budget	7	2.00	7.00	5.22
Clothier native cover	Regional nutrient budget	8	2.00	13.85	5.20
Clothier native cover	Clothier dairy estimate	9	2.00	15.50	5.20
Average native cover loss Tamaki + Putara	Site nutrient budget	10	1.23	7.00	5.27
Average native cover loss Tamaki + Putara	Regional nutrient budget	11	1.23	13.85	5.25
Average native cover loss Tamaki + Putara	Clothier dairy estimate	12	1.23	15.50	5.27
Average					**5.25**

Calculating losses from sheep/beef farming via the 'difference' method

138. A further methodology to calculate losses from Sheep/beef was available using a 'by difference' approach using the loads and assumptions about the loss rates from each of the land uses determined in the sections above. The methodology used the current in-river loads (Measured Loads) and subtracted the contributions from the other land use types to determine the load from sheep/beef farming (in-river).

139. For the sake of clarity the assumed in-river loss rates used in this method were

(a) Horticulture, direct losses 40 kg N/ha/year, in-river losses of 20 kg SIN/hectare.

(b) Cropping, direct losses 50.5 kg N/ha/year, in-river losses of 22.25 kg SIN/hectare.

(c) Built up/Other, direct losses 3 kg N/ha/year, in-river losses of 1.5 kg SIN/hectare.

(d) Exotic Cover, direct losses 4 kg N/ha/year, in-river losses of 2 kg SIN/hectare.

(e) Native Cover, direct losses 2.4 kg N/ha/year, in-river losses of 1.2 kg SIN/hectare.

(f) Dairy, direct losses as per the site nutrient budget average Table 34, in-river losses from these budgets assuming 0.5 attenuation.

The sheep/beef losses calculated using this method for each of the sites ranges from direct losses of -8.75 kg N/ha/year at the Waikawa at North Manakau site to 36.72 kg N/ha/yr at the Mangatainoka at SH2 site. Assuming an attenuation factor of 0.5 this translates to between -4.37 kg SIN/ha/year at the Waikawa at North Manakau site to 18.36 kg SIN/ha/yr at the Mangatainoka at SH2 site an average loss of 4.97 kg SIN/ha/yr. Removing the negative value from the Waikawa at North Manakau Road site, the average loss from sheep/beef is 5.6 kg SIN/year. Overall the average from these sites is similar to the value determined from the Mangatoro site analysis. However there a wide range of values for the sites (Table 37)

Table 37

Table 37: Calculations of losses from Sheep/beef farms using the 'by difference' method for the sites of this study. The values for dairy farms are included to allow for easy comparison of these.

Site	In-River losses (tonnes SIN/year)		Direct losses (tonnes N/ha/year)	
	Sheep/beef	Dairy	Sheep/beef	Dairy
Manawatu Catchment				
Manawatu at Weber Road	3.81	13.43	7.63	26.85
Manawatu at Hopelands	5.39	13.05	10.79	26.09
Tiraumea at Ngaturi	4.17	10.98	8.34	21.95
Mangatainoka at Larsons Road	3.26	12.06	6.52	24.11
Makakahi at Hamua	12.43	12.06	24.86	24.11
Mangatainoka at SH2	18.36	12.36	36.72	24.71
Mangahao at Ballance	9.06	10.98	18.13	21.95
Manawatu at Upper Gorge	7.57	12.65	15.13	25.29
Waikawa Catchment				
Manakau at SH1	5.14	8.00	10.29	16.00
Waikawa at North Manakau	-4.37	8.00	-8.75	16.00
Waikawa at Huritini	12.27	8.00	24.55	16.00
Rangitikei catchment				
Rangitikei at Mangaweka	0.38	13.19	0.76	26.38
Rangitikei at Onepuhi	1.48	13.19	2.96	26.38
Rangitikei at McKelvies	0.60	10.98	1.19	21.95

140. The loss rate results for sheep/beef farming via this method include a negative value for one of the Waikawa sites. This is not physically possible. The reason for this result is attributed to the small catchment area upstream of the Waikawa at North Manakau Road site and the use of average losses to calculate contributions to load at this site. In smaller catchments, the local conditions can be quite different to the averages over much larger areas such as the sites in the Manawatu Catchment.

141. The higher results for loss rates from Sheep/beef in the Mangatainoka may be attributable to a range of factors including but not limited to

(i) Higher rainfall in the Mangatainoka catchment

(ii) Poor practice of sheep/beef farming occurring in the catchment

(iii) Nutrient budgets for dairy underestimating the actual loss from dairy. For example due to the assumptions of best practice discussed above.

(iv) The areas of sheep/beef including more intensive blocks such as cropping blocks or grazing for dairy cattle.

(v) The area of sheep/beef being overestimated by the analysis method.

(vi) The attenuation rate in this catchment is lower i.e. more of nutrient that is lost from the land is measured at the water quality monitoring site.

142. The potential overestimate of losses of sheep/beef in the Mangatainoka, implies the estimation of losses from another source has been underestimated. For example, if the 'by difference' methodology is used in this catchment to estimate dairy losses and sheep/beef is set to 5.25 kg SIN/ha/year, the dairy loss rate in river is 32.7 kg SIN/year almost triple what the nutrient budgets suggest theses losses are.

143. The by difference methods enables calculation of the average relative contributions from the individual land use types to the in-river non-point source loads at each site. The results from this are shown in Table 38, Table 39.

Table 38: Relative contributions for the various land use types to Measured loads in-river when using the Sheep/Beef by difference approach. All units Tonnes SIN/year.

Site	Horticulture	Cropping	Builtup/Others	Exotic Cover	Native Cover	Sheep and/or Beef	Dairy	Total
Manawatu Catchment								
Manawatu at Weber Road	0.34	0.02	0.52	4.65	6.34	211.21	73.44	296.51
Manawatu at Hopelands	0.42	12.09	2.22	7.58	15.31	462.02	262.71	762.36
Tiraumea at Ngaturi	0.00	0.00	0.97	7.82	9.90	250.95	13.83	283.47
Mangatainoka at Larsons Road	0.00	0.00	0.02	0.13	5.41	6.37	3.23	15.16
Makakahi at Hamua	0.00	0.00	0.11	0.82	3.32	102.93	60.40	167.58
Mangatainoka at SH2	0.00	0.00	0.77	1.33	10.55	366.47	159.17	538.29
Mangahao at Ballance	0.00	0.00	0.16	0.51	21.84	59.73	28.31	110.55
Manawatu at Upper Gorge	1.8	12.4	4.6	19.6	65.3	1536.0	611.7	2251.5
Waikawa Catchment								
Manakau at SH1	0.2	0.2	0.0	0.8	0.4	4.0	0.1	5.6
Waikawa at North Manakau	0.1	0.0	0.0	0.6	2.9	-0.5	1.4	4.5
Waikawa at Huritini	2.0	0.5	0.0	1.8	3.3	23.2	12.8	43.7
Rangitikei catchment								
Rangitikei at Mangaweka	0.0	0.1	53.8	8.3	128.0	45.6	13.4	249.1
Rangitikei at Onepuhi	0.0	4.9	54.6	15.5	133.2	249.6	44.0	501.8
Rangitikei at McKelvies	0.3	39.1	56.5	22.5	134.7	126.1	164.0	543.1
Rangitikei at McKelvies modelled as if it is a target catchment	0.3	39.1	56.5	22.5	134.7	101.1	188.9	543.1

Table 39: Percentage relative contributions for the various land use types to Measured loads in-river when using the Sheep/Beef 'by difference' approach.

Site	Horticulture	Cropping	Builtup/Others	Exotic Cover	Native Cover	Sheep and/or Beef	Dairy	Total
Manawatu Catchment								
Manawatu at Weber Road	0%	0%	0%	2%	2%	71%	25%	100%
Manawatu at Hopelands	0%	2%	0%	1%	2%	61%	34%	100%
Tiraumea at Ngaturi	0%	0%	0%	3%	3%	89%	5%	100%
Mangatainoka at Larsons Road	0%	0%	0%	1%	36%	42%	21%	100%
Makakahi at Hamua	0%	0%	0%	0%	2%	61%	36%	100%
Mangatainoka at SH2	0%	0%	0%	0%	2%	68%	30%	100%
Mangahao at Ballance	0%	0%	0%	0%	20%	54%	26%	100%
Manawatu at Upper Gorge	0%	1%	0%	1%	3%	68%	27%	100%
Waikawa Catchment								
Manakau at SH1	3%	3%	0%	14%	6%	71%	2%	100%
Waikawa at North Manakau	2%	0%	0%	14%	64%	-11%	30%	100%
Waikawa at Huritini	5%	1%	0%	4%	7%	53%	29%	100%
Rangitikei catchment								
Rangitikei at Mangaweka	0%	0%	22%	3%	51%	18%	5%	100%
Rangitikei at Onepuhi	0%	1%	11%	3%	27%	50%	9%	100%
Rangitikei at McKelvies	0%	7%	10%	4%	25%	23%	30%	100%
Rangitikei at McKelvies modelled as if it is a target catchment	0%	7%	10%	4%	25%	19%	35%	100%

Section 7: Scenario Modelling

Introduction

144. Scenario modeling has been undertaken in the target catchments to estimate in-stream outcomes for a number of different approaches to managing non-point sourced nitrogen from dairy farming. The modeling is limited to changes in losses of Nitrogen from dairy farming following the direction of the DV POP.

145. For the purposes of undertaking scenario analysis a methodology that determined the relative contribution of SIN from different land uses to the current (measured) load was selected. This method is the 'by difference' method explained in Section 6 above.

146. The methodology used does have some limitations in that the only loss rates that changes per site are sheep/beef and dairying. There may well be localised differences in the loss rates from the other landuse types throughout the upstream catchments for sites analysed in this evidence. However, the advantage of this method is that it provides a way to fix the losses from all land uses other than dairy at a site. This is useful as all of the scenarios presented here are focused on the changing load in river as a result of changes in losses from dairy farming.

147. The scenarios modelled in this project were selected based on a range of potential options raised or discussed during mediation on the One Plan. Broadly the scenarios modelled are grouped as:

(a) Land Use Capability (LUC) based nitrogen loss limit approaches applied to dairy farming, either conversions only or all dairy farming.

(b) Single number based nitrogen loss limit approaches applied to dairy farming, either conversions only or all dairy farming.

(c) The 'Do nothing' approach, where no loss limits are applied to any land use.

148. The first scenario presents the current load of nitrogen measured at each site using existing rates of dairy leaching.

149. Scenarios 2 – 6 use the natural capital LUC loss limit approach across varying land use scenarios.

(a) Scenario 2 models the expected outcome of the DV POP in river using an 11% dairy expansion applying the loss limits only to the expanded area and assuming loss rates on the area currently in dairy to stay the same.

(b) Scenario 3 models the expected N load in river if the LUC loss limits from the DV POP applied to all dairy land under the current scenario (i.e. land in dairy from Clark and Roygard, 2008).

(c) Scenario 4 models the expected N load in river if the LUC loss limits applied to all dairy land under an 11% expansion scenario (i.e. current dairy area + an 11% increase).

(d) Scenario 5 models the expected N load in river if the Yr 1 LUC loss limits from the NV POP were applied to all dairy land under an 11% expansion scenario.

(e) Scenario 6 models the expected N load in river if the Yr 20 LUC loss limits from the NV POP were applied to all dairy land under an 11% expansion scenario

150. Scenarios 7 – 15 use a single number loss limit and apply it to dairy farming under an 11% dairy farm expansion.

(a) Scenario 7 uses the average regional loss limit from nutrient budgets for dairy farms provided to Horizons as a part of regulatory processes or on a voluntary basis and applies this to all dairy land under an 11% expansion scenario

(b) Scenario 8 uses the average loss limit from nutrient budgets for dairy farms upstream of the monitoring site provided to Horizons as a part of regulatory processes or on a voluntary basis and applies this to all dairy land under an 11% expansion scenario.

(c) Scenario 9 uses a loss limit of 15 kg N/ha/yr and applies and applies this to all dairy land under an 11% expansion scenario.

(d) Scenario 10 uses a loss limit of 18 kg N/ha/yr and applies and applies this to all dairy land under an 11% expansion scenario.

(e) Scenario 11 uses a loss limit of 21 kg N/ha/yr and applies and applies this to all dairy land under an 11% expansion scenario.

(f) Scenario 12 uses a loss limit of 24 kg N/ha/yr and applies and applies this to all dairy land under an 11% expansion scenario.

(g) Scenario 13 uses a loss limit of 27 kg N/ha/yr and applies and applies this to all dairy land under an 11% expansion scenario.

(h) Scenario 14 uses a loss limit of 30 kg N/ha/yr and applies and applies this to all dairy land under an 11% expansion scenario.

(i) Scenario 15 uses a loss limit of 33 kg N/ha/yr and applies and applies this to all dairy land under an 11% expansion scenario

151. Scenarios 16 – 19 provide the do nothing approach under an expansion scenario with a number of different loss rate scenarios.

(a) Scenario 16 assumes the loss rates of dairy stay the same as current loss rates combined with 11% increase in dairy area

(b) Scenario 17 assumes the loss rates of dairy increase by 5% on current loss rates combined with an 11% increase in dairy area

(c) Scenario 18 assumes the loss rates of dairy increase by 10% on current loss rates combined with an 11% increase in dairy area

(d) Scenario 19 assumes the loss rates of dairy increase by 15% on current loss rates combined with an 11% increase in dairy area.

152. The modeling presented in the sections below is an update from previous evidence on this topic (TEB v. 11 pages 5055-5060).

153. The changes to the results from the previous analysis have come about through a number of adjustments to the calculation methodologies for the scenarios and revision of the overall load calculations. Of note, the load for the Rangitikei at Onepuhi site has been updated following further quality assurance of the data utilised for this calculation.

154. Changes to the scenario analysis were considered minor and did not change the overall conclusions. However, there have been subtle shifts in some of the numbers in the scenario tables and therefore these have been updated below (Table 40, Table 41). A further table, presenting the results of the scenario's in the context of the target loads for each of the sites has also been provided (Table 42).

Table 40: Predicted SIN Load (Tonnes /Year) under 19 dairy N loss scenarios. TC = target catchment and con = conversions

				CURRENT LOAD	LUC APPROACHES					SINGLE NUMBER LIMITS APPROACHES									DO NOTHING APPROACHES			
			Year	2008	2030	2008	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030
			Scenario	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
			Loss Limit	Current loss	LUC DVPOP	DVPOP	DVPOP	NVPOP yr 1	NVPOP yr20	Regional average	Site average	15	18	21	24	27	30	33	Current loss	Current loss + 5%	Current loss + 10%	Current loss 15%
Site	Target Catchment	Target Load	Area applied	All dairy	Con only	all dairy in DVPOP TC	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con
Manawatu Catchment																						
Manawatu at Weber Road	Yes	69.6		297	301	282	286	283	270	291	302	266	275	285	294	303	312	321	302	306	310	315
Manawatu at Hopelands	Yes	364.3		762	775	719	731	718	670	745	779	655	689	722	756	789	823	857	779	794	808	823
Tiraumea at Ngaturi	No	222.4		283	284	283	284	284	284	285	284	280	282	284	286	288	290	292	284	285	286	287
Mangatainoka at Larsons Road	Yes	11.6		15	15	14	15	14	14	15	15	14	15	15	15	16	16	17	15	16	16	16
Makakahi at Hamua	Yes	91.1		168	166	158	157	152	142	164	167	142	150	159	167	175	184	192	167	171	174	177
Mangatainoka at SH2	Yes	264.3		538	528	522	512	504	472	518	530	460	482	503	525	546	568	589	530	539	547	556
Mangahao at Ballance	No	79.5		111	111	111	111	111	110	113	111	101	105	110	114	118	123	127	111	113	114	116
Manawatu at Upper Gorge	Yes[27]	1193.5		2251	2268	2171	2188	2157	2052	2221	2278	2022	2097	2172	2246	2321	2396	2471	2279	2312	2346	2380
Waikawa Catchment																						
Manakau at SH1	Yes	2		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Waikawa at North Manakau	Yes	8.1		4	5	5	5	5	5	5	5	5	5	5	5	6	6	6	5	5	5	5
Waikawa at Huritini	Yes	10		44	44	50	49	48	44	49	43	42	45	47	50	53	55	58	43	44	44	45
Rangitikei catchment																						
Rangitikei at Mangaweka	No	220		249	250	249	250	250	250	250	250	250	250	250	250	251	251	251	250	251	252	253
Rangitikei at Onepuhi	No	230.1		340	344	340	344	344	344	344	345	342	343	344	344	345	345	346	345	347	349	352
Rangitikei at McKelvies	No	248.3		543	563	543	563	563	558	568	559	502	527	552	576	601	626	651	560	569	578	587
Rangitikei at McKelvies	No[28]	248.3		543	563	542	562	566	524	547	562	495	514	534	554	574	593	613	563	574	584	595

[27] But with some upstream area excluded

[28] but modelled as in here as was included in NVOP

Table 41: Loading scenario results expressed as a percentage improvement from current state (positive percentages) or a percentage degradation from the existing state (a negative percentage). TC = target catchment and con = conversions

				CURRENT LOAD	LUC APPROACHES					SINGLE NUMBER LIMITS APPROACHES									DO NOTHING APPROACHES			
			Year	2008	2030	2008	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030
			Scenario	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
			Loss Limit	Current loss	LUC DVPOP	DVPOP	DVPOP	NVPOP yr 1	NVPOP yr20	Regional average	Site average	15	18	21	24	27	30	33	Current loss	Current loss + 5%	Current loss + 10%	Current loss 15%
Site	**Target Catchment**	**Target Load**	Area applied	All dairy	Con only	all dairy in DVPOP TC	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con
Manawatu Catchment																						
Manawatu at Weber Road	Yes	69.6		0%	-1%	5%	4%	4%	9%	2%	-2%	10%	7%	4%	1%	-2%	-5%	-8%	-2%	0%	-1%	5%
Manawatu at Hopelands	Yes	364.3		0%	-2%	6%	4%	6%	12%	2%	-2%	14%	10%	5%	1%	-4%	-8%	-12%	-2%	0%	-2%	6%
Tiraumea at Ngaturi	No	222.4		0%	0%	0%	0%	0%	0%	-1%	0%	1%	1%	0%	-1%	-2%	-2%	-3%	0%	0%	0%	0%
Mangatainoka at Larsons Road	Yes	11.6		0%	-1%	4%	3%	6%	8%	-1%	-2%	7%	4%	1%	-2%	-5%	-7%	-10%	-2%	0%	-1%	4%
Makakahi at Hamua	Yes	91.1		0%	1%	6%	6%	9%	15%	2%	0%	15%	10%	5%	0%	-5%	-10%	-15%	0%	0%	1%	6%
Mangatainoka at SH2	Yes	264.3		0%	2%	3%	5%	6%	12%	4%	2%	14%	10%	7%	3%	-1%	-5%	-9%	2%	0%	2%	3%
Mangahao at Ballance	No	79.5		0%	0%	0%	0%	0%	0%	-2%	0%	9%	5%	1%	-3%	-7%	-11%	-15%	0%	0%	0%	0%
Manawatu at Upper Gorge	Yes[29]	1193.5		0%	-1%	4%	3%	4%	9%	1%	-1%	10%	7%	4%	0%	-3%	-6%	-10%	-1%	0%	-1%	4%
Waikawa Catchment																						
Manakau at SH1	Yes	2		0%	0%	-1%	-1%	-1%	0%	-1%	0%	0%	0%	-1%	-1%	-2%	-2%	-3%	0%	0%	0%	0%
Waikawa at North Manakau	Yes	8.1		0%	-6%	-10%	-16%	-11%	-4%	-20%	-5%	-3%	-9%	-16%	-22%	-28%	-35%	-41%	-5%	-7%	-9%	-10%
Waikawa at Huritini	Yes	10		0%	0%	-14%	-13%	-10%	-2%	-12%	2%	4%	-2%	-8%	-14%	-21%	-27%	-33%	2%	0%	-2%	-3%
Rangitikei catchment																						
Rangitikei at Mangaweka	No	220		0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%
Rangitikei at Onepuhi	No	230.1		0%	-1%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-1%	-2%	-3%	-4%
Rangitikei at McKelvies	No	248.3		0%	-4%	0%	-4%	-4%	-3%	-5%	-3%	8%	3%	-2%	-6%	-11%	-15%	-20%	-3%	-5%	-6%	-8%
Rangitikei at McKelvies	No[30]	248.3		0%	-4%	0%	-3%	-4%	4%	-1%	-4%	9%	5%	2%	-2%	-6%	-9%	-13%	-4%	-6%	-8%	-9%

[29] But with some upstream area excluded

[30] but modelled as in here as was included in NVOP

Table 42: Predicted SIN Load expressed as a percentage of target load (i.e 100% = predicted load is equal to target load). TC = target catchment and con = conversions

				CURRENT LOAD	LUC APPROACHES					SINGLE NUMBER LIMITS APPROACHES									DO NOTHING APPROACHES			
			Year	2008	2030	2008	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030	2030
			Scenario	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
			Loss Limit	Current loss	LUC DVPOP	DVPOP	DVPOP	NVPOP yr 1	NVPOP yr20	Regional average	Site average	15	18	21	24	27	30	33	Current loss	Current loss + 5%	Current loss + 10%	Current loss 15%
Site	Target Catchment	Target Load	Area applied	All dairy	Con only	all dairy in DVPOP TC	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con	Dairy in DVPOP TC and con
Manawatu Catchment																						
Manawatu at Weber Road	Yes	69.6		426%	432%	405%	410%	407%	387%	418%	434%	383%	396%	409%	422%	435%	448%	461%	434%	440%	446%	452%
Manawatu at Hopelands	Yes	364.3		209%	213%	197%	201%	197%	184%	204%	214%	180%	189%	198%	208%	217%	226%	235%	214%	218%	222%	226%
Tiraumea at Ngaturi	No	222.4		127%	128%	127%	128%	128%	128%	128%	128%	126%	127%	128%	129%	129%	130%	131%	128%	128%	129%	129%
Mangatainoka at Larsons Road	Yes	11.6		131%	132%	125%	127%	123%	120%	131%	133%	121%	125%	129%	133%	137%	140%	144%	133%	134%	136%	138%
Makakahi at Hamua	Yes	91.1		184%	183%	174%	172%	167%	156%	180%	184%	156%	165%	174%	183%	193%	202%	211%	184%	187%	191%	195%
Mangatainoka at SH2	Yes	264.3		204%	200%	197%	194%	191%	179%	196%	200%	174%	182%	190%	199%	207%	215%	223%	200%	204%	207%	210%
Mangahao at Ballance	No	79.5		139%	139%	139%	139%	139%	138%	142%	140%	127%	133%	138%	143%	149%	154%	160%	140%	142%	144%	146%
Manawatu at Upper Gorge	Yes[31]	1193.5		189%	190%	182%	183%	181%	172%	186%	191%	169%	176%	182%	188%	194%	201%	207%	191%	194%	197%	199%
Waikawa Catchment																						
Manakau at SH1	Yes	2		278%	279%	282%	282%	281%	280%	282%	279%	278%	279%	281%	282%	283%	285%	286%	279%	279%	279%	280%
Waikawa at North Manakau	Yes	8.1		55%	59%	61%	64%	62%	58%	66%	58%	57%	61%	64%	68%	71%	75%	78%	58%	59%	60%	61%
Waikawa at Huritini	Yes	10		437%	436%	496%	495%	482%	444%	491%	429%	420%	447%	473%	500%	526%	553%	579%	429%	436%	443%	451%
Rangitikei catchment																						
Rangitikei at Mangaweka	No	220		113%	114%	113%	114%	114%	114%	114%	114%	114%	114%	114%	114%	114%	114%	114%	114%	114%	115%	115%
Rangitikei at Onepuhi	No	230.1		148%	150%	148%	150%	150%	150%	149%	150%	149%	149%	149%	150%	150%	150%	150%	150%	151%	152%	153%
Rangitikei at McKelvies	No	248.3		219%	227%	219%	227%	227%	225%	229%	225%	202%	212%	222%	232%	242%	252%	262%	226%	229%	233%	237%
Rangitikei at McKelvies	No[32]	248.3		219%	227%	218%	226%	228%	211%	220%	226%	199%	207%	215%	223%	231%	239%	247%	227%	231%	235%	239%

[31] But with some upstream area excluded

[32] but modelled as in here as was included in NVOP

Jon Roygard
SCIENCE MANAGER

Maree Clark
ENVIRONMENTAL SCIENTIST WATER

References

Clark, M.E. & Roygard, J.K.F. (2008) *Land use and land use capability in the Manawatu-Wanganui Region: Internal report to support policy development.* (Report: 2008/INT/616) Palmerston North, New Zealand: Horizons Regional Council.

Clothier, B., Mackay, A., Carran, A., Gray, R., Parfitt, R., Francis, G., Manning, M., Duerer, M. & Green, S. (2007) Farm strategies for contaminant management: a report by SLURI, the Sustainable Land Use Initiative, for Horizons Regional Council. Palmerston North, New Zealand: AgResearch.

Gibbs, M. (2011) Lake Horowhenua Review: Assessment of opportunities to address water quality issues in Lake Horowhenua. (Report No. HAM 2011-046) Hamilton, New Zealand: NIWA, prepared for Horizons Regional Council.

Kilroy, C., Nicholson, C., McArthur, K., Chakraborty, M. & Roygard, J. (2010) Review of Horizons Regional Council periphyton monitoring programme 2009. (Report CHC2010-0) Christchurch, New Zealand: NIWA.

Male, C., Magesan, G.N. & Paterson, J. (2011) Nitrogen leaching from gorse to Lake Rotorua and mitigation of leaching 'spike' during gorse conversion to pine forest. Proceedings of the International Water Association Diffuse Pollution Conference, Rotorua, New Zealand.

McArthur, K. & Clark, M. (2007) Nitrogen and phosphorus loads to rivers in the Manawatu-Wanganui Region: An analysis of low flow state. (Report No: 2007/EXT/793) Palmerston North, New Zealand: Horizons Regional Council.

Roygard, J. & McArthur, K. (2008) A framework for managing Non-point source and point source nutrient contributions to water quality. (Report No. 2008/EXT/792) Palmerston North, New Zealand: Horizons Regional Council.

Snow, V., Green, S. Hurst, H. & van den Dijssel, C. (2004) Nitrate leaching from vegetable production: Monitoring results. (Report No. 11282/2005) Palmerston North, New Zealand: HortResearch.