Priority sub-catchments for staged development of property plans

Technical Leaders Group 29th March 2016

Purpose

Provide technical information to CSG on prioritisation of sub-catchments for staged development of property plans.

TLG Recommendation

The TLG considers that 'Alternative option 2' best delivers on the CSG's guidance criteria for the prioritisation of sub-catchments for a three-stage development of property plans.

Background

Part of the policy mix currently being developed by the CSG is the requirement to develop and implement property plans across the entire catchment (draft Rules 5 and 6). In considering the practical roll-out of these property plans the CSG are seeking a staged approach, with those sub-catchments where the contaminant loss from farmland is ranked disproportionately high being in the first stage. In discussing a mocked-up draft at its meeting of 2-3 March, the CSG provided the following guidance to the TLG:

1. There was a preference towards using the combined ranking of all four contaminants as a way to establish those 'top priority' sub-catchments for the first tranche of farm plans. There was a view that the top 20% of combined rank sub-catchments should be in the first tranche of farm plans.
2. If the ranking analysis in #1 does not include those sub-catchments draining to the Lake Waikare – Whangamarino system, then the CSG asked that consideration be given to adding them into the first tranche of farm plans.
3. If the ranking analysis in #1 does not include sub-catchments that have a high priority ranking (top 10%?) for one contaminant, then consideration should be given to adding them into the first tranche of farm plans.
4. Also, as a result of that meeting and further work from the property plan sub-group, the CSG is now proposing 3 tranches for developing farm plans, all within the first 10 years. As described in the CSG's recommendations tabled at the HRWO Committee meeting of 22nd February:
    a. By 2019 'top priority' sub-catchments will have property plans
    b. By 2022 'second priority' sub-catchments will have property plans
    c. By 2026 'third priority' sub-catchments will have property plans

The TLG have considered prioritisation approaches that are consistent with the above guidance.

Approach

The analysis was carried out by Dr Annette Semadeni-Davies from NIWA, the developer of the catchment water quality module of the HRWO scenario model, with guidance from the TLG Chair. The water routing, water quality and land use information components of the HRWO model have been used to determine the relative extent of contaminant reduction required per hectare from farms in each sub-catchment to help close the gap between current state and desired state (Scenario 1) by:

- Removing the influence of point sources and geothermal inputs
- Including the N 'load to come' within the 'current state' of relevant sub-catchments as this is a better reflection of the water quality effects of current land management practices
- Using the routing algorithms to remove the effects of upstream sub-catchments so that the contaminant reductions required within each sub-catchment can be determined.

Findings

The results of the sub-catchment ranking process are presented in the Table ("DNA chart") and associated contaminant maps attached. Some key observations:

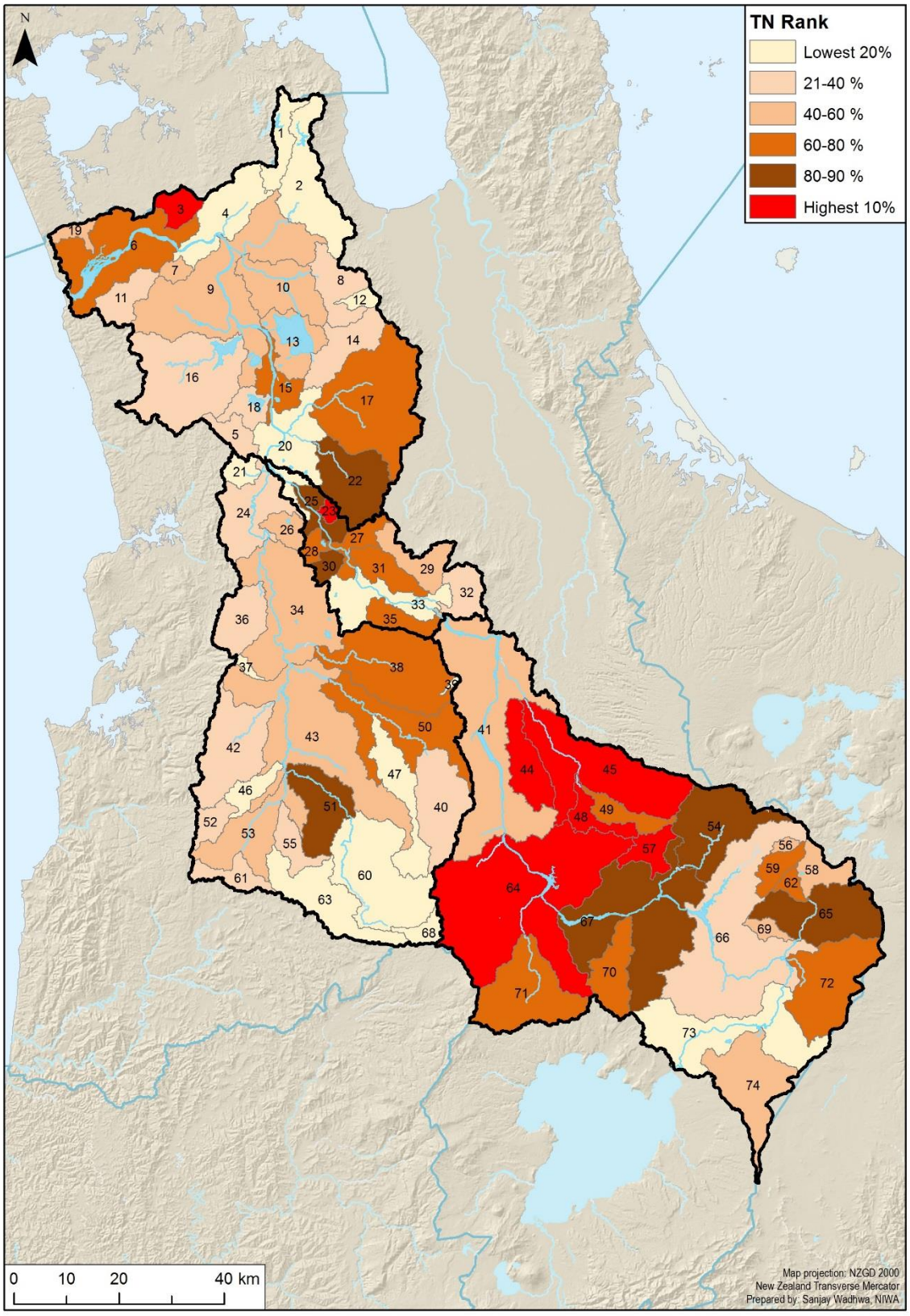
1. There is a cluster of high priority sub-catchments for both N and P in the Upper Waikato FMU.
2. There is a cluster of high priority sub-catchments for both *E.coli* and sediment in the Waipa FMU.
3. The Central and Lower FMUs contain some 'hot' and moderately 'hot' sub-catchments (red and dark brown, top 20%), for example, those draining to Lakes Whangape and Waikare and the Whangamarino for sediment.
4. This all leads to a 'mixed bag' with respect to the average ranks across all 4 contaminants.

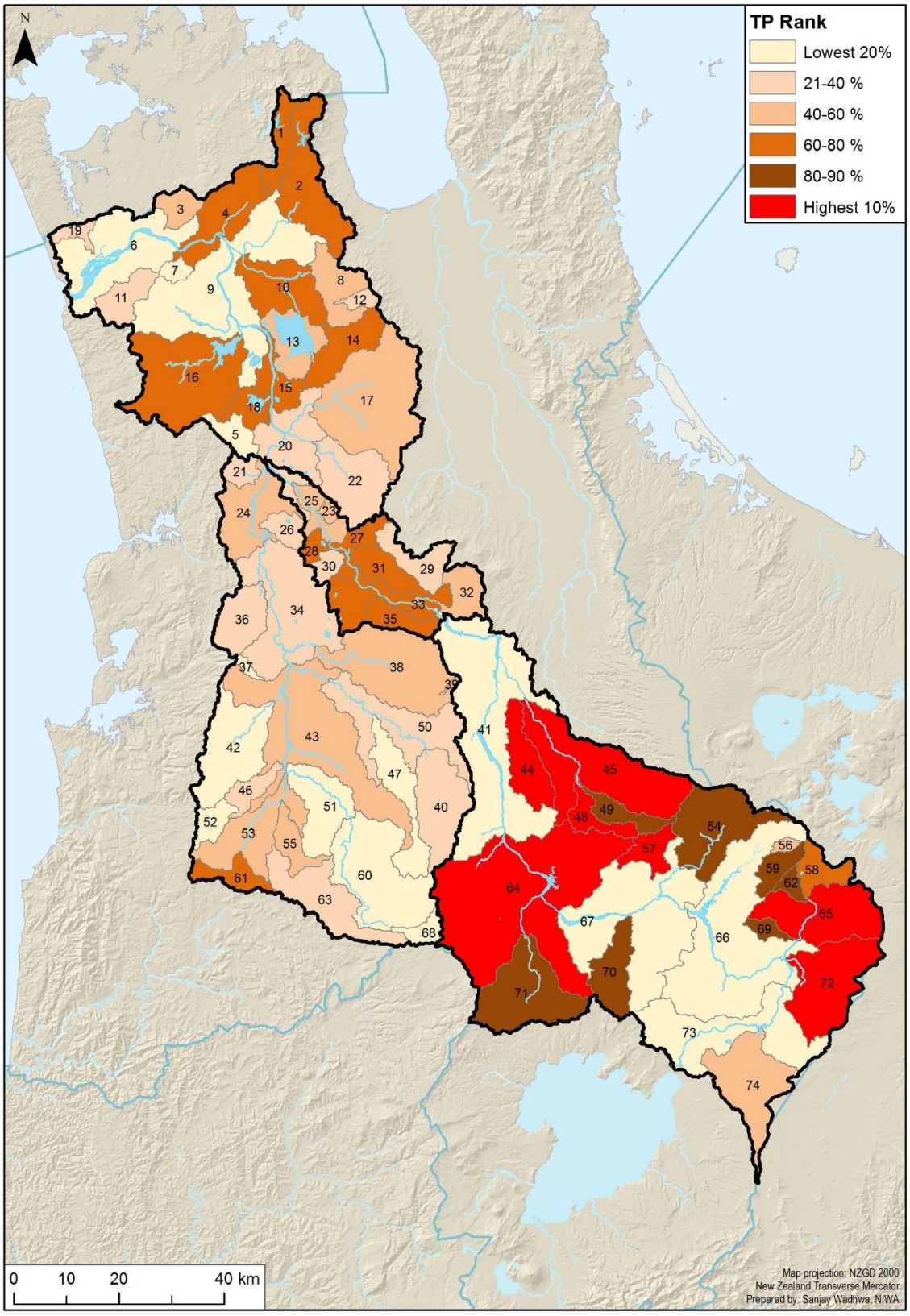
The spatial differences of priority rankings between contaminants are not unexpected, and reflect the outcome of the differing effects of biophysical setting (e.g., slopes, soil type, climate), current patterns of land use (intensity and practice), and spatially-different desired attribute states for the water (as per Scenario 1). That is, the suitability of current land use patterns from a water quality attribute perspective.

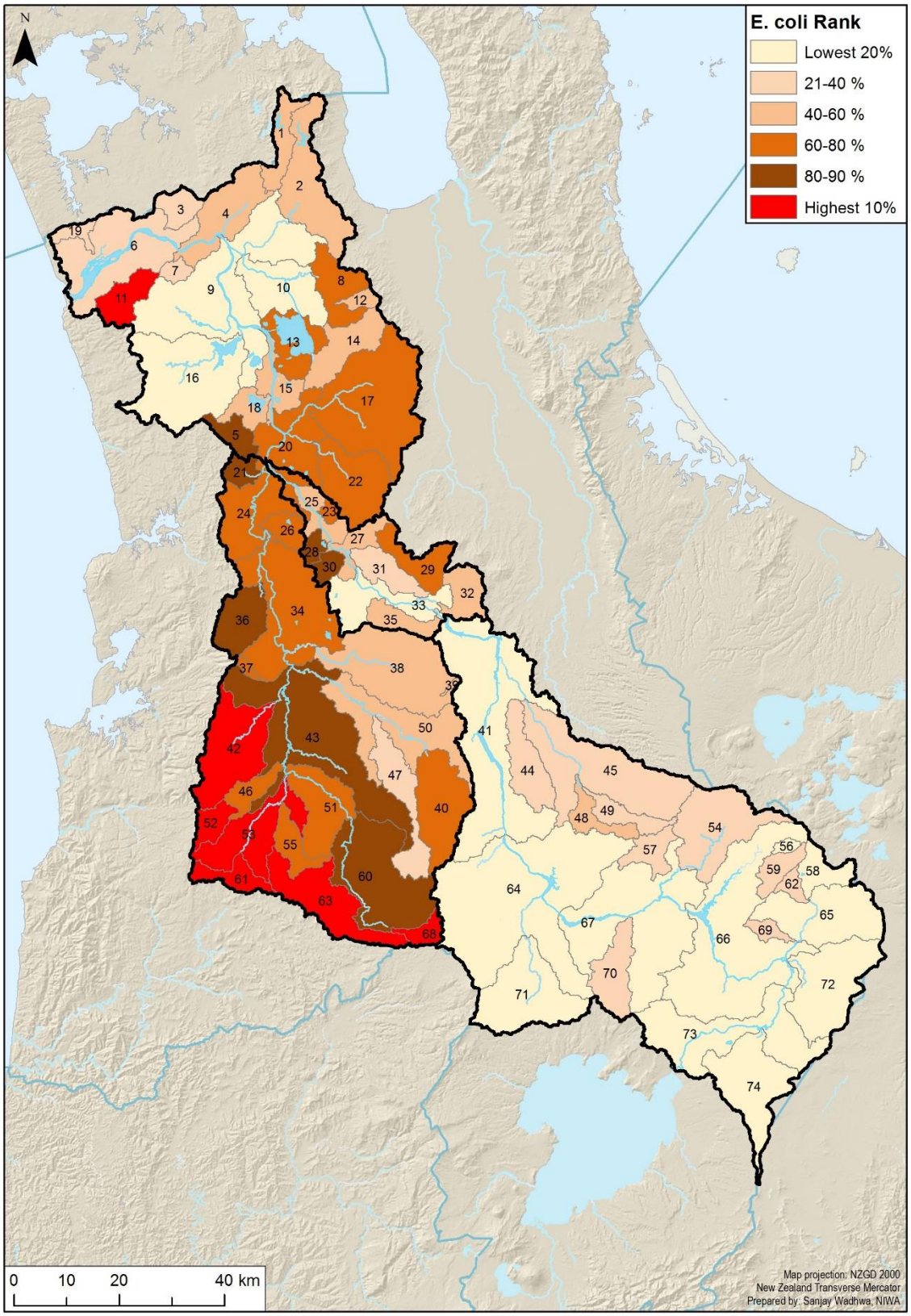
Based upon the guidance provided by the CSG, we have prepared three alternative options for breaking the sub-catchments into the three tranches – 'top priority', 'second priority' and 'third priority'. These are presented as the 'shades of purple' columns in the Table and are repeated in the 'shades of purple' maps. All columns in the Table have been sorted by Alternative option 2.

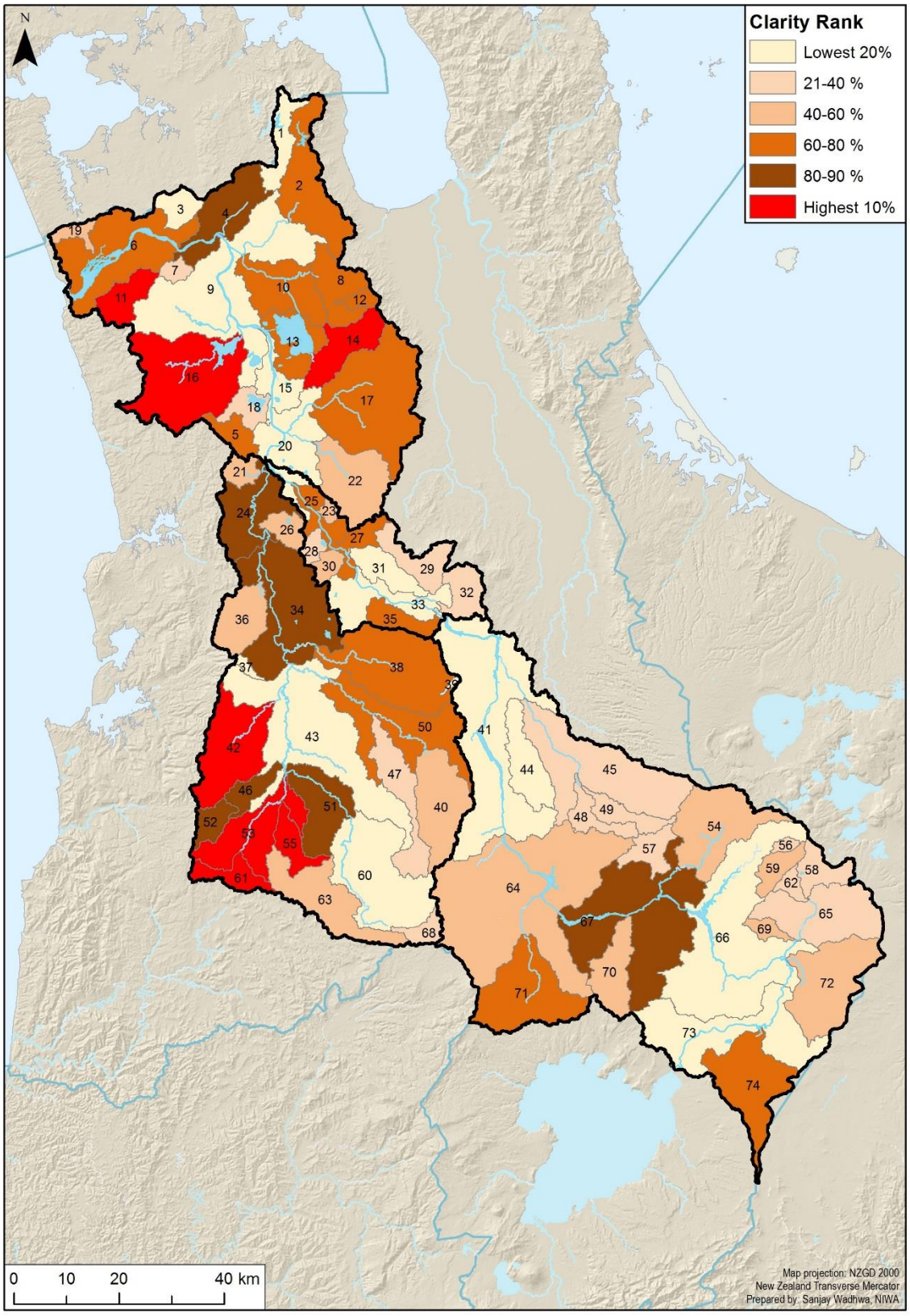
It is the TLG's view that alternative option 2 best meets all the CSG guidance criteria provided above. With this option, 31 sub-catchments with estimated total farm land area of 244,323 ha would be 'top priority' for property planning, 23 sub-catchments with estimated total farm land area of 235,380 ha would be 'second priority', and 20 sub-catchments with estimated total farm land area of 201,763ha would be 'third priority'.

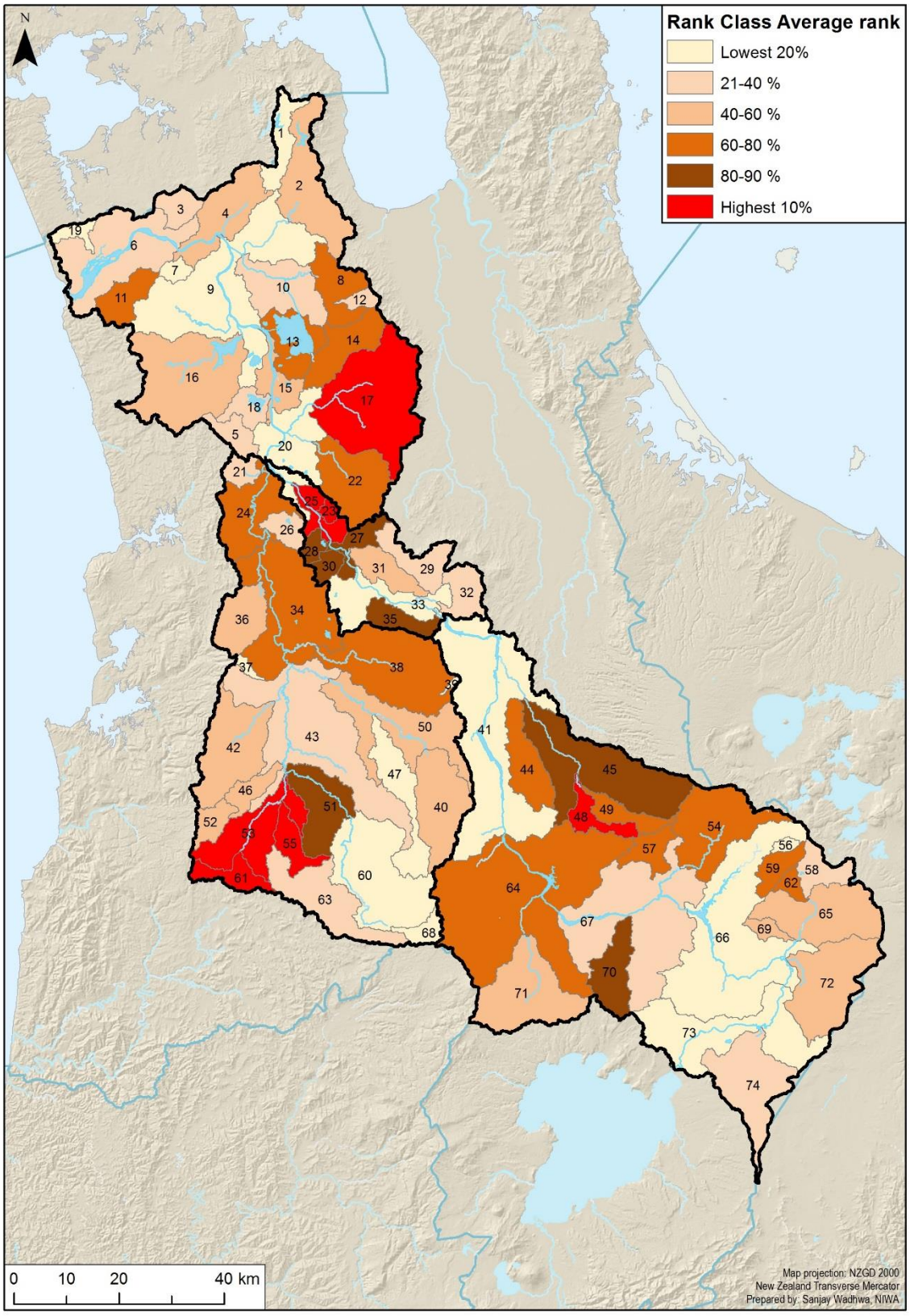
In a separate exercise, the Regional Council's implementation team are looking at the number and type of farms in the sub-catchments and will be providing the CSG with information on implementation feasibility.

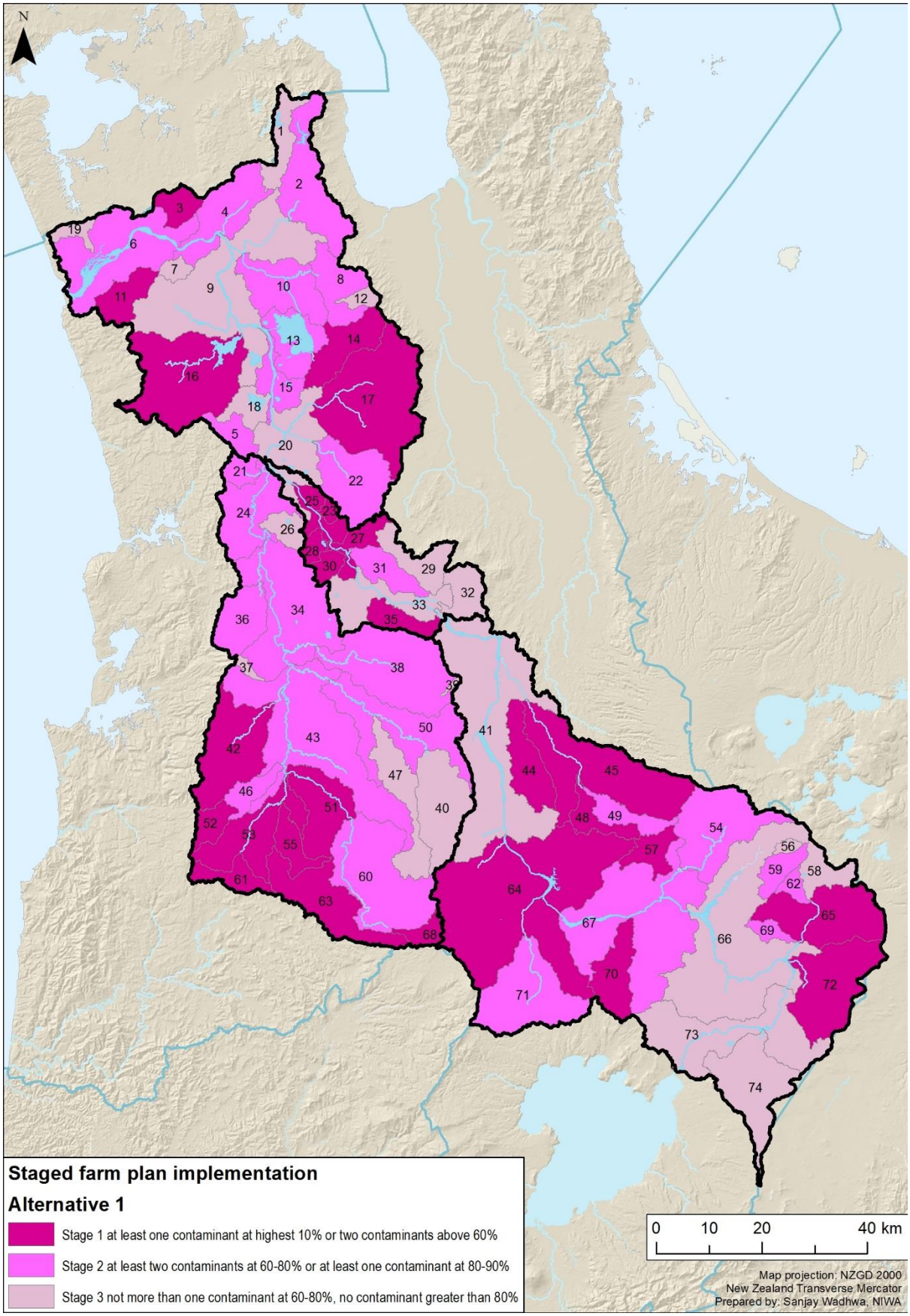

N
TN Rank
Lowest 20%
21-40 %
40-60 %
60-80 %
80-90 %
Highest 10%
0 10 20 40 km
Map projection: NZGD 2000
New Zealand Transverse Mercator
Prepared by: Sanjay Wadhwa, NIWA

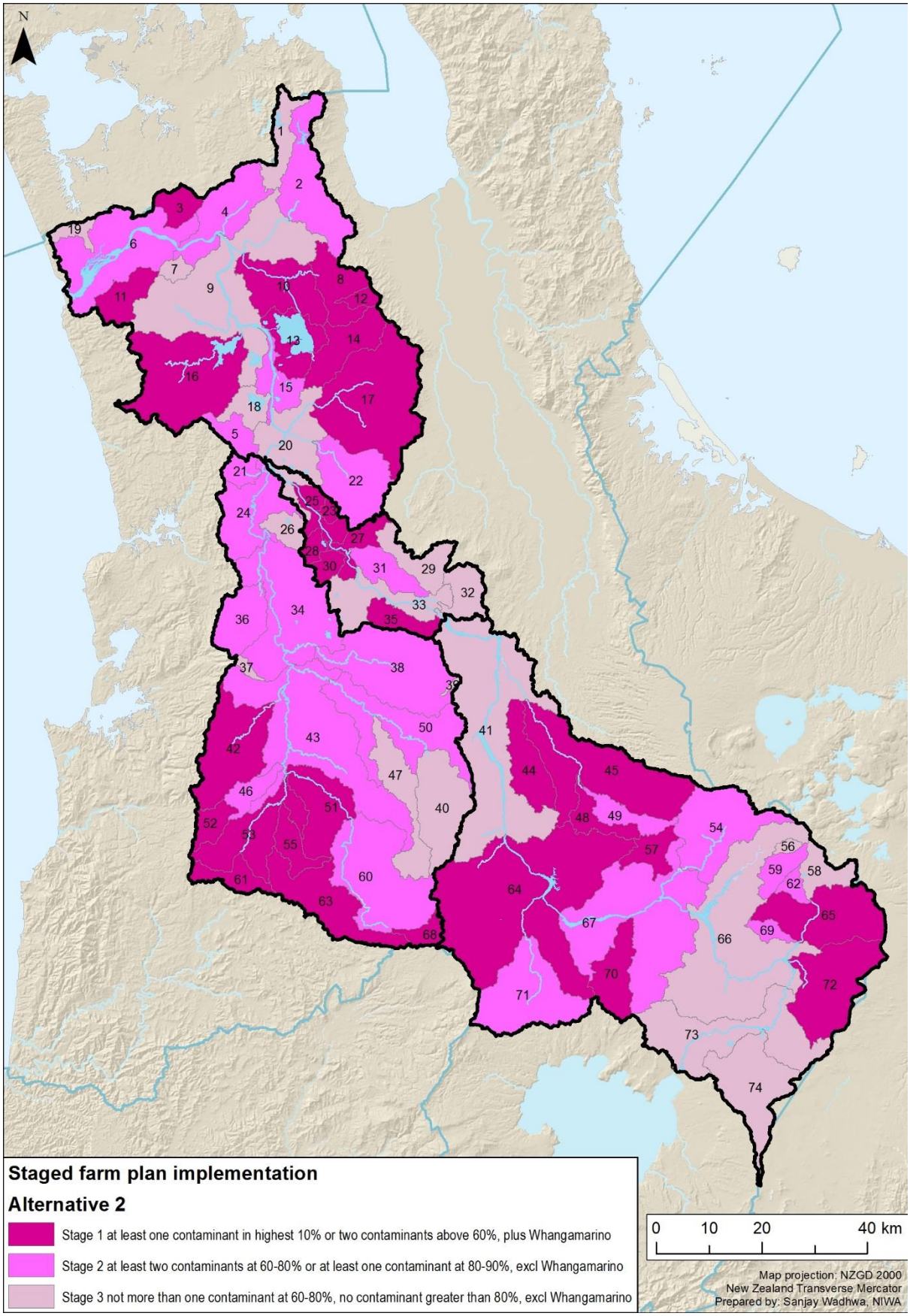

N
TP Rank
Lowest 20%
21-40 %
40-60 %
60-80 %
80-90 %
Highest 10%
0 10 20 40 km
Map projection: NZGD 2000
New Zealand Transverse Mercator
Prepared by: Sanjay Wadhwa, NIWA

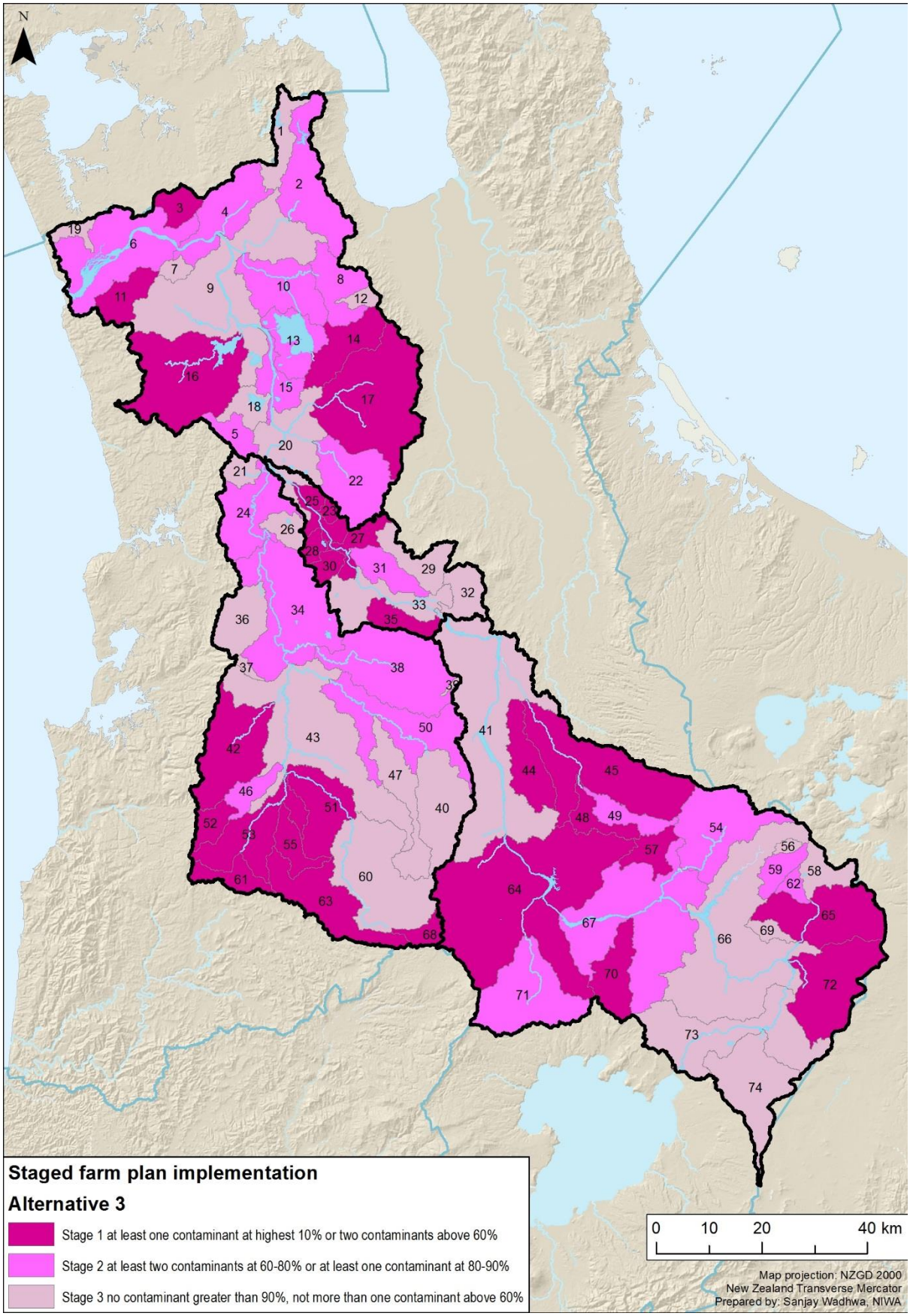

N
E. coli Rank
Lowest 20%
21-40 %
40-60 %
60-80 %
80-90 %
Highest 10%
0 10 20 40 km
Map projection: NZGD 2000
New Zealand Transverse Mercator
Prepared by: Sanjay Wadhwa, NIWA


N
Clarity Rank
Lowest 20%
21-40 %
40-60 %
60-80 %
80-90 %
Highest 10%
0 10 20 40 km
Map projection: NZGD 2000
New Zealand Transverse Mercator
Prepared by: Sanjay Wadhwa, NIWA


N
Rank Class Average rank
Lowest 20%
21-40 %
40-60 %
60-80 %
80-90 %
Highest 10%
0 10 20 40 km
Map projection: NZGD 2000
New Zealand Transverse Mercator
Prepared by: Sanjay Wadhwa, NIWA


N
Staged farm plan implementation
Alternative 1
Stage 1 at least one contaminant at highest 10% or two contaminants above 60%
Stage 2 at least two contaminants at 60-80% or at least one contaminant at 80-90%
Stage 3 not more than one contaminant at 60-80%, no contaminant greater than 80%
0 10 20 40 km
Map projection: NZGD 2000
New Zealand Transverse Mercator
Prepared by: Sanjay Wadhwa, NIWA


N
Staged farm plan implementation
Alternative 2
Stage 1 at least one contaminant in highest 10% or two contaminants above 60%, plus Whangamarino
Stage 2 at least two contaminants at 60-80% or at least one contaminant at 80-90%, excl Whangamarino
Stage 3 not more than one contaminant at 60-80%, no contaminant greater than 80%, excl Whangamarino
0 10 20 40 km
Map projection: NZGD 2000
New Zealand Transverse Mercator
Prepared by: Sanjay Wadhwa, NIWA


N
Staged farm plan implementation
Alternative 3
Stage 1 at least one contaminant at highest 10% or two contaminants above 60%
Stage 2 at least two contaminants at 60-80% or at least one contaminant at 80-90%
Stage 3 no contaminant greater than 90%, not more than one contaminant above 60%
0 10 20 40 km
Map projection: NZGD 2000
New Zealand Transverse Mercator
Prepared by: Sanjay Wadhwa, NIWA

Current state (2010-14)

	Ecosystem health								Human health for recreation	
	Median chlorophyll a	Maximum chlorophyll a	Median total nitrogen	Median total phosphorus	Median nitrate	95th percentile nitrate	Median ammonia	Maximum ammonia	95th percentile *E. coli*	Clarity
Waikato River @ Taupo Control Gates	A	A	A	A	A	A	A	A	A	A
Waikato River @ Ohaaki Br	A	B	A	A	A	A	A	A	A	A
Waikato River @ Ohakuri Tailrace Br	B	B	B	B	A	A	A	A	A	A
Waikato River @ Whakamaru Tailrace			B	B	A	A	A	A	A	B
Waikato River @ Waipapa Tailrace	B	B	B	C	A	A	A	A	A	B
Waikato River @ Narrows Boat Ramp	C	B	C	C	A	A	A	A	B	B
Waikato River @ Horotiu Br	C	B	C	C	A	A	A	A	<MAS	C
Waikato River @ Huntly-Tainui Br	C	B	C	C	A	A	A	A	<MAS	D
Waikato River @ Mercer Br	C	C	C	D	A	A	A	A	<MAS	
Waikato River @ Tuakau Br	C	C	C	D	A	A	A	A	<MAS	D
Waipa River at Mangaokewa Rd					A	A	A	A	<MAS	C
Waipa River at Otewa					A	A	A	A	<MAS	B
Waipa River at SH3 Otorohanga					A	A	A	A	<MAS	C
Waipa River at Pirongia-Ngutunui Rd Bridge					A	A	A	A	<MAS	D
Waipa River at Whatawhata					A	A	A	A	<MAS	D
Pueto Stm at Broadlands Rd Bridge					A	A	A	A	A	B
Torepatutahi Stm at Vaile Rd Bridge					A	A	A	A	A	
Waiotapu Stm at Homestead Rd Bridge					B	B	B	B	B	
Mangakara Stm (Reporoa) at SH5					B	B	A	B	<MAS	D
Kawaunui Stm at SH5 Bridge					C	B	A	B	<MAS	C
Waiotapu Stm at Campbell Rd Bridge					A	A	C	B	A	C
Otamakokore Stm at Hossack Rd					A	A	A	A	<MAS	C
Whirinaki Stm at Corbett Rd					A	A	A	A	A	B
Tahunaatara Stm at Ohakuri Rd					A	A	A	A	<MAS	C
Mangaharakeke Stm (Atiamuri) at SH30 (Off Jct SH1)					A	A	A	A	<MAS	C
Waipapa Stm (Mokai) at Tirohanga Rd Bridge					B	A	A	A	<MAS	C
Mangakino River (Whakamaru) at Sandel Rd					A	A	A	A	A	B
Whakauru Stm at U/S SH1 Bridge					A	A	A	A	<MAS	D
Mangamingi Stm (Tokoroa) at Paraonui Rd Bridge					C	B	B	B	<MAS	D
Pokaiwhenua Stm at Arapuni-Putaruru Rd					B	B	A	A	<MAS	C
Little Waipa Stm at Arapuni – Putararu Rd					B	B	A	B	<MAS	C
Karapiro Stm at Hickey Rd Bridge					A	B	A	A	<MAS	D
Mangawhero Stm (Cambridge) at Cambridge-Ohaupo Rd					B	B	B	B	<MAS	D
Mangaonua Stm at Te Miro Rd					A	A	A	A	<MAS	C
Mangaonua Stm at Hoeka Rd					B	B	B	B	<MAS	D
Mangaone Stm at Annebrooke Rd Bridge					C	B	A	A	<MAS	D
Mangakotukutuku Stm (Rukuhia) at Peacock Rd					A	B	B	B	<MAS	D
Waitawhiriwhiri Stm at Edgecumbe Street					A	A	C	B	<MAS	D
Kirikiriroa Stm at Tauhara Drive					A	B	B	B	<MAS	D
Komakorau Stm at Henry Rd					B	C	C	C	<MAS	D
Mangawara Stm at Rutherford Rd Bridge					A	B	B	B	<MAS	D
Awaroa Stm (Rotowaro) at Sansons Bridge–Rotowaro-Huntly					A	A	A	B	<MAS	D
Matahuru Stm at Waiterimu Rd Br					A	B	A	B	<MAS	D
Whangape Stm at Rangiriri-Glen Murray Rd					A	A	A	B	<MAS	D
Waerenga Stm at Taniwha Rd					A	A	A	A	<MAS	D
Whangamarino River at Jefferies Rd Bridge					A	B	A	B	<MAS	D
Mangatangi River at SH2 Maramarua					A	A	A	A	<MAS	D
Mangatawhiri River at Lyons Rd at Buckingsham Bridge					A	A	A	A	<MAS	B
Whangamarino River at Island Block Rd					A	A	A	B	<MAS	D
Whakapipi Stm at SH22 Bridge					C	C	A	B	<MAS	C
Ohaeroa Stm at SH22 Bridge					B	B	A	A	<MAS	D
Opuatia Stm at Ponganui Rd					A	A	A	A	<MAS	D
Awaroa River (Waiuku) at Otaua Rd Bridge opp Moseley Rd					B	B	A	B	<MAS	D
Ohote Stm at Whatawhata/Horotiu Rd					A	A	A	B	<MAS	D
Kaniwhaniwha Stm at Wright Rd					A	A	A	A	<MAS	D
Mangapiko Stm (Pirongia/Te Awamutu) at Bowman Rd					B	B	A	B	<MAS	D
Mangaohoi Stm at South Branch Maru Rd					A	A	A	A	<MAS	C
Mangauika Stm at Te Awamutu Borough Water Supply Intake					A	A	A	A	<MAS	A
Puniu River at Bartons Corner Rd Bridge					A	A	A	A	<MAS	D
Mangatutu Stm (Waikeria) at Walker Rd Bridge					A	A	A	A	<MAS	C
Waitomo Stm at SH31 Otorohanga					A	A	A	A	<MAS	D
Mangapu River at Otorohanga					A	A	A	B	<MAS	D
Waitomo Stm at Tumutumu Rd					A	A	A	A	<MAS	C
Mangaokewa Stm at Lawrence St Bridge					A	A	A	A	<MAS	C

Water quality outcomes if Scenario 1 achieved

	Ecosystem health								Human health for recreation	
	Median chlorophyll *a*	Maximum chlorophyll *a*	Median total nitrogen	Median total phosphorus	Median nitrate	95th percentile nitrate	Median ammonia	Maximum ammonia	95th percentile *E. coli*	Clarity
Waikato River @ Taupo Control Gates	A	A	A	A	A	A	A	A	A	A
Waikato River @ Ohaaki Br	A	A	A	A	A	A	A	A	A	A
Waikato River @ Ohakuri Tailrace Br	A	A	A	B	A	A	A	A	A	A
Waikato River @ Whakamaru Tailrace			A	B	A	A	A	A	A	A
Waikato River @ Waipapa Tailrace	A	A	A	B	A	A	A	A	A	A
Waikato River @ Narrows Boat Ramp	B	A	B	B	A	A	A	A	A	B
Waikato River @ Horotiu Br	B	A	B	B	A	A	A	A	B	B
Waikato River @ Huntly-Tainui Br	B	A	B	B	A	A	A	A	B	C
Waikato River @ Mercer Br	B	B	B	B	A	A	A	A	B	
Waikato River @ Tuakau Br	B	B	B	B	A	A	A	A	B	C
Waipa River at Mangaokewa Rd					A	A	A	A	B	B
Waipa River at Otewa					A	A	A	A	B	B
Waipa River at SH3 Otorohanga					A	A	A	A	B	B
Waipa River at Pirongia-Ngutunui Rd Bridge					A	A	A	A	B	C
Waipa River at Whatawhata					A	A	A	A	B	C
Pueto Stm at Broadlands Rd Bridge					A	A	A	A	A	A
Torepatutahi Stm at Vaile Rd Bridge					A	A	A	A	A	
Waiotapu Stm at Homestead Rd Bridge					A	A	A	A	B	
Mangakara Stm (Reporoa) at SH5					A	A	A	A	B	C
Kawaunui Stm at SH5 Bridge					B	A	A	A	B	B
Waiotapu Stm at Campbell Rd Bridge					A	A	B	A	A	B
Otamakokore Stm at Hossack Rd					A	A	A	A	B	B
Whirinaki Stm at Corbett Rd					A	A	A	A	A	A
Tahunaatara Stm at Ohakuri Rd					A	A	A	A	B	B
Mangaharakeke Stm (Atiamuri) at SH30 (Off Jct SH1)					A	A	A	A	B	B
Waipapa Stm (Mokai) at Tirohanga Rd Bridge					A	A	A	A	B	B
Mangakino River (Whakamaru) at Sandel Rd					A	A	A	A	A	A
Whakauru Stm at U/S SH1 Bridge					A	A	A	A	B	C
Mangamingi Stm (Tokoroa) at Paraonui Rd Bridge					B	A	A	A	B	C
Pokaiwhenua Stm at Arapuni-Putaruru Rd					A	A	A	A	B	B
Little Waipa Stm at Arapuni – Putararu Rd					A	A	A	A	B	B
Karapiro Stm at Hickey Rd Bridge					A	A	A	A	B	C
Mangawhero Stm (Cambridge) at Cambridge-Ohaupo Rd					A	A	A	A	B	C
Mangaonua Stm at Te Miro Rd					A	A	A	A	B	B
Mangaonua Stm at Hoeka Rd					A	A	A	A	B	C
Mangaone Stm at Annebrooke Rd Bridge					B	A	A	A	B	C
Mangakotukutuku Stm (Rukuhia) at Peacock Rd					A	A	A	A	B	C
Waitawhiriwhiri Stm at Edgecumbe Street					A	A	B	A	B	C
Kirikiriroa Stm at Tauhara Drive					A	A	A	A	B	C
Komakorau Stm at Henry Rd					A	B	B	B	B	C
Mangawara Stm at Rutherford Rd Bridge					A	A	A	A	B	C
Awaroa Stm (Rotowaro) at Sansons Bridge–Rotowaro-Huntly					A	A	A	A	B	C
Matahuru Stm at Waiterimu Rd Br					A	A	A	A	B	C
Whangape Stm at Rangiriri-Glen Murray Rd					A	A	A	A	B	C
Waerenga Stm at Taniwha Rd					A	A	A	A	B	C
Whangamarino River at Jefferies Rd Bridge					A	A	A	A	B	C
Mangatangi River at SH2 Maramarua					A	A	A	A	B	C
Mangatawhiri River at Lyons Rd at Buckingsham Bridge					A	A	A	A	B	B
Whangamarino River at Island Block Rd					A	A	A	A	B	C
Whakapipi Stm at SH22 Bridge					B	B	A	A	B	C
Ohaeroa Stm at SH22 Bridge					A	A	A	A	B	C
Opuatia Stm at Ponganui Rd					A	A	A	A	B	C
Awaroa River (Waiuku) at Otaua Rd Bridge opp Moseley Rd					A	A	A	A	B	C
Ohote Stm at Whatawhata/Horotiu Rd					A	A	A	A	B	C
Kaniwhaniwha Stm at Wright Rd					A	A	A	A	B	C
Mangapiko Stm (Pirongia/Te Awamutu) at Bowman Rd					A	A	A	A	B	C
Mangaohoi Stm at South Branch Maru Rd					A	A	A	A	B	B
Mangauika Stm at Te Awamutu Borough Water Supply Intake					A	A	A	A	B	A
Puniu River at Bartons Corner Rd Bridge					A	A	A	A	B	C
Mangatutu Stm (Waikeria) at Walker Rd Bridge					A	A	A	A	B	B
Waitomo Stm at SH31 Otorohanga					A	A	A	A	B	C
Mangapu River at Otorohanga					A	A	A	A	B	C
Waitomo Stm at Tumutumu Rd					A	A	A	A	B	B
Mangaokewa Stm at Lawrence St Bridge					A	A	A	A	B	B

Method of prioritising sub-catchments

Addendum to the memo to the Technical Leaders Group (29th March 2016; Doc#4065913)

Annette Semadeni-Davies, NIWA, 6th July 2016

This addendum presents the method used to prioritise the HRWO sub-catchments for staged development of property plans. The sub-catchments were ranked according to the amount of change in current contaminant yields (i.e., load normalised by area) required to meet the water quality objectives proposed by the Collaborative Stakeholder Group for the following attributes:

- Total nitrogen (TN) - the annual median concentrations meet or are beloweither 0.16 or 0.35 g/m^3 depending on location, within the main-stem of the Waikato River.
- Total phosphorus (TP) – the annual median concentration meet or are below 0.02 g/m^3 within the main-stem of the Waikato River.
- *E. coli* - the annual 95th percentile concentration meet or are below 260 or 540 cfu/100 ml depending on location.
- Clarity – the annual median visual clarity meet or are above either 1.0, 1.6 or 3.0 metres depending on location.

The current state of water quality for each sub-catchment[1] was evaluated using data collected for State of Environment (SOE) reporting that was supplied by WRC. The sub-catchments were ranked separately for each attribute with total suspended solids (TSS) used as a proxy for clarity following the relationship between TSS and clarity determined for the HRWO sub-catchments by Yalden and Elliot (2015). The ranks were then combined to identify the sub-catchments with the greatest overall contaminant losses.

The prioritisation method was similar for all the contaminants and hinges on the assumption that for each sub-catchment, the current state for each water quality attribute is directly proportional to the calculated mean annual load of the relevant contaminant. It was also assumed that the modelled loads have a linear relationship with the water quality attributes such that the percentage change in each attribute needed to reach the targets above is also the required percentage change in loads.

The method followed these steps:

1. Determine the current instream loads for each sub-catchment.
   Nutrient and *E. coli* loads were estimated using NIWA models that were developed for the HRWO (Semadeni-Davies et al., 2015b; Semadeni-Davies et al., 2015a). The instream loads calculated by these models includes the contributions from upstream catchments and point sources as well as the diffuse source loads generated by

[1] There are exceptions where no SOE data are available, and the concentrations for these sub-catchments were taken from concentration models developed for the HRWO.

different land covers including pastoral and horticultural land uses. Sediment loads were estimated by Landcare Research using the New Zealand Empirical Erosion Model (Palmer et al., 2013). The instream sediment load for each sub-catchment consists of the upstream load and the total load contributed by all sources in the sub-catchment.

2. Determine the load contribution from diffuse sources in each catchment.
   This step sequentially removed:
   - Incoming loads from upstream catchments;
   - Loads from any point sources found in each sub-catchment, including from geothermal sources. These point source loads were taken directly from the HRWO input data under the CSG-provided assumption that these would not change over the course of the plan change period.

   For sub-catchments that contain a large lake or hydro-dam, losses due to reservoir attenuation (taken from the model inputs) were calculated and added back to the instream load during this step to obtain the total load contribution from all sources.

3. For each sub-catchment, the loads from diffuse sources within the sub-catchment were further separated into loads generated by pastoral or horticultural land uses and loads from other land uses. Like point sources, it was assumed that the latter are not included in any management measures and represent 'unmanageable load'.
4. Loads generated by pastoral and horticultural land uses in the nutrient models are subject to catchment attenuation between the source and the stream network (Semadeni-Davies et al., 2015b). Attenuation determined as part of nutrient modelling were used to back-calculate the losses from these sources. The losses were added to the nutrient loads reaching the stream from these sources to obtain the total load generated by pastoral and horticultural land uses.
   Note that there are two sets of attenuation for TN, these are the current or *apparent* attenuation that was calibrated as part of modelling, and the "load to come" or *ultimate* attenuation estimated by the HRWO expert panel. This step used the apparent attenuation to determine the current generated load. Please refer to Semadeni-Davies et al. (2015b) for details.
5. The percentage difference between the observed state and the desired state for each attribute was calculated. If the observed state for a sub-catchment did not meet the desired state, this percentage difference was used to adjust the corresponding modelled instream load to calculate the load limit for the sub-catchment. Note that this step used the load-to-come concentration for TN, that is, the instream concentration calculated from the load-to-come load modelled using the ultimate attenuation.
6. Steps 2 to 4 were repeated using the adjusted instream load to determine the generated loads that would be required to meet the bottom-line with the exception that calculation for TN used the ultimate catchment attenuation rather than the apparent attenuation to model sub-catchment loads. For nutrients and *E. coli*, the

reduction in loads were calculated for pastoral and horticultural diffuse sources. For sediment, the reduction in loads were calculated for the sub-catchment as a whole.

7. The differences in generated loads was normalised by area to obtain differences in generated yields required to meet the desired state. Since a large sub-catchment with the same catchment characteristics and land use will contribute a higher load than a small sub-catchment, the use of yields allows the sub-catchments to be compared and ranked.
8. The yields were then ranked for each attribute with a rank of 1 having the lowest priority. The combined ranking for each sub-catchment is the rank of the average ranking for all the attributes. For example, Waikato at Ohaaki, which has relatively clean water from Lake Taupo, had the average rank of 8 and the combined rank of 2. The worst ranked sub-catchment was Mangatu which had an average rank of 56.3 giving it a combined rank of 74.
9. The rankings were then grouped into 6 classes for mapping. The classes are as follows: Best 20%; 20-40 %; 40-60 %; 60-80 %; 80-90 %; and Worst 10% .

An example of the calculation method (Steps 1-7) is given below for TN loads for the Waikato at Ohakuri sub-catchment.

Current situation

Current observed TN annual median concentration: 0.22 g/m^3

Modelled current mean annual instream load: 1453324 kg/y

Reservoir attenuation: 0.97

Modelled upstream load contribution: 1168502 kg/y
less reservoir attenuation in Waikato at Ohakuri sub-catchment: 1133172 kg/y

Modelled load contribution from Waikato at Ohakuri subcatchment:
320153 kg/y = 1453324-1133172

Sub-catchment load contribution adjusted for reservoir attenuation: 330134

Load contribution from point and geothermal sources: 1000 kg/y

Load contribution from non-pastoral or horticultural diffuse sources: 64050 kg/y

Load contribution from pastoral and horticultural diffuse sources reaching the stream network: 265084 kg/y

Apparent catchment attenuation (calibrated): 0.35

Current generated load from pastoral and horticultural diffuse sources: 757383 kg/y

Sub-catchment area with pastoral and horticultural land use: 35840 ha

TN generated yield from pastoral and horticultural sources = 21.1 kg/ha/y

Load to come

Modelled instream load calculated using ultimate attenuation (load-to-come): 1896772 kg/y

Modelled load-to-come concentration: 0.28 g/m^3

Desired state – Scenario 1

Concentration: 0.16 g/m^3

Percentage reduction from load-to-come concentration required to meet bottom line: 42.98%

Instream load limit required to meet bottom-line concentration:
1081544 kg/y = 1896772*(1-0.4298)

Modelled upstream load contribution: 811610 kg/y
less reservoir attenuation in Waikato at Ohakuri sub-catchment: 787070 kg/y
Note that the upstream contribution is lower than for the current state as it is assumed the upstream catchments are at the bottom-line concentration

Modelled load contribution from Waikato at Ohakuri subcatchment:
294478 kg/y = 1801544-787070

Sub-catchment load contribution adjusted for reservoir attenuation: 303655 kg/m^3

Load contribution from point and geothermal sources: 1000 kg/y

Load contribution from non-pastoral or horticultural diffuse sources: 64050 kg/y

Load contribution from pastoral and horticultural diffuse sources reaching the stream network: 229423 kg/y

Ultimate catchment attenuation: 0.70

Generated load limit from pastoral and horticultural diffuse sources: 327748 kg/y

TN generated yield from pastoral and horticultural sources = 9.1 kg/ha/y

Difference in yield required (and used for ranking) – 12.0 kg/ha/y

References

Palmer, D., Dymond, J. and Basher, L. (2013) Assessing erosion in the Waipa catchment using the New Zealand Empirical Erosion Model (NZeem®), Highly Erodible Land (HEL), and SedNetNZ models, Technical Report 2013/54: 31.
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Semadeni-Davies, A., Elliott, S. and Yalden, S. (2015b) Modelling nutrient loads in the Waikato and Waipa River Catchments: Development of catchment-scale models, Prepared for Technical Leaders Group of the Healthy Rivers / Wai Ora Project. NIWA Client report: HAM2015-089.

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Explanatory note to the CSG to accompany spreadsheets of contaminant loads

Prepared by the TLG

20th October 2015

At CSG #18 the CSG requested the detailed sub-catchment contaminant load data emanating from the 'stepping stone' scenario modelling to assist them in their deliberations on policy options and allocation. The accompanying spreadsheet contains the model data requested in the forms requested by the CSG.

As explained at CSG #18, in the timeframe available and with the other commitments to the project over the last week it has not yet been possible for the TLG to 'sanity' check the outputs (so therefore results are draft), to prepare maps of the load data (which will visually show 'hotspots'), or to prepare an interpretive narrative. This document is merely an explanatory note to help interested CSG members understand what they are looking at.

The load data for the four contaminants (nitrogen, phosphorus, sediment and microbes) for the current state (Base) and for the stepping-stone scenarios '10%', '25%', '50%', '75%' and '100%' of Scenario 1 are set out in the accompanying spreadsheet *Load data for CSG* for each of the 74 sub-catchments in the model. Location of each of the numbered sub-catchments and their FMU are shown in Map 1 at the end of this note.

The database contains two sets of four sheets, with the data set out either by parameter or contaminant – i.e., parameter (e.g., load/ha) for all 4 contaminants, or contaminant for all 4 parameters – take your choice.

The first four sheets in the excel database are:

- ***Catchment load***: the total load of contaminant per year for each sub-catchment at the current state (base) and after the mitigations applied in the '10%', '25%', '50%', '75%' and '100%' Scenarios.
- ***Load per total ha***: the load of contaminant for each sub-catchment expressed as kg/ha/year (except *E.coli* expressed as number per ha per year), for current state (base) and after the mitigations applied in the '10%', '25%', '50%', '75%' and '100%' Scenarios.
- ***Load removed***: the total load of contaminant removed from each sub-catchment per year by the mitigations applied in the '10%', '25%', '50%', '75%' and '100%' Scenarios compared to current state (base).
- ***Load removed per productive ha***: the annual load of contaminant removed from each sub-catchment expressed as kg/ha in production (i.e., excluding miscellaneous areas such as native forest), by the mitigations applied in the '10%', '25%', '50%', '75%' and '100%' Scenarios compared to current state (base). This is a measure of the 'intensity' of the load reduction as it relates to that area of the sub-catchment that is treatable by the mitigations.

The second four sheets repeat these data, arranged by contaminant. Each of the sheets labelled ***nitrogen***, ***phosphorus***, ***ecoli*** and ***sediment*** contain for the respective contaminant the catchment load, load per total ha, load removed and load removed per productive ha.

Please note that point sources are included in the above within the sub-catchment that they fall. These can often be spotted as 'odd-ball' high loads per hectare (e.g. Central Waikato sub-catchment #25 which includes the point source load from the Hamilton City Council Wastewater Plant).

Terms in italics below refer to the named sheets in the excel database.

Total contaminant loads
The total annual mass load of each contaminant in the current state (base) for each scenario is summarised by FMU in Table 1. Total load from each sub-catchment within each FMU is shown for all contaminants in c*atchment load* and for individual contaminants in *nitrogen, phosphorus, ecoli, and sediment*.

Comparing FMUs shows that current state (base) total mass loads of nitrogen and phosphorus are highest from the Upper Waikato FMU and lowest from the Central Waikato. Sediment load and microbial load are greatest from the Waipa FMU. Microbial load is lowest from the Central Waikato FMU.

Table 1: The total mass load entering water in the current state (base) and for scenarios '10%', '25%', '50%', '75%' and 100% of Scenario 1, for each contaminant and each FMU

	scenario	Upper Waikato	Central Waikato	Lower Waikato	Waipa
Nitrogen load (tonnes/yr)	Base	4135	871	3833	3887
	10%	3943	852	3547	3766
	25%	3636	794	3325	3499
	50%	3370	640	2795	3037
	75%	3102	384	2219	2347
	100%	3219	382	2223	2347
Phosphorus load (tonnes/yr)	Base	391	124	257	231
	10%	321	122	237	214
	25%	296	116	219	200
	50%	271	80	171	171
	75%	247	32	142	138
	100%	256	32	142	138
Sediment load (tonnes/yr)	Base	165,000	20,478	223,997	224,525
	10%	121,628	19,458	203,641	199,446
	25%	120,099	16,388	171,195	172,602
	50%	117,785	13,662	120,505	133,112
	75%	112,916	11,197	84,033	110,501
	100%	112,962	11,153	83,894	110,431
Microbial load (10^{15} /yr)	Base	13.5	6.3	26.2	40.2
	10%	11.1	5.9	21.8	35.6
	25%	10.5	5.2	18.8	31.5
	50%	10.2	4.0	13.2	22.3
	75%	8.2	2.8	10.6	18.3
	100%	8.0	2.8	10.5	18.3

Total mass load per FMU depends on catchment size, land use mix, and point sources. Total land area and area of productive land are given in *catchment load* for each sub-catchment. The areas of total and productive land in each FMU are summarised in Table 2. The percentage of the total area in each FMU that is classified as productive land is slightly higher for Upper Waikato than for the other FMUs (83, 71, 73 and 75%, respectively, for Upper, Central, Lower and Waipa).

Sub-catchment areas both within each FMU and across FMUs vary substantially in both total size and in the fraction of land classified as productive (see *catchment load*).

Table 2 Area of each FMU (ha)

FMU	Productive ha	Total ha
Upper Waikato	364,408	440,795
Central Waikato	39,946	56,573
Lower Waikato	216,265	295,604
Waipa	233,327	309,332

Contaminant loads and loads removed can therefore be expressed on a per ha basis for better comparison between sub-catchments and FMUs (*load per ha* and *load removed per productive ha*).

Load removed

The total load removed by mitigations for each of the stepwise scenarios to reach Scenario 1 is shown in *Load removed* for each sub-catchment and for each FMU or separately for each contaminant in *nitrogen, phosphorus, ecoli, and sediment*. The load to be removed is that derived from all land in the catchment.

Mitigations used in the model are management practices on productive land or at the edge of field of productive land, **only**. Total load removed and load removed per ha of productive land for each sub-catchment within each FMU are shown in the excel sheets *load removed* and *load removed per productive ha*, and for each contaminant in *nitrogen, phosphorus, ecoli, and sediment*. The loads to be removed are summarised in Tables 3 and 4.

Within any given scenario and FMU, sub-catchments vary widely in the load removed per hectare of productive land (Table 4). For example, in the Lower Waikato at 10%, the load of N to be removed ranges from 0.23 to 4.14 kg N/ha/yr for individual sub-catchments. The high extremes of load removal required per hectare of productive land can be distorted by point sources within those sub-catchments.

Relative differences between sub-catchments at the '10%' level may not be reflected at the '25', '50', '75' or '100%' level, e.g. sub-catchment 20 in the Lower Waikato has the lowest removal rate at 10% but the highest at 50, 75 and 100%. This reflects the way in which the model optimises the use of mitigations at least cost. This is particularly obvious when sub-catchments with point sources are part of the comparison – e.g. sub-catchment 25 in the Central Waikato, where the mitigation of improved point source treatment only gets invoked in scenarios of '50%' and above.

Table 3: The total load entering water in the current state (base) and the load removed by mitigations to achieve 10%, 25%, 50%, 75% and 100% of the change in concentration of contaminant to meet Scenario 1, for each contaminant and each FMU

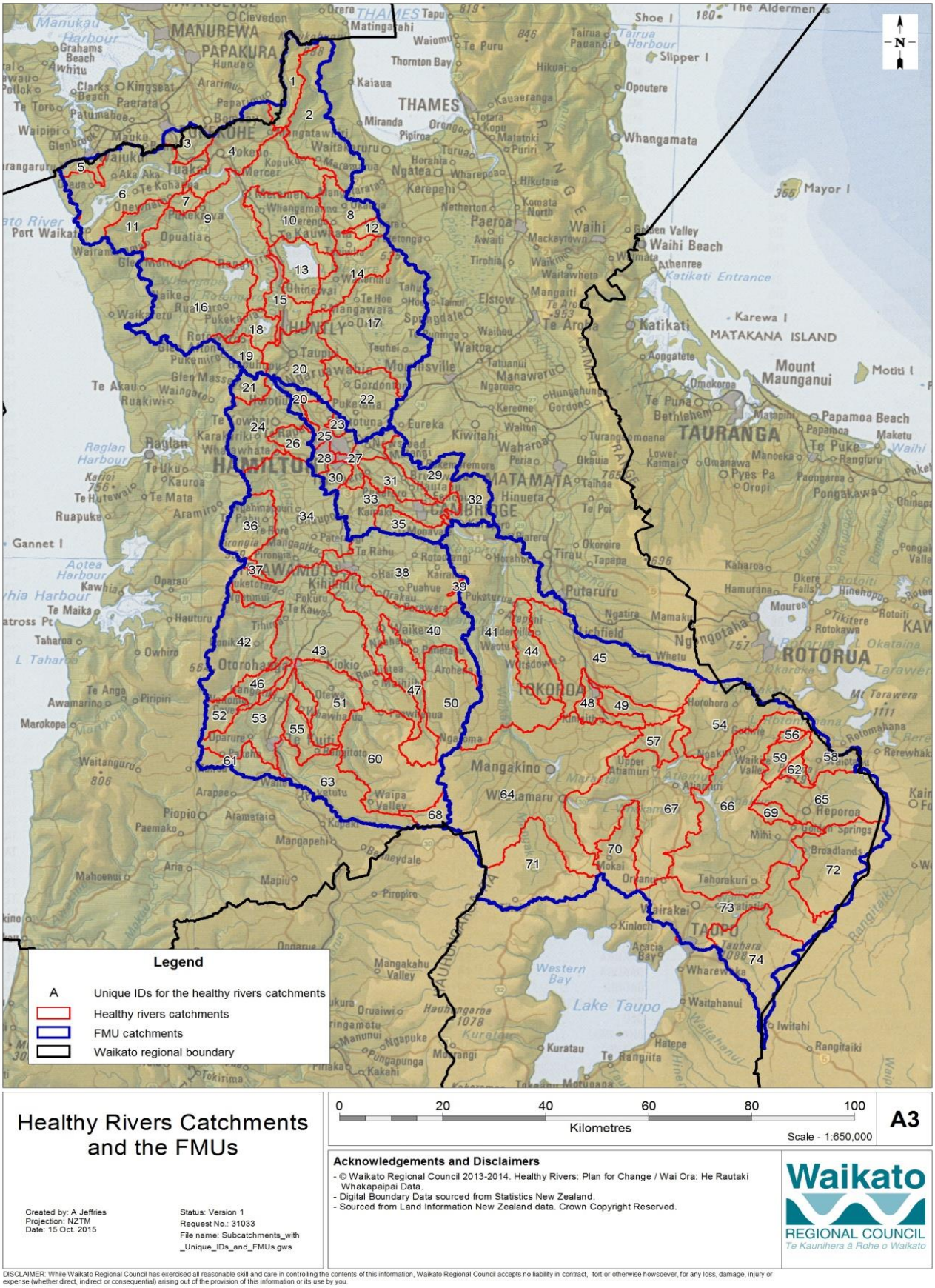
	scenario	Upper Waikato	Central Waikato	Lower Waikato	Waipa
Nitrogen (tonnes/yr)	Base	4135	871	3833	3887
N load removed (tonnes/yr)	10%	192	19	286	122
	25%	499	78	507	389
	50%	765	231	1038	850
	75%	1033	488	1613	1541
	100%	916	489	1610	1541
Phosphorus (tonnes/yr)	Base	391	124	257	231
P load removed (tonnes/yr)	10%	70	1.9	20	17
	25%	95	7.5	38	31
	50%	119	44	86	60
	75%	144	91	115	93
	100%	135	91	115	93
Sediment (tonnes/yr)	Base	165,000	20,478	223,997	224,525
Sediment load removed (tonnes/yr)	10%	43,372	1019	20,355	25,079
	25%	44,901	4089	52,802	51,922
	50%	47,215	6816	103,492	91,413
	75%	52,084	9281	139,964	114,024
	100%	52,038	9325	140,103	114,093
Microbial load (10^{15} /yr)	Base	13.5	6.3	26.2	40.2
Microbial load removed (10^{15} /yr)	10%	2.4	0.5	4.3	4.6
	25%	2.9	10.1	7.3	8.7
	50%	3.3	2.4	13.0	17.9
	75%	5.3	3.6	15.5	22.0
	100%	5.5	3.6	15.6	22.0

Table 4 Average, median and range across sub-catchments within each FMU of load removed per ha productive land

	FMU	Upper Waikato			Central Waikato			Lower Waikato			Waipa		
	scenario	average	median	range	average	median	range	average	median	range	average	median	range
N load removed (kg/ha)	**10%**	1.39	0.92	-3.88-6.33	0.63	0.49	0.11-1.34	1.05	0.73	0.23-4.14	0.60	0.60	-0.16-2.06
	25%	2.16	1.69	-3.88-8.33	1.74	1.54	0.26-4.45	1.99	1.80	0.30-7.71	1.62	1.64	0.22-3.93
	50%	3.03	2.22	-3.88-17.5	9.09	3.90	0.44-52.61	3.96	2.83	0.44-15.1	3.04	2.86	0.29-6.03
	75%	3.75	2.49	-3.88-23.5	21.84	7.74	1.37-155.2	6.57	5.22	0.99-21.7	5.66	5.27	0.80-9.18
	100%	3.54	2.49	-3.88-23.5	21.89	7.74	1.37-155.3	6.61	5.25	0.99-21.7	5.66	5.27	0.80-9.18
P load removed (kg/ha)	**10%**	0.26	0.28	-0.10-0.55	0.08	0.05	0.00-0.27	0.12	0.06	0.02-0.40	0.08	0.07	0.03-0.25
	25%	0.33	0.30	0.03-0.86	0.19	0.17	0.11-0.37	0.18	0.16	0.02-0.40	0.16	0.16	0.05-0.33
	50%	0.39	0.31	0.03-1.14	2.62	0.48	0.14-22.46	0.39	0.33	0.02-1.53	0.30	0.29	0.05-0.53
	75%	0.46	0.36	0.07-1.78	5.94	0.55	0.17-55.06	0.55	0.49	0.02-1.55	0.43	0.44	0.09-0.77
	100%	0.44	0.32	0.04-1.78	5.95	0.55	0.18-55.06	0.56	0.50	0.02-1.55	0.43	0.44	0.09-0.80
Sediment load removed (kg/ha)	**10%**	149	124	3.2-586	24	25	0.0-62	250	60	0.0-1845	193	43	0.0-834
	25%	157	134	3.1-586	103	103	1.2-229	342	97	0.0-1875	355	306	35.3-1156
	50%	164	150	7.2-586	171	188	1.6-385	517	269	6.8-1875	597	365	36.9-1696
	75%	173	155	8.0-586	211	194	22.2-576	651	433	6.8-1875	735	588	36.9-2299
	100%	173	155	8.0-586	212	198	22.2-576	653	433	6.8-1875	737	588	36.9-2299
Microbial load removed (10^{18}/ha)	**10%**	0.25471	0.010765	-0.006-0.026	0.02260	0.01202	0-0.08	0.01956	0.01214	0-0.09	0.44703	0.014944	0.003-0.06
	25%	0.31181	0.015568	-0.006-0.035	0.04843	0.03267	0.007-0.12	0.03030	0.02266	0.001-0.12	0.87469	0.034862	0.02-0.086
	50%	0.35282	0.015836	-0.006-.05	0.10314	0.07708	0.007-0.25	0.05227	0.04646	0.01-0.10	1.84923	0.083287	0.03-0.16
	75%	0.45498	0.022981	0.003-0.07	0.15423	0.08637	0.04-0.64	0.06600	0.06107	0.01-0.15	2.29771	0.100389	0.03-0.185

	100%	0.47463	0.022993	0.003-0.07	0.15423	0.08637	0.04-0.64	0.06700	0.06107	0.01-0.15	2.29772	0.100389	0.03-0.185

Map 1 Sub-catchment number and FMU map



Explanatory note to the CSG to accompany maps of contaminant loads

Prepared by the TLG

22 November 2015

The contaminant load data already provided to the CSG has been mapped to allow spatial assessment of the sub-catchment loads and, as requested by the CSG sub-group, the load to be removed at 25% of Scenario 1, for each of nitrogen, phosphorus, *E.coli* and sediment. In addition, the spreadsheet has been updated to calculate load per productive ha excluding forestry, and a combined ranking has been mapped.

Mapping of sub-catchment loads

There are four maps for each contaminant. All maps use constrained land use data.

1. Baseline load per sub-catchment, being the current state load in tonnes (sediment, N, P) or numbers of *E.coli* entering water from each sub-catchment
2. Baseline load per sub-catchment total area, being the current state sub-catchment load expressed in kg or number of *E.coli* per ha
3. Load to be removed from each sub-catchment at 25% of Scenario 1, being the load that needs to be removed from each sub-catchment to achieve 25% of the reduction in concentration in the water required for Scenario 1, in tonnes or numbers of *E.coli* entering water from each sub-catchment
4. Load to be removed per sub-catchment at 25% of Scenario 1 per productive area, being the load that needs to be removed from each sub-catchment to achieve 25% of the reduction in concentration required for Scenario 1 expressed in kg or number of *E.coli* per productive ha. Productive ha is the sum of the ha in pasture, horticulture and forestry.

On each map, the 74 sub-catchments are grouped and coloured to rank them from highest to lowest. The groupings are based on the values for the top 10% (7 sub-catchments), next 10% (7 sub-catchments), then in 20% groupings (each of 15 sub-catchments).

The map legends provide the ranges in values across the sub-catchments being grouped. For example, the Baseline P load from the lowest 15 sub-catchments ranges from 0.19 to 2.86 tonnes per sub-catchment and from the highest 7 sub-catchments from 37.21 to 77.31 tonnes.

Combined ranking of sub-catchment loads

Additional maps are provided based on a combined ranking. The combined rankings are calculated in the spreadsheet 'Ranking contaminants'. For each of the four loads mapped above, the value for each sub-catchment is shown with its ranking from 1 to 74 (1=lowest, 74=highest). The four contaminant ranks were added together to give a combined ranking score for each load, and the combined scores ranked from the lowest to the highest. No weighting was applied to contaminants in calculating the combined score.

The rank for each contaminant and the combined ranks are coloured in groups as used above i.e. the highest 10% combined scores to the lowest 20% combined scores and then mapped.

The combined ranking spreadsheets allow visual scanning of rankings across all contaminants, showing, for example, whether the combined score reflects a similar ranking across all contaminants or whether ranks are high for one contaminant but not for the others.

Exclusion of forestry

The contaminant load data already provided has been updated ('Load data for CSG incl minus forestry') to show the sediment load to be removed expressed per kg productive ha

minus forestry. The load to be removed from each sub-catchment at 25% of Scenario 1 expressed per ha of productive land minus forestry is mapped for each contaminant (four maps in total).