HAWKE'S BAY
REGIONAL COUNCIL

Tutaekuri, Ahuriri, Ngaruroro, Karamu Catchments

Riparian Assessment

April 2014

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Environmental Science - Land Science

Tutaekuri, Ahuriri, Ngaruroro, Karamu Catchments

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Executive summary

A model will be developed to examine the interactions between waterways and land use activities (as previously carried out in the Tukituki catchment). This work will inform the proposed plan change process for the TANK catchments (Tutaekuri, Ahuriri, Ngaruroro and Karamu).

This desktop exercise uses aerial photography and existing databases such as the Land Cover Database. Each of the TANK catchments are divided into sub-catchments (Tutaekuri = 6 sub-catchments, Ahuriri = 4, Ngaruroro = 12, Karamu = 11) for analysis. Stream line data was derived from the River Environment Classification database (REC). It was decided that a 30 m buffer on each side of a centre line along the river would be deemed as the riparian zone in which stock disturbance (which represents the level of stock access) and riparian vegetation (structure and type) were assessed. Only second to fourth order streams were assessed. First and fifth or larger order streams were not assessed. First order streams were excluded due to shear number of such streams in the region. Fifth and larger order streams were excluded as most of them were braided rivers whose river beds often over 60 m wide (total width of buffer), hence the assessments of their riparian conditions within 30 m buffer of the centre of the river is not relevant.

The study identified that riparian condition is better in sub-catchments situated in higher altitude than those situated at a lower altitude. It is due to the high country being less developed for pastoral land use, or that stock access is limited due to steep terrain within riparian margins. Level of stock disturbance and riparian vegetation condition generally shows correlation, for example, where there is a high level of stock disturbance, condition of riparian vegetation is poor. But such correlation was not the case for Ahuriri and Karamu Catchments.

The Ahuriri and Karamu catchments accommodate major urban areas. Some of the Karamu's sub-catchments have a high concentration of cropland, orchards and vineyards (e.g. Hastings Streams, Raupare, and Mangateretere). In these sub-catchments, stock disturbance is very limited (unless grazing is part of the cropping operations) but riparian vegetation is often poor.

The study has met its primary objective in providing baseline data of riparian condition in TANK catchments. However it is acknowledged that the current approach is limited, in particular with regards to accuracy and inadequacy of addressing impacts from non-pastoral land use (e.g. cropping) to waterways. Where more detail is required, consideration of alternative approaches such as those undertaken by Waikato Regional Council and Auckland Council may be necessary.

1 Introduction

Hawke's Bay Regional Council is reviewing sections of its Regional Resource Management Plan that deal with water quality and water allocation in the Tutaekuri, Ahuriri, Ngaruroro and Karamu (TANK) catchments. As was the case for the Tukituki Plan Change, it is envisaged that a model will be developed to simulate the linkages between land uses and their impacts (e.g. water takes, nutrient inputs) and freshwater habitats (water level, quality and ecology). A large number of environmental variables are described in these models. Riparian condition is a key variable in some of the modelled processes).This study is intended to provide this information, from an examination of riparian conditions in the TANK catchments.

The riparian zone is generally described as the vegetated strip of land along streams and rivers where interactions between land and waterways occur. Landform on which such vegetated land occur includes hill slope and flood plains.

Riparian zones have two important aspects, buffering and its intrinsic values. It buffers movements of sediment, nutrient and water from land to waterbodies by its roots, stems, canopy and litterfall on ground surface. It has intrinsic values as transitional ecosystems (terrestrial and aquatic) in which plants and animals reside and drive fundamental ecosystem functions such as nutrient and water cycles. Riparian zone creates and maintains microclimate which is favourable for aquatic ecosystems.

Because of these two important functional aspects, riparian buffer zones are effective and practical management tools for reducing impacts of land use activities on aquatic systems.

Riparian assessment in the Tukituki catchment (Hasiba 2016) has demonstrated a link between the level of stock disturbance and riparian vegetation condition. For example where there is high level of stock access and resulting disturbance of vegetation, riparian vegetation structure and plant types are often in poor condition (Hashiba, 2013).

This disturbance has the consequence that ecological health of streams can be deleteriously affected by the absence of riparian vegetation and by unrestricted access of stock to streams and their riparian margins. These impairments can be reduced by effective riparian management.

The purpose of this assessment is to provide baseline information on riparian condition in the TANK catchments.

2 Methodology

Assessment was entirely a desktop exercise using ArcGIS (version 10.1). Aerial imagery (Kiwi Image Aerial 2010) was the primary information on which riparian condition was determined. Thus riparian conditions reported in this document is the description of what the 'condition' was as at year 2010.

TANK catchments are divided into hydrological sub-catchments using Hawke's Bay Water Management Catchments (HBRC featureclass) (Figure 2-1, Table 2-3). This data was overlaid with the River Environment Classification[1] data to extract streams and rivers within the catchments of interest.

[1] River Environment Classification (REC): polyline data of all the streams and rivers of New Zealand. Streams and rivers consist of a number of reaches represented by a unique ID. Visual assessment was done on each reach of a stream (2nd to 4th order) in this data.

A 30-m buffer was generated for each reach of the REC data and was overlaid with the aerial imagery. It is within this buffer area that vegetation types were assessed. It is acknowledge that buffer width required for different goals (e.g. nutrient attenuation). However this exercise follows the previous work done form the Tukituki (Hashiba, 2013) by using '30 m' to be an indicative riparian buffer boundary. Below is the summary of rationale for the boundary;

- According to a riparian study done by former Ministry for Agriculture and Environment (Parkyn, 2004), a buffer of 20 – 30 m wide is the most effective width for nitrate removal from land
- For the riparian indigenous vegetation to be sustainable, a buffer width of 20 m or more is needed (Parkyn et al., 2000; Parkyn, 2004).

Criteria for assessing the condition of riparian vegetation and the level of stock access were adopted from Sarrazin and Zimmermann (2003), and are summarised below. As this method was designed based on (then) Standard HBRC stream Habitat Assessment, it is deemed suitable to apply to streams in TANK (and any other catchments in the region).

Table 2-1: Riparian vegetation class (from Sarrazin & Zimmermann, 2003).

Riparian Vegetation Class	Characteristics
Excellent	Predominantly indigenous vegetation with dense groundcover which provides sufficient shading along the stream banks, is mainly intact and the riparian vegetation width is larger than 5 m.
Good	The riparian vegetation is dominated by exotic species. The completeness of the bank or the streamside vegetative buffer is generally reduced, although the lateral extent is still sufficient to provide benefits in terms of shading to the stream.
Fair	The riparian vegetation is full of gaps and does not provide sufficient shading or other benefits for the stream environment. Vegetation consists predominantly of exotic species and the width of the bankside vegetation is small.
Poor	The stream/river is nearly void of any trees and suffers from insufficient shading. Predominantly pasture grasses and weeds make up the vegetative cover along the waterway.

Table 2-2: Stock disturbance class (from Sarrazin & Zimmermann, 2003).

Stock Disturbance Class	Characteristics
Excellent	Stock has no access to the waterway and/or[2] no stock damage is visible.
Good	Stock has access to a small part of the stream and/or river and stock damage is low.
Fair	Stock has access to most of the stream and/or river and stock damage is evident.
Poor	Stock has access to the entire stream and/or river and stock damage presents a strong impairment.

[2] The original description of the characteristics do not define if it is 'and' or 'or' or 'and/or'. It is interpreted as 'and/or' for the current assessment

Riparian vegetation types were determined following the classification system of the Landcover Database (version 3) (a polygon data of land cover types of New Zealand). Where vegetation types are different on either side of the stream, both vegetation types were recorded.

The assessments were completed for 2nd to 4th order streams. There were too many 1st order streams in the region to assess. Fifth and larger order streams were excluded because most are braided rivers whose river beds are over 60 m wide, which is in excess of the total width of the buffer.

In some instances during analyses it was difficult to interpret aerial images. Assumptions were made in an attempt to resolve these difficulties. Assumptions are summarised in Appendix A. Where confidence level is low during the assessment, it is recorded as Ground truthing 'Required' in the attribute table.

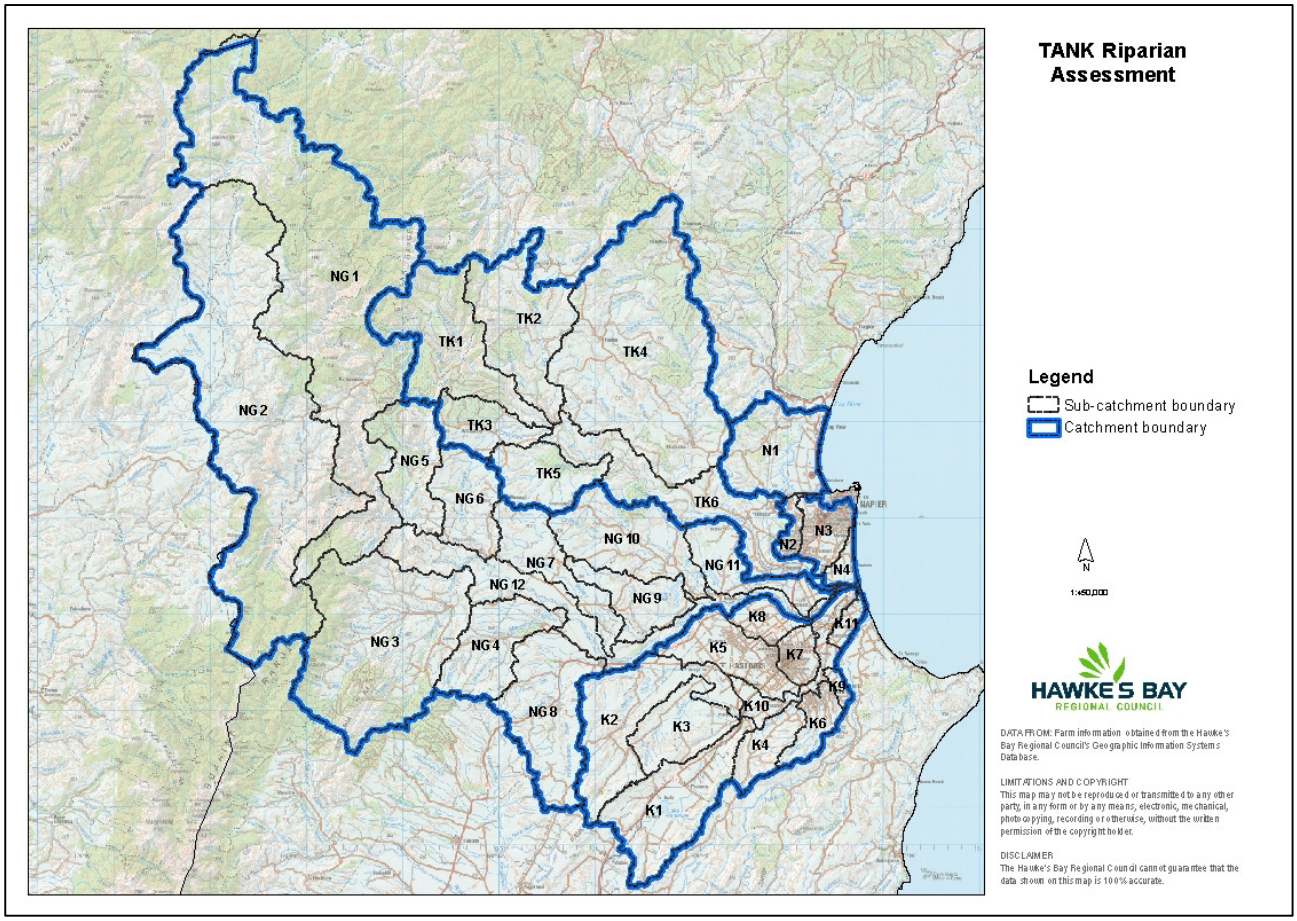

Figure 2-1: TANK catchment area overview. Tutaekuri, Ahuriri, Ngaruroro and Karamu catchments are divided into sub-catchments.

Table 2-3: Sub-catchment codes and names within TANK catchment area. Total stream length is a sum of second to forth order streams that were assessed in this study.

Catchment	Sub-Catchment Code	Sub-Catchment Name	Catchment Area (Hectares)	Total Stream Length Assessed (km)
Ahuriri	N1	Ahuriri Lagoon Tributaries	8,917	69
Ahuriri	N2	Taipo	1,260	12
Ahuriri	N3	Napier Drains	3,276	22
Ahuriri	N4	Napier South	1,110	5
Karamu	K1	Poukawa	11,044	78
Karamu	K2	Paritua-Karewarewa	12,005	72
Karamu	K3	Awanui	6,165	41
Karamu	K4	Louisa	3,483	25
Karamu	K5	Irongate-Southland	6,213	22
Karamu	K6	Havelock North Streams	2,742	25
Karamu	K7	Hastings Streams	2,106	15
Karamu	K8	Raupare	2,367	18
Karamu	K9	Mangateretere	597	5
Karamu	K10	Karamu-Clive Corridor	3,683	23
Karamu	K11	Muddy Creek	1,058	22
Ngaruroro	NG1	Upper Ngaruroro	52,601	302
Ngaruroro	NG2	Taruarau	49,545	341
Ngaruroro	NG3	Poporangi	25,680	203
Ngaruroro	NG4	Mangatahi	7,686	67
Ngaruroro	NG5	Omahaki	7,408	62
Ngaruroro	NG6	Otamauri	6,251	53
Ngaruroro	NG7	Kikowhero	6,569	60
Ngaruroro	NG8	Maraekakaho	12,241	86
Ngaruroro	NG9	Waitio	5,196	40

Catchment	Sub-Catchment Code	Sub-Catchment Name	Catchment Area (Hectares)	Total Stream Length Assessed (km)
Ngaruroro	NG10	Ohiwia	10,431	83
Ngaruroro	NG11	Tutaekuri-Waimate	5,468	45
Ngaruroro	NG12	Ngaruroro Corridor	12,171	33
Tutaekuri	TK1	Upper Tutaekuri	13,455	84
Tutaekuri	TK2	Mangatutu	12,103	91
Tutaekuri	TK3	Otakarara	4,713	43
Tutaekuri	TK4	Mangaone	33,903	232
Tutaekuri	TK5	Waikonini	5,846	51
Tutaekuri	TK6	Tutaekuri Corridor	13,086	56

3 Results

This section shows the results of the assessment on stock disturbance (Figure 3-1, Figure 3-2), riparian vegetation class (Figure 3-3, Figure 3-4), and riparian vegetation type (Figure 3-5, Figure 3-6 & Appendix B).

3.1 Ahuriri Catchment

Stock disturbance level was relatively low across all sub-catchments except N1.

Riparian vegetation class is low across the catchment, meaning vegetation is predominantly non-woody exotic and there is insufficient shading. Main vegetation types are exotic grassland in most of the sub-catchments, some of which form green space in the urban area. Riparian vegetation class is very poor in N 4 where many water courses are open drains.

3.2 Karamu Catchment

Stock disturbance level is high in the upper sub-catchments (K1, K2 and K3) while it is relatively low in lower sub-catchments (K7, K8, K9, K10 and K 11).

Riparian vegetation is mainly exotic dominant such as exotic grassland and cropland (including vineyard and orchard) which generally lacks the provision of shading to streams.

3.3 Ngaruroro Catchment

Level of stock disturbance is low in many of the upper sub-catchments (NG 1, NG 2, NG 3 and NG 5). Riparian vegetation class is excellent for majority of streams in these sub-catchments.

The other sub-catchments have fairly high level of stock access to the waterbodies, and riparian vegetation become less ideal for providing shading to the streams and more dominated by exotic species rather than indigenous species.

3.4 Tutaekuri Catchment

Like the Ngaruroro Catchment, headwater sub-catchments (TK1 and TK 2) of the Tutaekuri Catchment retain good riparian conditions, with low level of stock disturbance and good riparian vegetation. Riparian vegetation is predominantly indigenous forest, scrub and shrubland in these sub-catchments.

TK 3, TK 4 and TK 5 showed relatively low level of disturbance from stock access and reasonable riparian vegetation class mainly dominated by exotic forest.

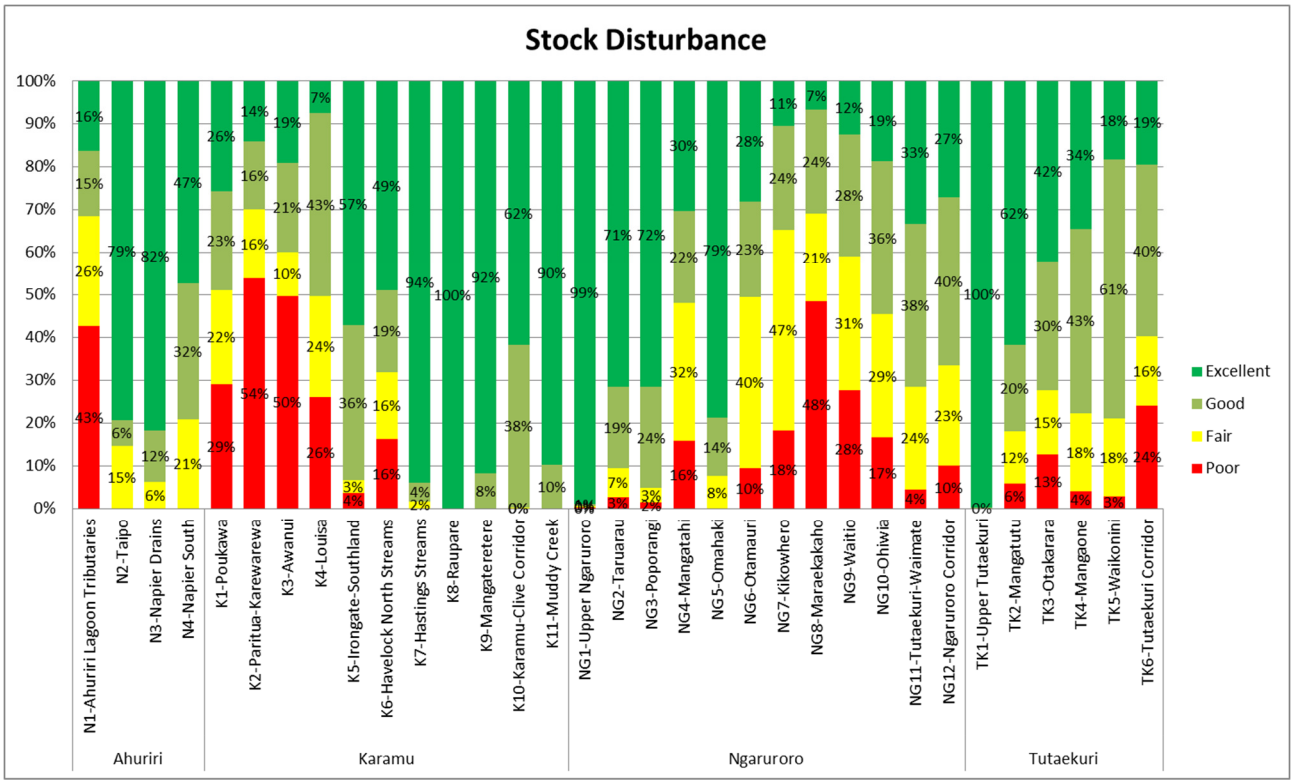

Figure 3-1: Summary of stock disturbance level. Figure shows stock disturbance level based on the level of stock access. 'Excellent' is where there is no stock access to the stream and/or no stock damage is present on stream banks, while 'Poor' is where stock has access to the entire reach and/or stock damage shows strong impairment. Percentage is calculated against the total length of the 2nd to 4th order streams within a sub-catchment.

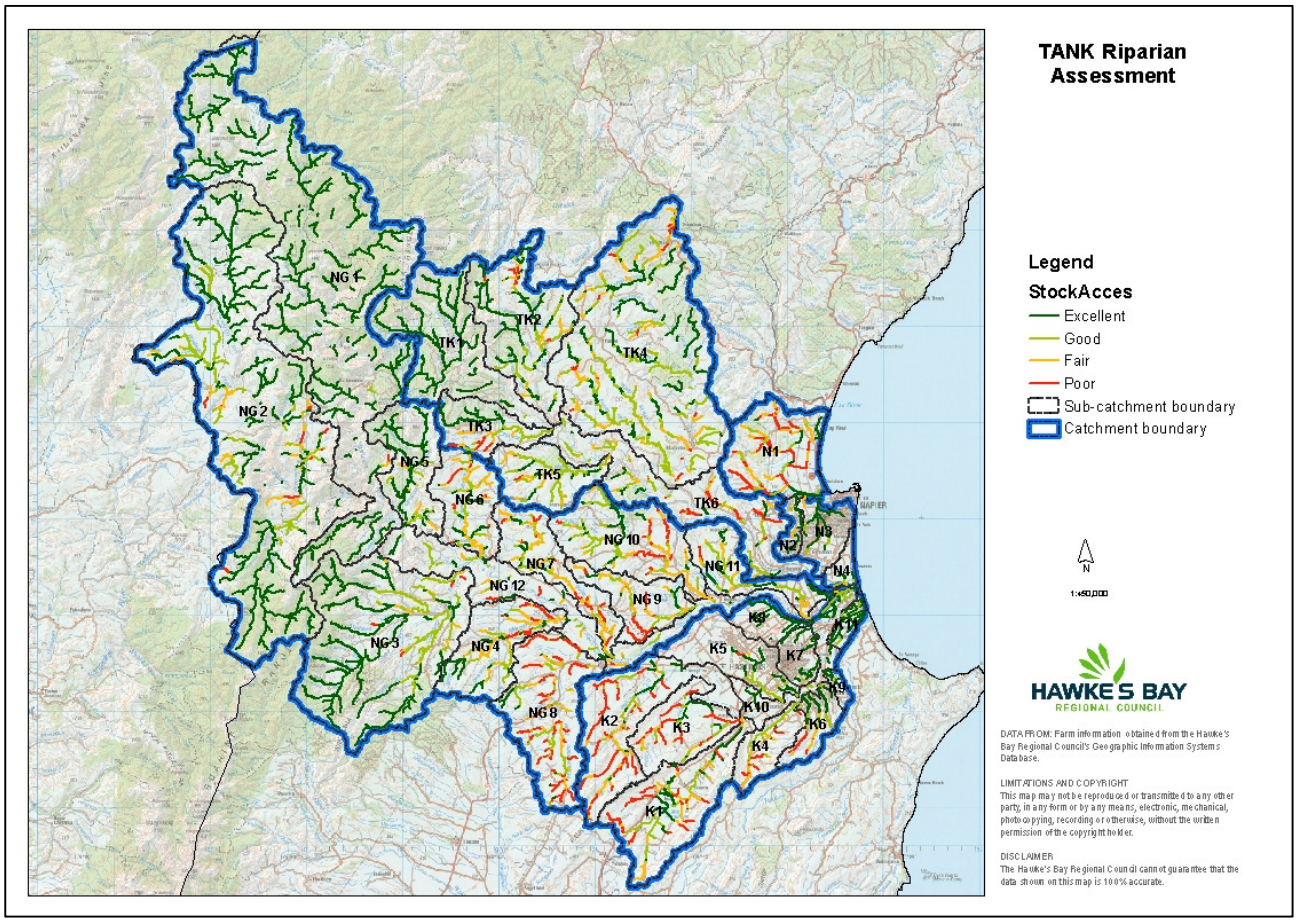

Figure 3-2: Spatial view of stock disturbance level. Map showing the level of stock access and associated damage to the riparian margin in four categories from Excellent (no stock disturbance) to Poor (high stock disturbance). Stock Access in the map legend is stock disturbance.

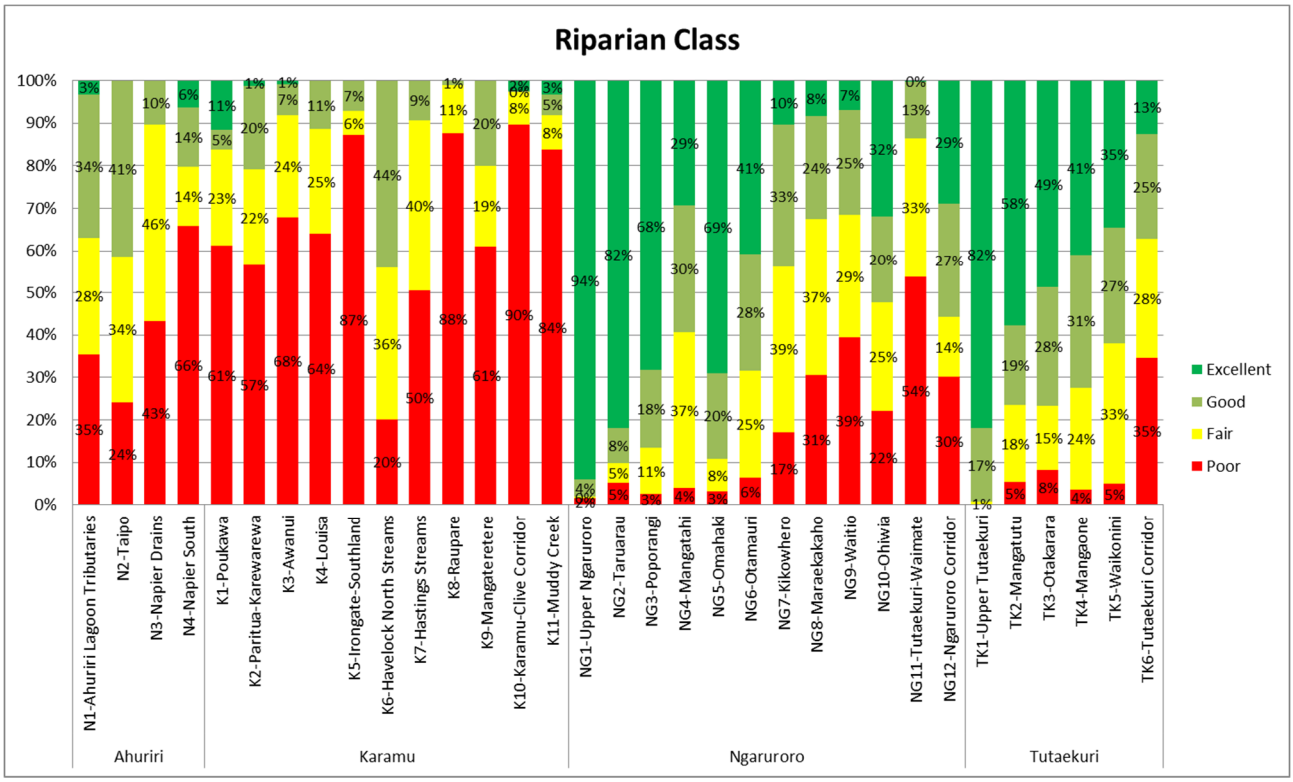

Figure 3-3: Summary of riparian vegetation class. Riparian vegetation class is based on the level of shading and native or exotic dominance. 'Excellent' is where riparian vegetation provides enough shading to the stream and vegetation is dominated by native species while 'Poor' is where riparian vegetation provides little shading to the stream and there is devoid of woody species. Percentage is calculated against the total length of the 2nd to 4th order streams within a sub-catchment.

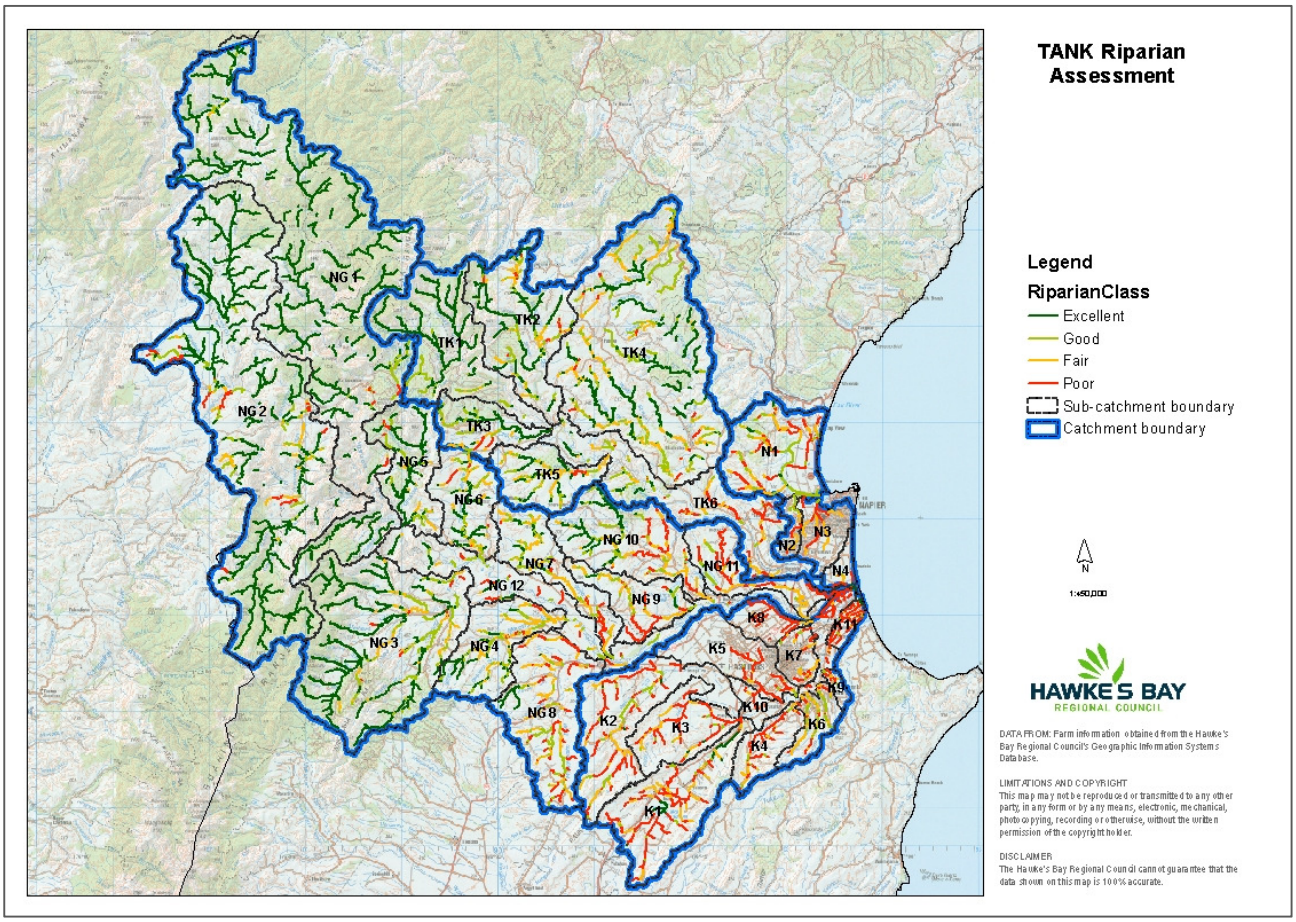

Figure 3-4: Spatial view of riparian vegetation class. Map showing riparian vegetation class based on the level of shading to a stream and vegetation composition, using four catagories from Excellent (plenty of shading and native vegetation) to Poor (little or no shading and no trees). 'RiparianClass' in the map legend is riparian vegetation class.

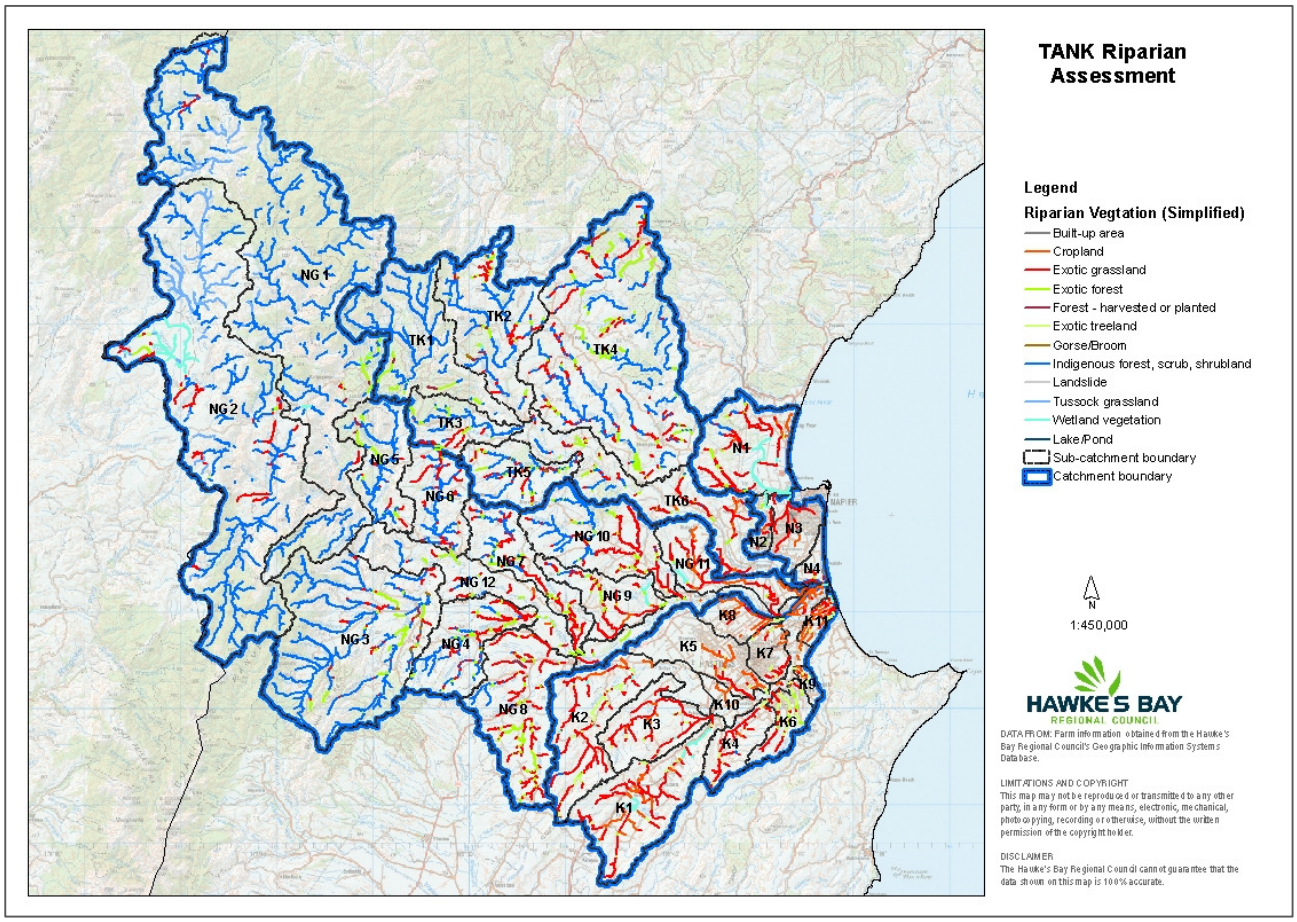

Figure 3-5: Riparian vegetation type. Classifications used are broadly following Land Cover Classes of Land Cover Database but some of the land cover classes are summarised into broader categories as follows: Cropland includes vineyard, orchard and other cropping operation; Indigenous forest, scrub and shrubland includes indigenous forest, broadleaved indigenous hardwoods, manuka/kanuka and grey scrub. Exotic tree land is an area that has canopy cover of about 20 – 80 % (Atkinson, 1985).

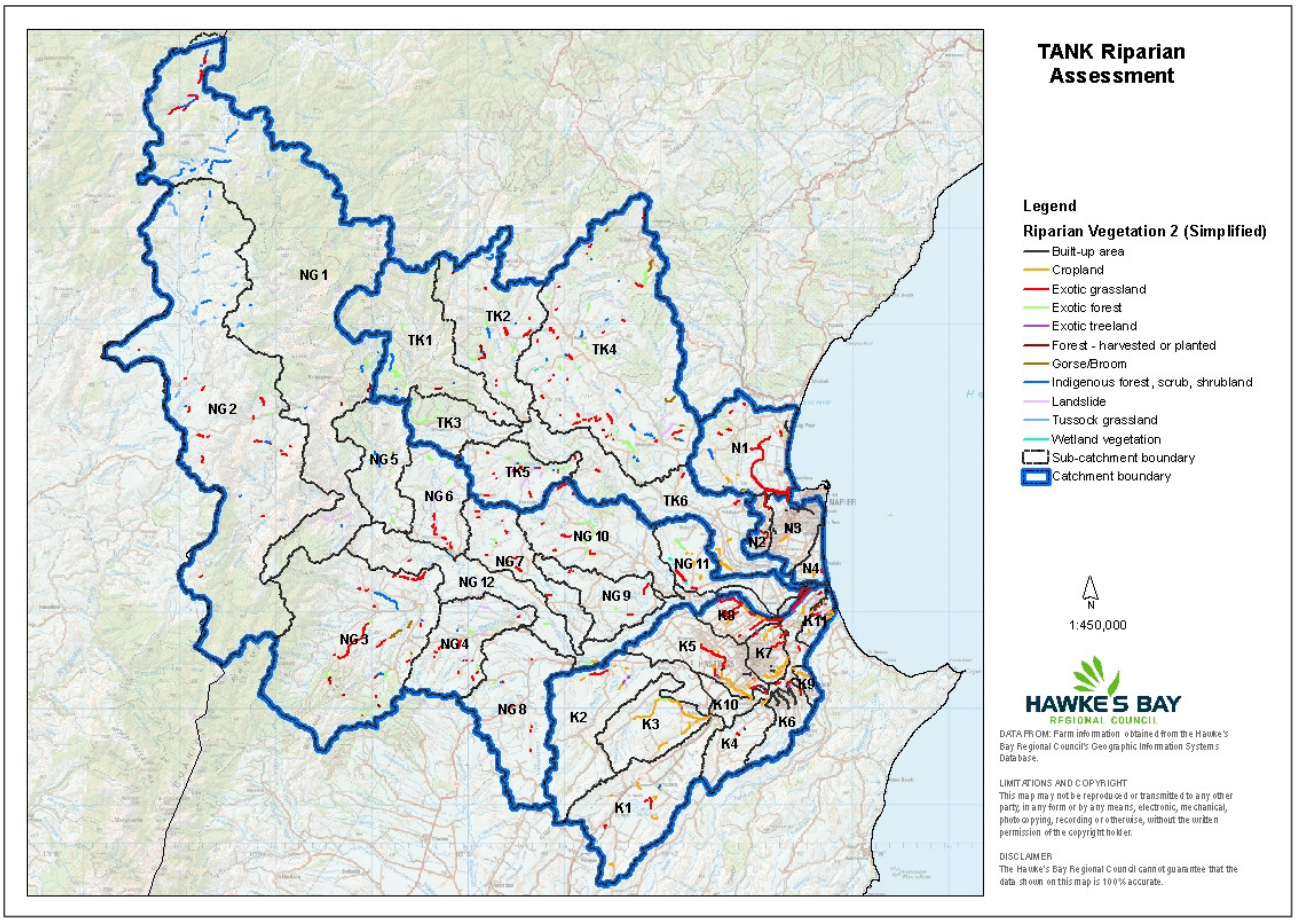

Figure 3-6: Riparian vegetation class where there is more than one dominant type. Map shows riparian vegetation types which co-dominates with other vegetation types shown in Figure 3-5. Light grey line is where there is no co-dominant vegetation type.

4 Discussion

4.1 Relationship between stock disturbance and riparian vegetation

Ngaruroro and Tutaekuri catchments present correlations between the stock disturbance and riparian vegetation class where stock disturbance level is low ('Excellent' or 'Good'), riparian vegetation is predominantly woody (indigenous or exotic) which provides sufficient shading (resulting in 'Excellent' or 'Good'). Such relationship between stock disturbance level and riparian vegetation is consistent with the result of Tukituki catchment riparian assessment (Hashiba, 2013).

Excellent riparian condition in headwaters of Ngaruroro and Tutaekuri catchments is explained by the steep terrain of these areas, which makes the area unsuitable for any development. Coincidentally, large parts of the steep country are formally protected (e.g. under the administration of DoC, Nga Whenua Rahui and QE II) and so stock have no access (see Figure 4-1).

On the other hand, the Ahuriri Catchment presents little correlation between the level of stock disturbance and riparian vegetation class. In Ahuriri, all of the sub-catchments except Ahuriri Lagoon Tributaries (N1) are dominated with residential and industrial development. While there is little or no disturbance from stock access, streams in these areas often lack riparian vegetation, or sometimes do not have any riparian setbacks from residential or industrial development.

Lower Karamu Catchment also has little correlation between stock disturbance and riparian vegetation class. Vineyards, orchards and other copping land concentrate in the lower Karamu (K7, K8, K9, K10 and K 11). Cropland is deemed to have little or no grazing, even though there are often grass strips between cropland and streams. However riparian vegetation on streams flowing through cropland typically lacks sufficient woody vegetation to provide shading.

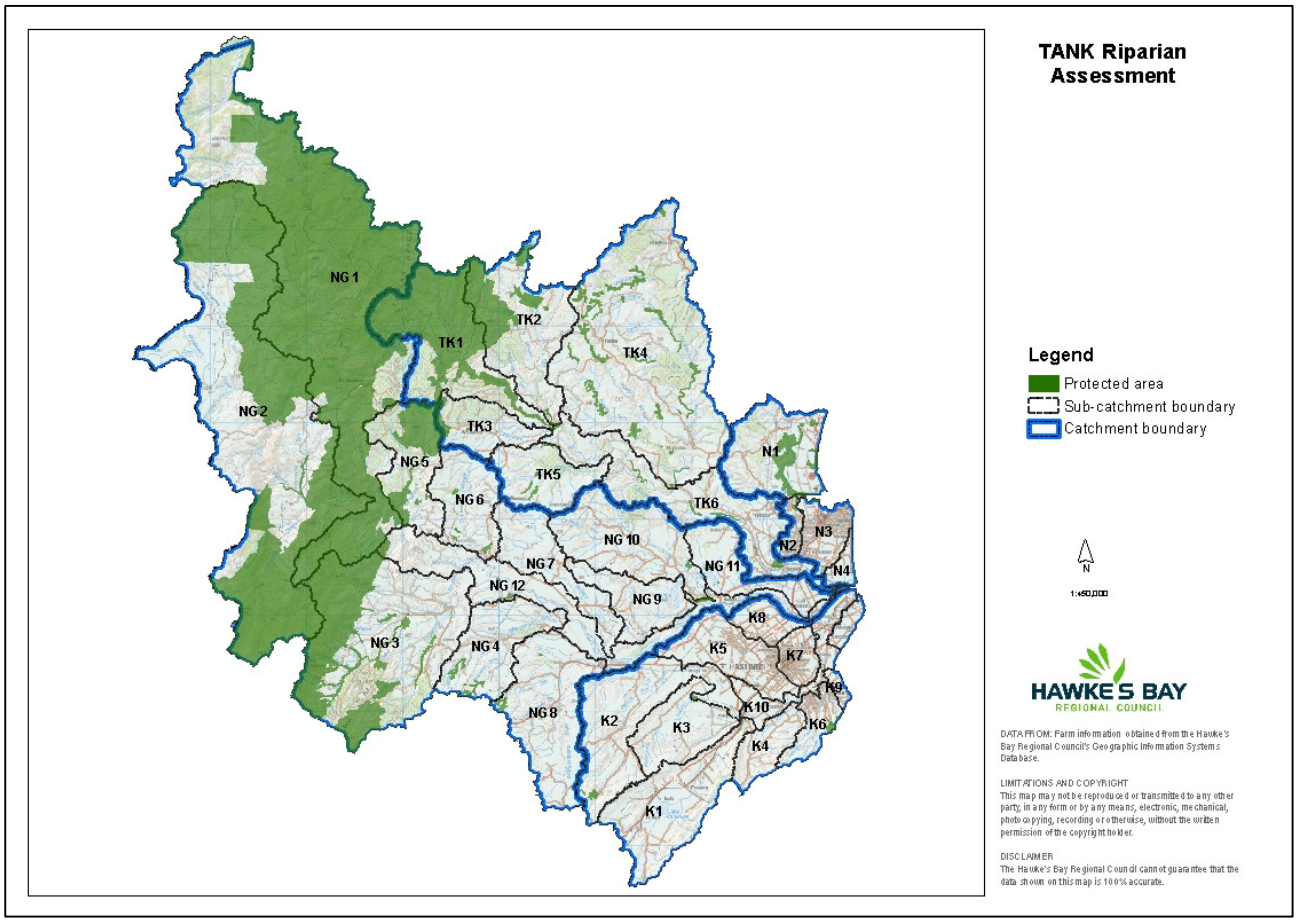

Figure 4-1: Protected area. Protected area includes public conservation area (managed by Department of Conservation), Nga Whenua Rahui kawenata area, and QEII covenanted area.

4.2 Limitations of methodologies

This desktop assessment methodology has its limitations. Table 4-1 summarises the level of ground truthing necessary. For example, 21 % of the total reach (km) assessed in sub-catchment N1 requires ground truthing. There are broadly four elements that trigger the necessity for ground truthing. These elements are explained in the following sections (4.2.1, 4.2.2, 4.2.3, and 4.2.4).

Table 4-1: Streams that requires ground truthing for riparian assessment. Percentage of modelled stream length within a sub-catchment that requires ground truthing for stock disturbance and/or riparian vegetation class assessment.

Catchment	Sub-Catchments	% of total length
Ahuriri	N1-Ahuriri Lagoon Tributaries	21%
	N2-Taipo	35%
	N3-Napier Drains	22%
	N4-Napier South	52%

Catchment	Sub-Catchments	% of total length
Karamu	K1-Poukawa	37%
	K2-Paritua-Karewarewa	25%
	K3-Awanui	49%
	K4-Louisa	49%
	K5-Irongate-Southland	40%
	K6-Havelock North Streams	3%
	K7-Hastings Streams	2%
	K8-Raupare	18%
	K10-Karamu-Clive Corridor	5%
	K11-Muddy Creek	8%
Ngaruroro	NG1-Upper Ngaruroro	7%
	NG2-Taruarau	30%
	NG3-Poporangi	19%
	NG4-Mangatahi	15%
	NG5-Omahaki	6%
	NG6-Otamauri	6%
	NG7-Kikowhero	9%
	NG8-Maraekakaho	8%
	NG9-Waitio	14%
	NG10-Ohiwia	19%
	NG11-Tutaekuri-Waimate	51%
	NG12-Ngaruroro Corridor	53%
Tutaekuri	TK1-Upper Tutaekuri	1%
	TK2-Mangatutu	18%
	TK3-Otakarara	16%
	TK4-Mangaone	28%
	TK5-Waikonini	27%
	TK6-Tutaekuri Corridor	27%

4.2.1 Limitation of assessment using aerial image

To conduct an assessment purely as a desktop exercise using aerial photography poses difficulties in determining whether stock has access to a stream, or determining if the dominant vegetation is native or exotic.

Fence lines are often discontinuous from one farm to the next and can be purely an indication of property boundaries and does not always serve as an indicator of stock exclusion. Fences can also be under the canopy of vegetation, and cannot seen in the aerial photographs. These issues can hinder accurate assessment of whether stock exclusion is present or not.

4.2.2 Limitations due to the complexity of land use practices

In a situation such as when one side of a stream is cropland (vineyard, orchard or other cropping) and the other side is a farm, particularly without fencing, it was difficult to assess if the stock has access and to what degree (see Appendix A for details of which approach was taken for various situations).

Cropping practices may include grazing at some point in their rotation, or cropping history (P. Manson, B. Powell, W. Hesketh, personal communication, 2013). Thus, it cannot be entirely assumed that stock is excluded from streams running through cropland.

Urban streams (e.g. in Ahuriri Catchments) showed little correlation between the stock access and riparian vegetation because the level of stock access and its disturbance is relatively low in such area. However riparian vegetation and sufficient shade are often lacking in urban streams.

These uncertainties and lack of correlation suggest that a different approach may be required for streams and rivers in the cropping and urban areas to get a better picture of riparian conditions. For example, an assessment of riparian on cropping streams may need to be more focused on riparian class rather than stock damage, given the largest impacts to such waterways may be cultivation of land (and use of heavy machines) right up to the waterways and subsequent nutrient and sediment inputs (personal communication, B. Powell, April 2014). However this study used the same criteria for cropland. Similar consideration may be necessary for urban streams where stock access level is minimum but vegetation and shading are often lacking, which leads to poor riparian condition. The current assessment method does not address such issues associated with urban streams.

4.2.3 Confusion caused by a 30m buffer

There was a confusion caused by having a 30 m buffer and applying the Sarrazin-Zimmermann (S-Z) criteria, particularly the one for Riparian Vegetation Class (Table 2-1). It is mainly due to the fact that a 30m buffer is set up from nutrient mitigation perspective, whereas the S-Z criterion is mainly looking at shading function of riparian vegetation.

A 30-m buffer is set given that 30-m or wider buffer would be sufficient for eliminating most of the nutrients and sediment input from the land use. Riparian vegetation type was recorded for a dominant vegetation type within the buffer.

The S-Z criteria for riparian vegetation class is developed based on indigenous or exotic dominance and the level of shading that vegetation provides to a stream (Table 2-1). For instance, if the riparian vegetation is predominantly indigenous forest providing sufficient shading, it is 'Excellent' but if it is exotic forest providing plenty of shading, the criteria 'Good' applied.

Shading can be provided from a single line of trees along a stream (Parkyn, 2004). In this case the vegetation width can be as narrow as 5 m while the rest is dominated by exotic grass. If shading was the only aspect to evaluate, Riparian Vegetation Class for a single-lined trees can be 'Excellent' (as there is enough shading). However, to evaluate the native-exotic dominance within a 30-m buffer, Riparian Vegetation Class is 'Good' or worse as it is dominated by pasture grass.

Therefore, having 30-m buffer and using the S-Z criteria can, on occasion, produce inaccurate assessments of Riparian Vegetation Class.

4.2.4 Limitations of the Sarrazin-Zimmermann criteria

The S-Z criterion for Riparian vegetation class looks at one aspect of riparian vegetation, i.e. shading. The S-Z criterion for riparian vegetation class assumes that '> 5 m' which is deemed to provide sufficient shading to a stream (Table 2-1).

Parkyn (2004) and Parkyn et al. (2000) has done literature reviews on functions of different riparian width. Below are key points from these reviews;

- > 45 m buffer may be needed to maintain the microclimate of riparian/stream zone
- > 30 m buffer is needed to maintain or protect in-stream biodiversity or existing aquatic functions from disturbance from land use.
- > 10 m buffer is needed to maintain the in-stream temperature
- > 5 m is needed to minimize the air temperature rise along the stream.

Width of riparian vegetation is an important factor for sustainability of the riparian vegetation (Parkyn et al., 2000). For example, riparian plantings wider than 15 m is likely to be self-sustaining while 5 m planting is likely require on-going maintenance such as weed control.

Therefore, having a single specification of '5 m or more' may lead to inadequacy of assessing condition of riparian vegetation.

5 Conclusion

This assessment has provided baseline information and an overview of riparian conditions across the four catchments that comprise the TANK area. It has identified areas with relatively poor riparian conditions associated with stock access and/or lack of good riparian vegetation.

This project found that the Karamu and Ahuriri catchments are characterised with the presence of major urban areas. Karamu also contains large area of horticultural land. In these two catchments the riparian areas showed very low levels of disturbance from stock access but relatively poor vegetation class. This can be compared with pastoral streams further inland where poor riparian conditions are often associated with stock access rather than poor riparian vegetation class. This may indicate that different management approaches are necessary to address water quality and sedimentation issues with regard to the lowland streams as opposed to the streams further inland.

The information provided in this report can also assist other sections of the council such as Land Management with prioritizing areas where increased investment through the Regional Landcare Scheme (RLS) would have most benefit. The policy and planning section of the council may also benefit from the information presented in this report when considering new plan changes or updating existing regional plans.

The information presented in this report not only directly helps councils decision making but it will form an integral part of the sediment production and transportation model (SedNetNZ) that predicts sediment loss and movement at a farm scale.

Some limitations with this methodology were experienced, particularly in relation to the complexity of land use practices that are not easy to interpret from aerial imagery or other databases. To increase reliability ground truthing will be required for some identified areas. There are also some limitations in the criteria

used to account for riparian vegetation width in relation to the in-stream habitat conditions and consequently biodiversity values. For example, the criteria adopts '5 m width' as a minimum to provide 'sufficient shade' to the stream, despite the 5 m is unlikely to have an effect on instream temperature.

The methodology outlined in this document is relatively cost-effective in acquiring baseline data for large areas and wide range of land uses. For a more detailed evaluation of our riparian zones it is anticipated that much more ground work will be involved.

Auckland Council and Waikato Regional Council have carried out riparian surveys of their regions using different methodologies to the one presented here and that may be an approach HBRC will consider in the future. Their methodologies are presented in Appendix C of this report.

6 References

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Appendix A Assumptions made during the assessment

Overall assumptions

These assumptions (except the last bullet point) are derived from a previous study carried out for the Tukituki Catchment (Hashiba, 2013).

- Where terrain is steep and may be unsuitable for grazing, with good or light vegetation, it was assumed that stock access to the streams was relatively lower risk.
- Where the river forms a gorge and/or large landslide exists, it was assumed that there was less risk of stock to get access to the stream.
- It was assumed that smaller streams were more susceptible to stock access/disturbance.
- 'Stock damage' and 'strong impairment' included soil erosion and visible changes in colour of waterways due to erosion and nitrification.
- Where river becomes braided and the 30 m riparian zone buffer was primarily river gravels, riparian condition was assessed outside of this buffer.
- Areas of forestry were deemed to have minimum level of stock access.
- For vegetation type assessment, 'Manuka/Kanuka' was recorded where applicable. In the current assessment, 'Manuka/Kanuka' can be forest, scrub or shrubland In the Land Cover Database V3 'Manuka/Kanuka' is classed as shrubland. However both species (particularly kanuka) can form forest.

Assumptions made for the current assessment

These situations emerged during the current assessment. These scenarios were not considered in the previous study for Tukituki Catchment as it was the first assessment. This time, the author's thinking on method has evolved and lead to the need to document decision making process in relation to limitations of method. Decisions were made to resolve the difficulties, which were explained in the 'Approach taken' column. However these approaches may change in the future assessment of riparian conditions.

Situation	Approach taken
A stream (or 'drain') flows through cropland or orchards, no fence along the riparian zone, and devoid of any vegetation	Stock access – Excellent or Good Note that: damage can be from cultivation (tractor mark etc); Cropland can become grazing area over winter or over some years. Riparian vegetation class - Poor Riparian Vegetation – Bare land, crop, exotic grassland etc.
One side of a stream is cropland and other side is a pasture, no fence visible, damage very light	Stock access – Good Riparian vegetation class – Poor Riparian vegetation – exotic grassland
Where streams form part of the estuaries or FW wetlands	Riparian vegetation class – Excellent if it is wetland vegetation dominated by indigenous species (pers. comm. Haidekker)
Headwater streams Riparian vegetation is dominated by manuka/kanuka scrub, or other open vegetation, secondary vegetation caused by (presumably) natural process (such as natural fire).	Riparian vegetation class – Excellent as it is dominated by indigenous. Scoring range can be lower than indigenous forest for example (pers. comm. Haidekker). Vegetation type is also assessed under the column, hence analyses based on difference in vegetation types are also possible (e.g. indigenous forest as opposed to manuka/kanuka being secondary forest)
Headwater streams - Where river becomes braided and 30 m buffer is often dominated with river gravels (e.g. Ngaruroro headwater catchments)	Riparian vegetation class is assessed immediately outside of the braided riverbeds.
Headwater streams - Where both sides are grasslands Where grassland is dominant but also manuka/kanuka is major	Riparian vegetation class = Fair if no shade Riparian vegetation class = Good
Exotic forest and riparian condition	Trees are present Good – for mature stand Fair – for young stand, open canopy Harvested stand, and possibly new planting (cannot see in the aerial photos) Poor or Fair – for depending on the erosion situation

One side of stream is indigenous vegetation, other side is exotic vegetation  	Riparian condition = Good As 'Excellent' is native dominance, not co-dominance with exotic species. Both vegetation types are recorded in the attribute table.
(a) Immediate riparian is predominantly exotic grassland. Indigenous vegetation remains beyond the grass strip.  (b) 	(a) Stock access – Fair (because bulls were observed in proximity to this stretch, and assumed stock can access this part of the river) Riparian condition – Good? (because 30-m buffer is native scrub) or Fair? (vegetation immediately next to the water is exotic grass or landslide, and scrub is too far to provide 'sufficient shading') It was assessed as 'Good' (with Groundtruth 'Required') (Feb 2014) (b) Pers comm. S. Heidekker (April 2014) – unless tree canopy extends over (or fairly close to) waterways, there is not much shading, particularly when streams run West – East. Therefore, situation like photo (b), riparian condition is 'Fair' despite being dominated by manuka/kanuka.

Thin vegetation providing presumably sufficient shade Shelter belt  	Riparian vegetation class = Good Riparian vegetation = Exotic grassland Riparian Vege2 = Exotic forest (though it is not 'equally dominant')
Manuka/Kanuka  	Riparian vegetation class =Good, even though exotic grassland is dominant

Appendix B Riparian vegetation types

Table B-1: Summary of riparian vegetation types. The table summarises the data from Figure 3-5, showing a proportion of a sum of lengths of all streams (2 - 4th order) in a sub-catchment. Cropland includes vineyard, orchard and other cropping. Indigenous forest, scrub and shrubland includes indigenous forest, broadleaved indigenous hardwoods, manuka/kanuka and grey scrub. For example, 7 % of the streams in Ahuriri Lagoon Tributaries (N1) have cropland within riparian zone.

Catchment	Sub Catchments	Built-up area	Cropland	Exotic grassland	Exotic forest	Exotic treeland	Forest - harvested or planted	Gorse/Broom	Indigenous forest, scrub, shrubland	Tussock grassland	Wetland vegetation	Landslide	Lake/Pond	Grand Total
Ahuriri	N1-Ahuriri Lagoon Tributaries	1.0%	7.0%	57.5%	6.6%				6.2%		21.6%			100.0%
	N2-Taipo	18.8%	9.1%	30.7%	8.9%						32.6%			100.0%
	N3-Napier Drains	9.1%	6.7%	72.7%	1.2%						10.4%			100.0%
	N4-Napier South	15.4%		72.6%	5.7%						6.3%			100.0%
Karamu	K1-Poukawa		22.5%	60.7%	0.3%	4.8%					11.7%			100.0%
	K2-Paritua-Karewarewa		11.0%	67.4%	1.1%	17.1%			1.3%		2.2%			100.0%
	K3-Awanui		8.9%	84.3%	0.6%	5.3%					0.9%			100.0%
	K4-Louisa		4.4%	80.4%		12.4%			2.8%					100.0%
	K5-Irongate-Southland		55.3%	37.0%		7.8%								100.0%
	K6-Havelock North Streams	1.1%		44.6%	15.3%	38.9%								100.0%
	K7-Hastings Streams	5.0%	31.9%	49.4%		13.7%								100.0%
	K8-Raupare		73.9%	18.5%		7.6%								100.0%
	K9-Mangateretere		48.0%	13.0%	5.8%	33.2%								100.0%
	K10-Karamu-Clive Corridor		85.6%	10.6%		1.3%					2.5%			100.0%
	K11-Muddy Creek		59.6%	26.0%		11.2%					3.2%			100.0%

Catchment	Sub Catchments	Built-up area	Cropland	Exotic grassland	Exotic forest	Exotic treeland	Forest - harvested or planted	Gorse/Broom	Indigenous forest, scrub, shrubland	Tussock grassland	Wetland vegetation	Landslide	Lake/Pond	Grand Total
Ngaruroro	NG1-Upper Ngaruroro			2.4%	2.5%		0.4%		82.9%	10.9%	0.7%	0.1%		100.0%
	NG2-Taruarau			9.6%	1.2%	0.4%			60.8%	20.5%	7.4%			100.0%
	NG3-Poporangi			6.7%	9.5%		1.3%	2.1%	80.3%			0.1%		100.0%
	NG4-Mangatahi			39.7%	17.2%		1.0%	0.4%	41.7%					100.0%
	NG5-Omahaki			7.7%	13.5%		3.2%		75.6%					100.0%
	NG6-Otamauri			31.2%	7.0%	0.2%			61.4%			0.2%		100.0%
	NG7-Kikowhero			54.6%	17.8%		0.1%	0.5%	27.1%					100.0%
	NG8-Maraekakaho		0.4%	65.0%	23.3%		1.9%	0.1%	9.3%					100.0%
	NG9-Waitio		6.5%	61.9%	17.4%				7.0%		7.2%			100.0%
	NG10-Ohiwia			47.3%	10.0%		0.4%		42.4%					100.0%
	NG11-Tutaekuri-Waimate	0.6%	32.3%	58.5%	3.3%						5.2%			100.0%
	NG12-Ngaruroro Corridor		5.3%	35.8%	23.8%			0.9%	32.8%			1.4%		100.0%
Tutaekuri	TK1-Upper Tutaekuri				11.4%		2.2%		86.4%					100.0%
	TK2-Mangatutu			18.6%	8.7%		3.2%	1.2%	67.7%		0.7%			100.0%
	TK3-Otakarara			21.0%	14.1%		2.7%		62.1%					100.0%
	TK4-Mangaone			24.5%	18.7%		0.5%	0.5%	55.5%			0.3%	0.1%	100.0%
	TK5-Waikonini			21.6%	16.2%		4.4%	0.7%	57.1%					100.0%
	TK6-Tutaekuri Corridor		9.8%	52.8%	16.8%		2.3%		18.3%					100.0%

Appendix C Review of riparian survey methods used by Auckland and Waikato Councils

Waikato Regional Council (formerly Environment Waikato) designed the riparian survey method to quantify the level of protection (fencing, vegetation) and the state of vegetation and erosion in the riparian margins of pastoral streams (Hill and Kelly, 2002). The survey was conducted in 2002 and 2007, and a characterisation report was published in 2010 (Storey, 2010) to summarise the data and to review the methodology.

Auckland Council (formerly Auckland Regional Council) initially examined the applicability of the Waikato method and followed the overall approach (i.e. field survey rather than remote survey). Table C-1 summarises the methodologies taken by Waikato and Auckland councils.

Some of the Waikato's parameters measured in the field, particularly the site character, were not used for the following analyses. However they can be useful information for other studies such as State of the Environment monitoring (Storey, 2010). Auckland has measured fewer parameters though the presentation of the data is similar to Waikato's report.

Both Waikato and Auckland councils have examined the option of remote survey using aerial and satellite image, but concluded that the method was limited in delivering accurate records of riparian characteristics. Instead of conducting a census collection, they deployed statistics to sample subset of the region's riparian margins which would represent the overall riparian margins. It is a sensible approach under the limited resources.

Another similarity of their approaches is that their survey is designed only for pastoral streams. This reduces the initial sampling population size dramatically, compared to the TANK riparian assessment where all land use (cover) types were assessed. It may also resolve one of the issues arisen from TANK riparian assessment, which was the difficulty in applying the criteria to non-pastoral streams. The criteria used in the TANK riparian assessment cannot accommodate the potential impact from non-pastoral land use such as cropland and orchard.

Both survey methods have their advantages, and can be an effective way to survey riparian conditions in Hawke's Bay. Further investigations may be necessary.

Table C-1: Summary of riparian survey methods developed by Waikato Regional Council and Auckland Council.

	Waikato Regional Council (Hill and Kelly, 2002; Storey, 2010)	**Auckland Council (Neale et al., 2009)**
Purpose of the survey	State of riparian protection and stream response on pastoral land use (dairy and drystock)	Benchmark the current status of livestock access to pastoral streams (dairy, drystock, rural residential), providing information on the extent of the problem and a baseline against which to measure any change
Sampling design	Stratified random sampling Strata: Catchment boundary, LUC group (1-4, 5-8), Stream order (Strahler) Statistical power to detect a 30 % change from a mean over a 10 year period.	Statistical power similar to Waikato
Number of sites	380 sites in 2002 310 sites in 2007	60 sites in each land use (dairy, drystock, rural residential, 180 sites in total)
Sampling unit	1000 m on each opposite bank	500m on each opposite bank
Parameters (measured in field)	Fencing (type, number of cross wires, temporary or permanent, effectiveness) Vegetation (native/exotic/mix/grass, structure, dominant species, height, width) Erosion (type, position, stability, protection Accessway (type, length, location) Obstruction (type, length, location) Site character (weather, land use, channel width, channel type, valley width, channel shape, stream bed type)	Fencing (presence or absence, effective or ineffective, permanent/temporary) Vegetation (dominant vegetation type, height, width[3]) Erosion (none/inactive/active)
Cost	Unknown (not provided)	Unknown (not provided)
Suggested improvements to the methodology	From Storey (2010) Increase sample size to detect changes in subset of data[4]. Equalise sample size between water management zones. Add parameters (estimate of stock access, ground cover vegetation, level of shading).	

[3]Four vegetation types are created, pastureland, wetland, native woodland and exotic woodland. Each vegetation type has their default height or height range (e.g. 1-3 m, 3-10 m or >10 m).

[4] Example: include data from Dairy Clean Stream Accord – qualifying sites.