Appendix 6

Defining nutrient (nitrogen) loss limits within a water management zone on the basis of the natural capital of soil

An appendix to the Farm Strategies for Contaminant Management report by SLURI, the Sustainable Land Use Research Initiative for Horizons Regional Council

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Table of Contents

Executive summary

- Current nitrogen (N) loadings in the Upper Manawatu River and Mangatainoka are more than twice the water quality standard set for each Water Management Zone (WMZ) by Horizons Regional Council in consultation with community.

- Horizons Regional Council have good data sets on the contribution of point-source N loadings to these two rivers and in a recent study "Farm strategies for contaminant mitigation" for Council by SLURI a direct link between land use and management decisions as it influences N losses and loadings in the Upper Manawatu river were established.. That study found significant reduction in the N loading could be achieved by a focus on intensive dairy operations.

- In a debrief with the Council's Research and Policy Teams on the findings in the draft report the observation was made that limiting policy development to existing intensive land uses, which includes cropping, market gardening, dairy and irrigated intensive sheep and beef, would result in improves to water quality, only if there was no further expansion of intensive land uses in the balance of the catchment. Any policy approach would therefore need to consider all land in the catchment from the outset.

- In this appendix to the "Farm strategies for contaminant mitigation" report, a number of catchment based approaches for achieving the water quality standard are identified and discussed. They included: capping current production systems, placing a limit on nutrient losses from intensive land uses, calculating an average nutrient loss limit for each hectare of land in the catchment, or allocating a nutrient loss limit for each hectare of land based on the biophysical potential of natural capital of the soil.

- Of the approaches listed, **allocating the nutrient loss limit based on the natural capital of the soil in the catchment** offered a basis for developing policy that is linked directly to the underlying natural biophysical resources in the catchment. It is independent of current land use and places no restrictions on future land-use options. It also provides all land users in the catchment with certainty by defining a nutrient loss limit based on the suite of soils they own, beyond this resource consent would be required and that includes a nutrient budget and mitigation strategy.

- The **Nitrogen (N) loss limit** is defined as the amount of N lost by leaching from the soil growing a legume based pasture fixing N biological, under optimum pastoral management (optimum grazing practice, Olsen P in optimum range, etc), before the introduction of additional technologies (N fertilisers, effluent and manures, intensive cropping, irrigation, etc). To calculate the N loss limit for a landscape unit, the values for attainable potential livestock carrying capacity for in a legume based pasture under optimum pastoral management, before the introduction of additional technologies listed in the extended legend of the Land use capability (LUC) worksheets are transformed to pasture production and used in OVERSEER® to calculate N leaching loss under a pastoral use.

- This new and novel natural-capital based approach was tested in two catchments (Upper Manawatu and Mangatainoka) using average data from the extend legend of the North Island LUC worksheets. At the farm scale the N-loss limit could be calculated using the information in the New Zealand Land Resource Inventory (NZLRI), or from information obtained from on-farm mapping. The approach offers the potential to utilise site specific information, including soil type, drainage class, landscape type and geo-spatial position, along with local rainfall to inform the calculations in OVERSEER®.

- To inform future debate and assist in refining current policy using this approach the following issues require further examination including a review of natural resource based policy initiatives elsewhere in the world, the potential for using the approach as a trading scheme, testing of the approach with landowners in the region operating a range of intensive land uses in catchment with different geophysical configurations, the influence of the resolution of land based information on the calculated values, an examination of the efficiency of resource use when allocating nutrient loss limits based on the soils natural capital and the availability of and effectiveness of mitigation options to land owners farming landscapes with different potentials and limitations to use**.**

- We consider that this capital based approach to managing nutrient is a new methodology that should be at the forefront of sustainable development. We believe that the resilience of our future land-use production systems will be measured on their sustainable exploitation of natural capital, whilst minimising external coast to the environment. This approach in whatever final form it takes will achieve wins both way: productivity and protection.

1. Background

Current nitrogen (N) loadings in the Upper Manawatu River and Mangatainoka are more than twice (744,000 and 518,000 kgN/yr, respectively) the N limits (341,000 and 238, 000 kgN/yr, respectively) set based on recommended standards for the Notified standards in the One Plan. To be in a position to develop a water management action plan, the point and non-point source N loadings into the river have to be established as the first step in managing down these nutrient loadings.

Horizons Regional Council have good data sets on the contribution of the major point source N loadings to the river and in a recent study conducted by SLURI the contribution of non-point source N loading from dairy and sheep and beef in the Upper Manawatu catchment were established. In that study the N loss in the river from the average dairy farm was found to amount to 15.4 kg/ha/yr. For sheep and beef the N loss was much smaller 3.9 kg/ha/yr. Over 90% of the total N in the river is from these two non-point sources, with dairy contributing about half of the N loading in the river, despite only representing 16% of the land use in the catchment.

The N loss from the average dairy farm calculated using OVERSEER® in the Upper Manawatu catchment was found to be 31 kgN/ha/yr, and for the average sheep and beef farm 7 kgN/ha/yr. By using a nitrogen transmission co-efficient of 0.50 for both dairying and sheep and beef operations, a direct link could be made between land use and management decisions as it influences N losses and loadings in the river.

In the short-term, significant reductions in the N loading in the river could be achieved by a focus on intensive dairy operations, as existing mitigations options offer the potential to reduce N losses by up to a third on the average dairy farm. While this approach offers a short-term policy option for Horizons Regional Council, it is based on the assumption that there will be no further conversion of sheep and beef to more intensive land uses (e.g. cropping, market gardening, dairy) or any further intensification of sheep and beef sector, all of which have the potential to increase the N loading in the river. Any policy approach will therefore need to consider all land owners in the catchment from the outset for a long-term water management action plan to achieve the goals of the community.

2. Options for achieving the water quality standard

There are a number of approaches Horizons Regional Council could use to achieve the water quality standard, including;

1. **Capping current production systems and nutrient (e.g. nitrogen) losses.** Manage down regardless of N losses from individual farms, as is the case currently under consideration for the Taupo catchment.

2. **Place a limit on the losses of nutrient (e.g. nitrogen) from intensive land uses** Place restrictions of any further intensification, or require mitigation practices as an integral part of any ongoing land development.

3. **Calculate a nutrient (e.g. nitrogen) leaching loss limit for each ha.** Using OVERSEER® to achieve the water quality standard and apply equally to each land owner. For the Upper Manawatu WMZ this would be 6.5 kgN/ha (Calculation =341,000 kgN/yr divided by 130,000 ha Transmission co-efficient =0.50). At current loading the average loss per ha is 15 kgN/ha.

4. **Allocate a nutrient (e.g. nitrogen) loss limit based on the biophysical potential of natural capital of the soils.**

Option 1 favours, on one hand, the existing intensive land users and penalises land owners as yet not fully developed. It locks in the current land use pattern, and has the potential to limit future land use change.
Option 2, like 1, has a focus on limiting/controlling N loss by regulating land use. It would require a tight definition of intensification and a detailed description of each land use.

Option 3 fails to recognise that soils differ in their properties. Some soils will have very low N leaching losses because of physical limits to production (e.g. LUC VII).

Option 4 does not target a land use, intensity of use, or place a limit on production. Rather it allocates a nutrient (N) loss limit to each landscape unit based on the biophysical potential of natural capital of the soils.

3. Option 4. Nutrient loss limit based on the natural capital of the soil

Allocating a nutrient loss limit based on the natural capital of the soil in the catchment offered an approach for developing policy that is linked directly to the underlying natural biophysical resources in the catchment. It is independent of current land use and places no restrictions on future land use change or options. It does provide all land uses in the catchment with certainty by defining a nutrient loss limit, beyond which a resource consent would be required, that included a nutrient budget and mitigation strategy. It is not too dissimilar to the concept of a water use take limit.

The nutrient (e.g. nitrogen) loss limit is defined as the amount of N lost by leaching from the soil growing a legume-based pasture fixing N biological, that is under optimum management (optimum grazing practice, Olsen P in optimum range, etc), before the introduction of additional technologies (N fertilisers, effluent and manures, intensive cropping, irrigation, etc). A legume based pasture system is self-regulating biological process with an upper limit on the amount of N that came be fixed and made available for plant growth and the environment. Potential production therefore reflects the underlying capacity of the soil to produce and cope.

To calculate the N loss limit for a given landscape unit, the potential animal stocking rate that can be sustained by a legume-based pasture fixing N biological, under optimum management, before the introduction of additional technologies, listed in the extended legend of the LUC worksheets "Attainable potential livestock carrying capacity" are transformed to pasture production and used in OVERSEER® to calculate N leaching loss under a pastoral use.

By linking N loss limits to each landscape unit the difficulties associated with having to define land use (i.e., Option 1 and 2) is avoided. This approach recognises soils differ in their productive capacity. Technologies used to lift production beyond that of a legume based pasture (N fertiliser, Irrigation, Supplement) would require the use of mitigation practices to prevent any further increases in N leaching losses. Option 3 fails to recognise that soils differ in their properties. Some soils will have very low N leaching losses because of physical limits to production (e.g. VIII). Another potential advantage of Option 4 is that in catchments with no water quality problems at the present time, land owners can be provided with an indication of the level of production and associated nutrient losses they can reached, before mitigation practices would become an integral part of ongoing farming practices.

4. Case studies

Option 4 is explored more in two case studies; the Upper Manawatu and Mangatainoka catchments. For this exercise the natural capital of the soils in the catchment, is calculated from the potential stocking rate that could be sustained by a well managed legume based sward, taken from the extended legend of the LUC worksheets "Attainable potential livestock carrying capacity" for the North Island. The potential livestock carrying capacities were transformed to pasture production and used in OVERSEER® to calculate N leaching losses under a pastoral use. The N losses by leaching calculated from OVERSEER® summarised for LUC class I-VII for the North Island and used in the Upper Manawatu and Mangatainoka catchment case studies are presented in Fig. 1. As the limitations to use increase (i.e. Class I to VII) the underlying capacity of soil to sustain a legume based pasture system declines, as does the potential N loss by leaching.

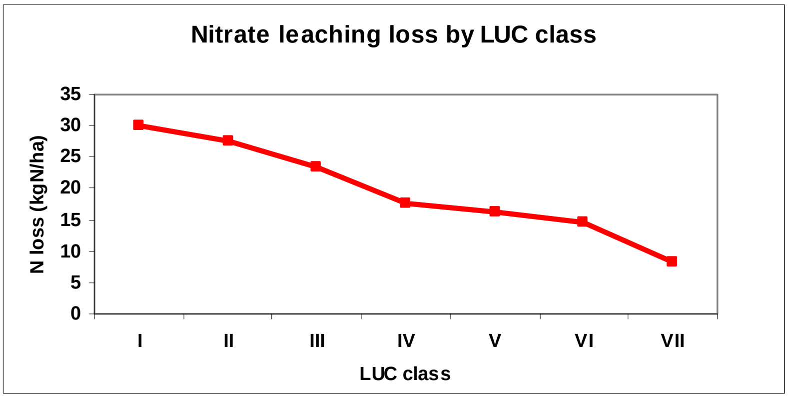


Fig.1 Nitrate leaching loss calculated using OVERSEER (Developed dairy operation, Annual rainfall 1200 mm) associated with the potential livestock carrying capacity of listed in the extended for LUC class I-VII in the North Island.

4.1. Upper Manawatu Catchment

The landscape in the Upper Manawatu catchment is dominated by Class VI, with sheep and beef the dominant land use, in particular in the catchment above Weber Road.

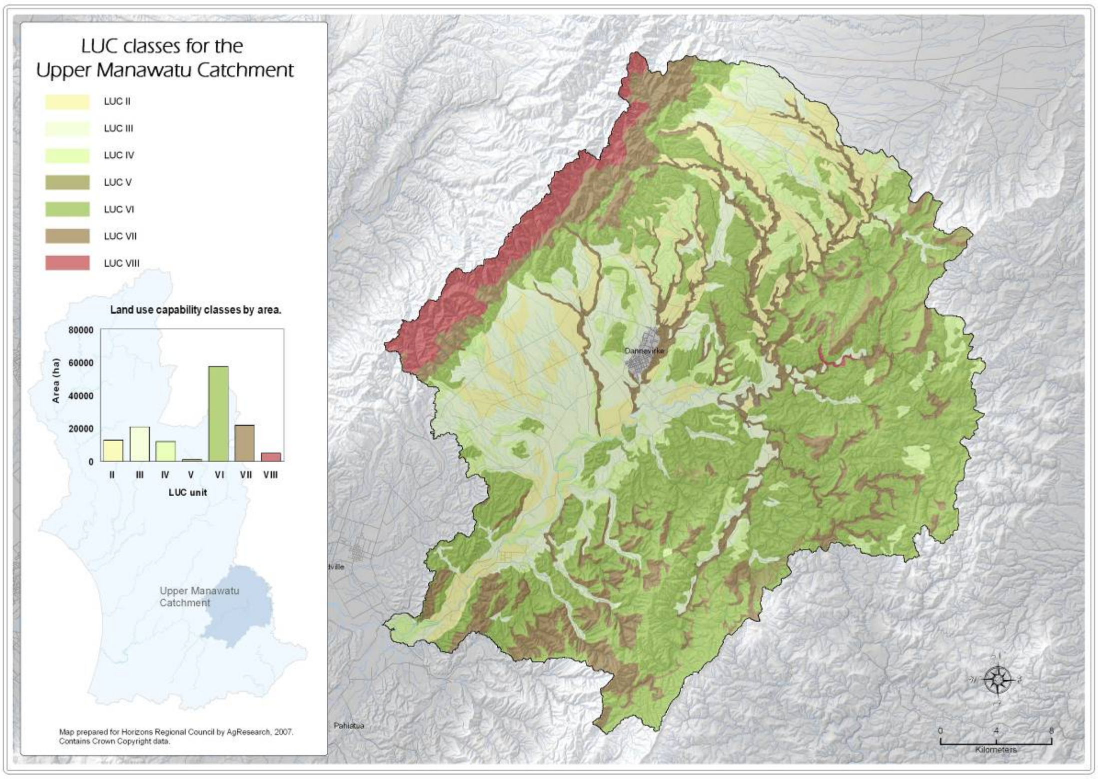


Fig.2 LUC classes for the Upper Manawatu.

If all the soils in the Upper Manawatu catchment were farmed at 90% of potential as listed in the extended legend, and assuming a transmission coefficient of 0.5 for all land classes, the N loading in the river would be 921 tonnes annually. This is higher than current loadings in the river.

LUC class	Area (ha)	N Loss based on potential production (kgN/ha/yr)	Fraction of potential	Nitrate Loss limit kgN/ha/yr	Transmission Co-efficient	Total N loading in river (kgN/yr)
II	12424	27.4	0.9	24.7	0.5	153348
III	20257	23.5	0.9	21.1	0.5	213978
IV	11508	17.5	0.9	15.8	0.5	90729
V	907	16.3	0.9	14.7	0.5	6666
VI	57254	14.5	0.9	13.1	0.5	373897
VII	22108	8.3	0.9	7.5	0.5	82431
VIII	5180	0.0	0.9	0.0	0.5	0
Total	**129638**					**921049**

Table 1 Area of each LUC class, calculated N loss associated with the potential productivity of the soils in each LUC class using Overseer and the contribution of the soils in each LUC to the N loading in Upper Manawatu river and average N loss per ha per yr if each LUC is farmed at 90% of potential.

The calculation in Table 1 was limited to the use of the potential for the "average" soil in each LUC class. The approach offers the potential to utilise site specific information, including soil type, drainage class, landscape type and geo-spatial position within the extended legend, along with rainfall to inform OVERSEER®. This would increase the accuracy of the calculated values.

LUC class	Area (ha)	N Loss based on potential production (kgN/ha/yr)	Fraction of potential	Nitrate loss limit kgN/ha/yr	Transmission Co-efficient	Total N loading in river (kgN/yr)
II	12424	27	0.75	20.6	0.5	127790
III	20257	23	0.75	17.6	0.5	178315
IV	11508	18	0.75	13.1	0.5	75608
V	907	16	0.75	12.3	0.5	5555
VI	57254	15	0.75	10.9	0.5	311580
VII	22108	8	0.75	6.2	0.5	68693
VIII	5180	o	0.75	0.0	0.5	0
Total	**129638**					**767541**

Table 2 Area of each LUC class, calculated N loss associated with the potential productivity of the soils in each LUC class using Overseer and the contribution of the soils in each LUC to the N loading in Upper Manawatu river and average N loss per ha per yr if each LUC is farmed at 75% of potential.

When the fraction of potential production is limited to 75% on all LUC classes, the N at the farm scale and the resulting N load in the river are very close to the present loading. If the short-term goal was to prevent any further increase in the N loading in the river the N loss values in column 5 provides an N loss limit, before requiring the introduction of a mitigation practice. If the long-term goal is a reduction on the current N loading in the river, then an adjustment can be made to the fraction of potential production that is permissible, before a mitigation strategy must be initiated. The major strength of this approach is that in calculating the limit it considers the whole catchment. Further it is not prescriptive, but rather places a limit on the emission, or farm loss, above which a mitigation practice must be employed, rather than an input cap. The approach also offers the opportunity to engage directly and in a very transparent way with land owners and the wider community in setting the targets, without being prescriptive.

4.2. Mangatainoka catchments

The Mangatainoka catchment has 18,500 ha of Class I-IV and the balance is Class VI-VIII. Dairying covers approx. 14,500 ha and sheep and beef approx. 22,823 ha. The average rainfall used in the following calculation was 1600 mm

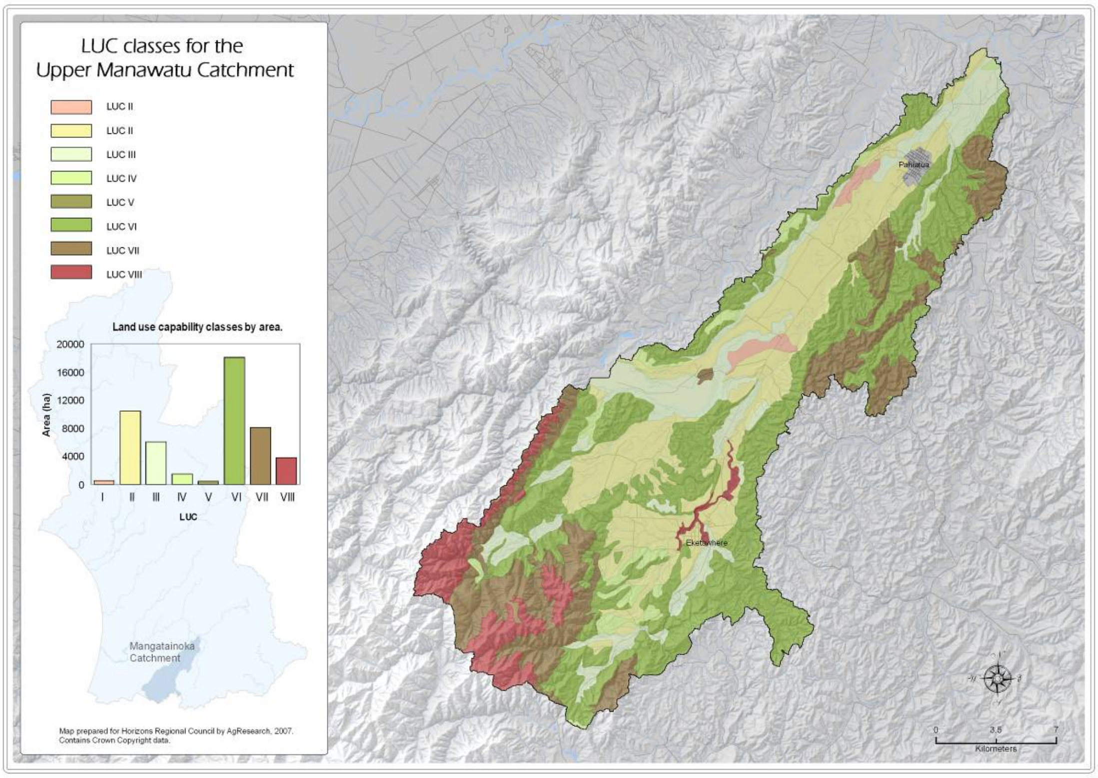


Fig.3 LUC classes for the Mangatainoka.

In the following analysis the calculated N loss for the “average” soil in each LUC class used in the Upper Manawatu analysis was used in the Mangatainoka catchment, despite the average rainfall in the catchment being 250-400 mm higher than in the Upper Manawatu.

LUC class	Area (ha)	N Loss based on potential production (kgN/ha/yr)	Fraction of potential	Nitrate loss limit kgN/ha/yr	Transmission Co-efficient	Total N loading in river (kgN/yr)
I	549	30	0.90	27	0.5	7412
II	10,394	27	0.90	25	0.5	128292
III	6,074	23	0.90	21	0.5	64161
IV	1,498	18	0.90	16	0.5	11810
V	409	16	0.90	15	0.5	3006
VI	18,110	15	0.90	13	0.5	118267
VII	8,057	8	0.90	7	0.5	30041
VIII	3,874	0	0.90	0	0.5	0
Total	**48965**					**362988**

Table 3 Area of each LUC class, calculated N loss associated with the potential productivity of the soils in each LUC class using Overseer and the contribution of the soils in each LUC to the N loading in Upper Manawatu river and average N loss per ha per yr if each LUC is farmed at 90% of potential.

Using these values when all the soils in the Mangatainoka are farmed at 90% of potential as listed in the extended legend and assuming a transmission coefficient of 0.5 for all land classes the N loading in the river would be 363 tonnes. This is much lower than the current N loadings in the river, reflecting in part the use of average N loss values in the calculation. These analysis need to be run with N losses calculated for this environment.

LUC class	Area (ha)	Nitrate Loss based on potential production (kgN/ha/yr)	Fraction of potential	Nitrate loss limit kgN/ha/yr	Transmission Co-efficient	Total N loading in river (kgN/yr)
I	549	30.0	0.75	23	0.5	6176
II	10,394	27.4	0.75	21	0.5	106910
III	6,074	23.5	0.75	18	0.5	53467
IV	1,498	17.5	0.75	13	0.5	9842
V	409	16.3	0.75	12	0.5	2505
VI	18,110	14.5	0.75	11	0.5	98556
VII	8,057	8.3	0.75	6	0.5	25034
VIII	3,874	0.0	0.75	0	0.5	0
Total	**48965**					**302490**

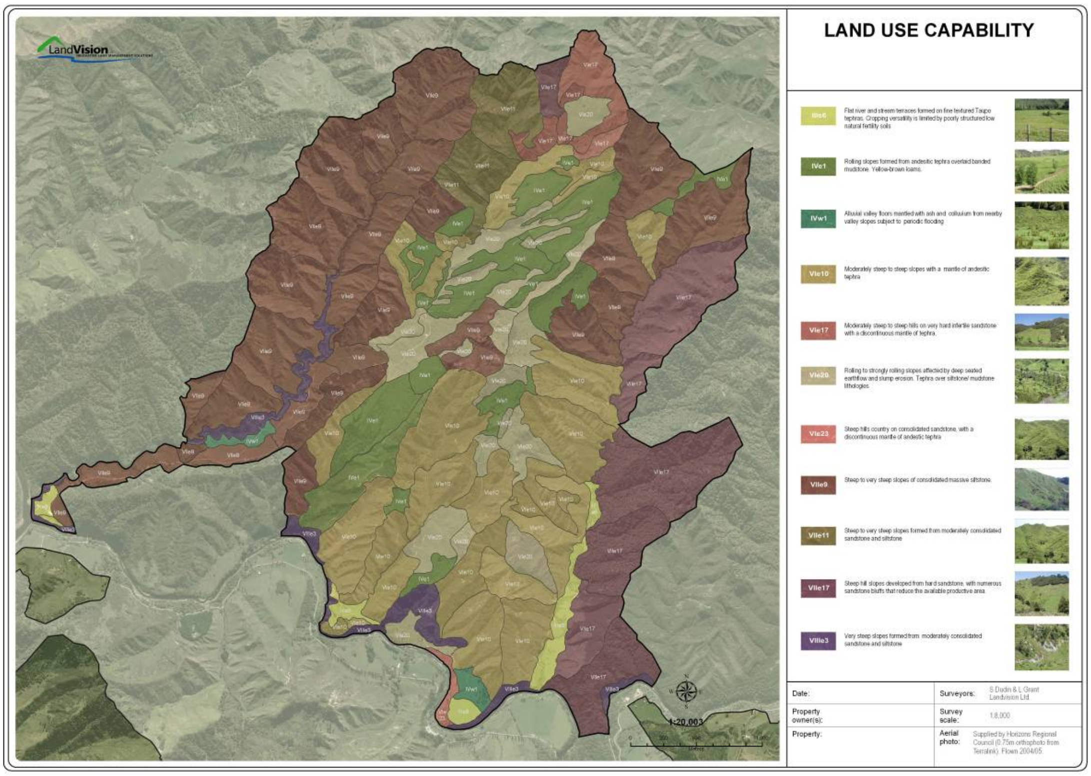
Table 4 Area of each LUC class, calculated N loss associated with the potential productivity of the soils in each LUC class using Overseer and the contribution of the soils in each LUC to the N loading in Upper Manawatu river and average N loss per ha per yr if each LUC is farmed at 75% of potential.

When the fraction of potential is reduced to 75% then the loadings are approaching the long-term N loading for the river.

5. Calculating the N loss limit on-farm

At the farm scale, the N loss limit could be calculated using the information in the NZLRI, or from information obtaining from on-farm mapping (Fig. 4). Horizons Regional Council has a copy of the NZLRI in its data base, so individual landowners could request the required information for their land holdings. This input data is required in OVERSEER to calculate the N loss limit for that land holding.

Recognising the NZLRI was designed to provide an indication of the distribution of soils at the district, rather than the paddock scale, it could be used as a first approximation, with the land owner having the opportunity to obtain a more detailed soil map and calculating N loss limits from the paddock scale information, along with local rainfall data if available.



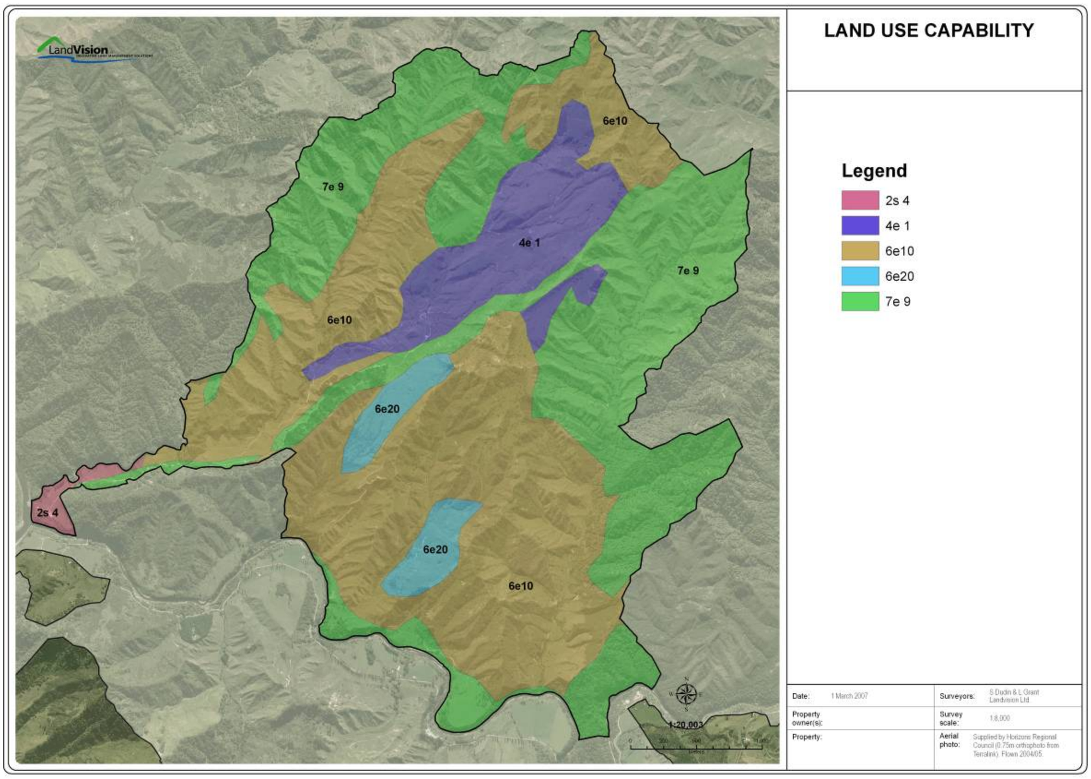


Fig.4 LUC units for a farm mapped at the paddock scale (top) and taken from the NZLRI (bottom).

6. Next step

The approach of allocating **nutrient loss limit based on the natural capital of the soil in the catchment** offers a basis for developing policy that is linked directly to the underlying natural biophysical resources in the catchment, irrespective of current land-use or future options. We stress that this is independent of current land use and places no restrictions on future land use options. It provides all land users in the catchment with certainty by defining a nutrient loss limit based on the suite of soils they own, beyond which resource consent would be required, that included a nutrient budget and mitigation strategy. The approach offers the opportunity for innovation and to engage directly and in a very transparent way with land owners and the wider community in setting the targets

To inform future debate, and assist in refining current policy using this approach, the following issues require further examination including a review of natural-resource based policy initiatives elsewhere in the world. There is the potential for using the approach as a trading scheme, testing of the approach with landowners in the region operating a range of intensive land uses in catchment with different geophysical configurations, assessing the influence of the resolution of land based information on the calculated values, an examination of the efficiency of resource use when allocating nutrient loss limits based on the soils natural capital and the availability of and effectiveness of mitigation options to land owners farming landscapes with different potentials and limitations to use**.**

He we suggest in more detail what might, in bullet form, be worth assessing

6. 1. Policy development

- Explore the extent to which natural resource based approaches have been used internationally to address nutrient management?
- Examine the literature and review other natural resource based policy approaches for defining N loss limits.
- Include as part of the analysis a comparison of output and input policy based approaches to nutrient management
- Examine the potential for the approach to be used as part of a trading scheme within the water management zone.
- Determine ability to incorporate into the rule more detailed information in the extended legend (e.g. soil type, drainage class, rainfall, distance from water courses, etc).

6. 2. Testing of the approach

- Engage three intensive farming businesses and assess the impact of the approach on the economics of the business. Assess the acceptability to the land owner by building detailed nutrient plans for their farms, from both the NZLRI data base and from farm scale resource mapping
- Test the approach in some other catchments in the region
- Examine the following scaling issues at farm and catchment scale.
    - Average versus site specific date (soils, rainfall, etc)
    - NZ LRI versus paddock mapping (3 case studies Class I-III, II VI and VI-VII)
    - Impact of the LUC handbook update
- Examine the impact of extreme events (Flooding, drought, etc).
- Spatial tools for rainfall, LUC and presentation of OVERSEER® output.

6.3. Allocation of rights

- Explore the efficiency of resource use by soil within each LUC class E.g. Production(kg and $) per unit N lost
    - Should the loss limit be weighed equally across all soil units to the same degree?
- List the mitigation options (types and cost benefits) available by soil within each LUC class. Land owners on soils in class I have more mitigation options than those of land class with limitations to use, should the weighting on the loss limits reflected the greater flexibility that affords land owners on that land class?

7. Conclusion

We consider that this capital based approach to managing nutrient is a new methodology that should be at the forefront of sustainable development. We believe that the resilience of our future land-use production systems will be measured on their sustainable exploitation of natural capital, whilst minimising external coast to the environment. This approach in whatever final form it takes will achieve wins both way: productivity and protection.