Northland Stream Habitat Assessments 2007 and comparison with 2004 and 2005

February 2008
Northland Regional Council
Private Bag 9021
Whangarei 0140
www.nrc.govt.nz

Executive summary

This report presents the results from the habitat assessments carried out in February and March 2007 at 22 State of Environment (SOE) sites and six rivers both upstream and downstream of different resource consent activities throughout Northland. The habitat assessment included quantifying the stream habitat, assessing stream health (habitat quality) and channel and stream stability.

Two of the 22 SOE sites had high habitat quality assessment scores that indicate optimal habitat for aquatic biota; Waipapa River at Forest Ranger and Waipoua River at SH12 rest area, while 11 had scores indicating suboptimal habitat and the remaining nine had scores indicating marginal habitat. No SOE sites had scores indicating poor habitat quality for aquatic life.

Five of the 12 resource consent sites had scores indicative of optimal habitat for aquatic biota, while four had scores indicating suboptimal habitat and the remaining three had scores indicating marginal habitat. Again none of the resource consent sites had scores indicating poor habitat.

This report also compared the results from the 2007 habitat assessments to those carried out in 2004 and 2005 at the same sites. Fifteen of the 19 SOE sites showed fairly stable habitat quality assessment scores over the last four years. Scores indicate that stream habitat quality has improved at four sites. There has been little change over the past four years in the habitat quality at the 12 resource consent sites.

This report also presents the results from the 2007 periphyton sampling. Chlorophyll a (periphyton biomass) varied greatly between the 18 RWQMN sites sampled.

The results of the 2007 macroinvertebrate monitoring are presented in a separate report (Pohe and Hall 2007), which is available on the Regional Council website at the following link:

http://www.nrc.govt.nz/Resource-Library-Summary/Research-and-reports/Rivers-and-streams/

Stream habitat assessments will continue to be carried out every second year at the State of Environment (RWQMN sites) and resource consent (upstream and downstream) sites. Annual monitoring of periphyton (selected sites) and macroinvertebrates will continue along with the monthly water quality sampling at all State of the Environment sites (i.e. RWQMN sites).

Contents

Cover photo: The relatively pristine upstream site of Dam A, with good diversity and abundance of quality habitat for fish and macroinvertebrates.

1 Introduction

This report has been prepared as a continuation of the Northland Regional Council's Freshwater Environmental Monitoring Programme. It provides the 2007 monitoring results of the habitat assessments carried out at 22 State of the Environment (SOE) Monitoring sites and six resource consent sites (both upstream and downstream) throughout the Northland region.

This report also compares the 2007 results with similar surveys carried out at the same sites in 2004 and 2005.

1.1 Sampling sites

1.1.1 State of the Environment sites

There are 22 State of Environment sites scattered throughout Northland, as shown in table 1 (below). These sites represent a range of geologies, river orders and land uses such as the example sites shown in the photographs below.

Table 1: State of the Environment sites with their site numbers and grid references.

Site name	NRC site number	Grid reference NZMS 260
Victoria- Awanui River system		
Awanui - d/s Kaitaia sewage discharge	100370	O04:660-756
Awanui - FNDC take by SH1	100363	O04:353-761
Victoria - Thompsons Bridge	105532	O04:480-727
Waipapa River		
Waipapa - Forest Ranger	101752	P05:730-581
Waitangi River		
Waitangi - Whakataha Road	103178	P05:928-557
Waitangi - Waklins/Watea	101752	P05:061-577
Waipoua River		
Waipoua - SH12 rest area	103304	O06:624-164
Wairua-Mangakahia River system		
Whakapara - Cableway	102249	Q06:260-279
Mangaharuru - Apotu Road Bridge	100281	Q06:248-196
Mangaharuru end of Main Road	100237	Q06: 296-170
Waiotu - SH1 Bridge	102248	Q06:222-291
Wairua - Purua	101753	Q06:150-158
Mangere - Knight Road Bridge	101625	Q06:143-108
Mangakahia - Titoki Bridge	101038	P07:058-069
Kaihu - Gorge	102256	P07:726-042
Opouteke - Suspension Bridge	102258	P06:891-113
Mangakahia - Gorge	103307	P06:873-194
Kaeo River		
Kaeo river - Dip Road	102674	P04:812-778
Ruakaka River		
Ruakaka - Flyger bridge	105008	Q07:373-914
Punakitere River		
Punakitere - Taheke Recorder	105231	P06:707-377
Waiarohia Stream		
Lovers Lane	108359	Q07:298-076
Whau Valley Road Bridge	107773	Q07:284-105

1.1.2 Resource Consent sites

There were six resource consent activities throughout Northland monitored in 2007, as shown in table 2 (below). Each resource consent activity has two sites monitored, one upstream and one downstream of the consent discharge or water take.

Table 2: Resource consent activities with their upstream and downstream sites and District.

Consent type	NRC site number (upstream - downstream)	District
Dam and water take A	106114 - 105937	Whangarei
Dam and water take C	106509 - 106508	Far North
Oxidation pond discharge A	100279 - 101280	Whangarei
Oxidation pond discharge B	103316 - 103317	Far North
Meatworks discharge	100007 - 100010	Far North
Quarry discharge	103823 - 103824	Far North

An example of the large variation in stream habitat between all the sites sampled is shown in the photographs below.

Photographs above are of hard bottomed sites including a headwater stream with excellent channel shading (left) and the Kaihu River, with good riparian vegetation and riffle habitat but little shading (right).

Photographs above are of soft bottomed sites including a weed and algal dominated stream in intensive pastoral catchment (left) and the turbid slow flowing Manganui River (right).

2 Methods

2.1 Habitat assessment

Comprehensive habitat assessments were carried out at all sites. This included both qualitative and quantitative assessment of factors such as stream stability, periphyton, riparian vegetation and the composition of organic and inorganic substrate.

General habitat information was recorded, including predominant surrounding land use, presence of litter, evidence of livestock access, percentage of shading, percentage of filamentous algae cover and the presence of macrophytes (aquatic plants) as either none, rare, common, or abundant.

2.1.1 Physiochemical Measurements

Several physiochemical measurements were collected at the time of macroinvertebrate sampling using a YSI meter, including water temperature (^{o}C), dissolved oxygen (mg/l), dissolved oxygen % (% sat), and conductivity (uS). Water clarity (m) was measured using the black disc method.

2.1.2 Streambed and channel stability

Stability of the streambed and channel at each site was assessed using the Pfankuch stability index (Pfankuch, 1975), which involves assigning scores to 15 environmental variables (scored according to their perceived importance) within predetermined criteria for the upper bank, lower bank and stream bottom. The scores are summed and can range from 38 to 152 where a lower total score indicates a more stable stream channel.

2.1.3 Stream habitat quality

The qualitative habitat assessment involved assigning scores to the following stream characteristics: aquatic habitat abundance, aquatic habitat diversity, hydrologic heterogeneity, channel alteration, bank stability, channel shade, and riparian vegetation integrity. Scores for each characteristic ranged from 0 to 20, with 0 to 5 indicating poor habitat quality for that characteristic, 6 – 10 indicating marginal, 11 – 15 suboptimal and 16 – 20 indicating optimal habitat quality. Therefore the highest possible score is 140.

2.1.4 Streambed type (substrate)

The habitat was quantified by recording habitat characteristics at 11 roughly equidistant locations along the sample reach, including riparian canopy cover and understorey vegetation (both 0-5 m and 5-20 m from the stream); bank type (earth, rock, mixed, or manmade) and bank stability (stable or unstable) on both banks; wetted width; maximum depth; flow type (run, riffle, pool, chute/waterfall); organic substrate (detritus, bryophytes, macrophytes, algae, algae, woody debris, tree roots or none); and inorganic substrate (bed rock, boulder, cobble, gravel, silt/sand/soft clay, hard packed clay, and manmade). For the organic and inorganic substrate, five observations were made across the width of the stream at roughly equal intervals at each of the 11 locations, with the most dominant substrate type recorded.

These were then calculated into average stream depth and width and relative proportions of the different riparian vegetation, bank type, stability, flow type and substrate type classes over the stream reach for each site.

2.2 Periphyton sampling

Periphyton was carried out at RWQMN (SOE) sites where there was suitable stone substrate to sample. The periphyton was scraped of four randomly chosen stones at each site from a known area of 4 cm^2 and stored in four separate containers, following the quantitative method 1b (pg 48) from Biggs and Kilroy (2000). These were sent to Hills Laboratories for chlorophyll α analysis, using the method from page 77 of the periphyton monitoring manual (Biggs and Kilroy 2000).

Another periphyton sample was collected at each site, which was made up of four subsamples (one from each of the four stones). These were sent to the algal services laboratory at the National Institute of Water and Atmospheric Research for identification. These samples were examined and assigned relative abundances based on the methods on page 97 of the periphyton monitoring manual (Biggs and Kilroy 2000).

2.3 Data analysis

The data from the habitat quality and quantity assessments was entered into Microsoft Excel™. This allows comparison of the substrate, vegetation, stability, and over all habitat quality across all sites, particularly important when comparing upstream and downstream of a resource consent activity. Comparisons were also made between the 2004, 2005 and 2007 data for each site, where available.

The average Chlorophyll α was calculated for the four samples and standard deviation was calculated to show the amount of variation between the four samples for each site.

2.4 Sampling period

All habitat assessments were carried out in February and March 2007, when streams are likely to be under the most stress due to low flows and summer temperatures. This sampling time is consistent with 2004 and 2005.

3 Results for the SOE sites

3.1 SOE site results for 2007

The habitat type varied considerably between sites such as river size, land use, substrate type and size, riparian vegetation and stability (Appendix A). For example, river width varied from 1.5 to 25 metres. Most sites are situated in moderately to highly modified landscapes including pastoral, forestry and urban land uses, except for Waipapa at Forest Ranger and Waipoua at SH12 rest area, which are situated in near-pristine native forest parks.

3.1.1 Physico-chemical characteristics

Temperature and dissolved oxygen measurements taken during sampling were within a safe range for aquatic life at all of the sites. Temperature ranged from 15.4 to 21.6 °C and dissolved oxygen ranged from 6.2 to 11.03 mg/L, as shown in table 3 in Appendix A. The two Waiarohia Stream sites and the Awanui River upstream of the Waihue channel had electrical conductivities higher than 200 μS, which is an indication of possible contamination.

Water clarity varied from 0.39 m in Ruakaka River to 5.15 m in Kaihu River. Water clarity was less than the contact recreational guideline of 1.6 m at nine of the 22 sites (MfE 1994). However it was only less than the default trigger value for the protection of aquatic ecosystems of 0.8 m (ANZECC 2000) at four sites: Ruakaka, Mangere, Victoria and Waiarohia at Whau Valley. Water clarity was low at the Victoria River site due to river works being carried out upstream and at the Waiarohia site due to the occurrence of an algal bloom.

3.1.2 Streambed (Substrate)

Half the SOE sites are dominated by soft-bottomed substrate such as clay, sand/silt and gravel, as shown in figure 1 (below). Waiarohia Stream site at Whau Valley has manmade substrate such as concrete pylons, which is most likely as a result of its urban location.

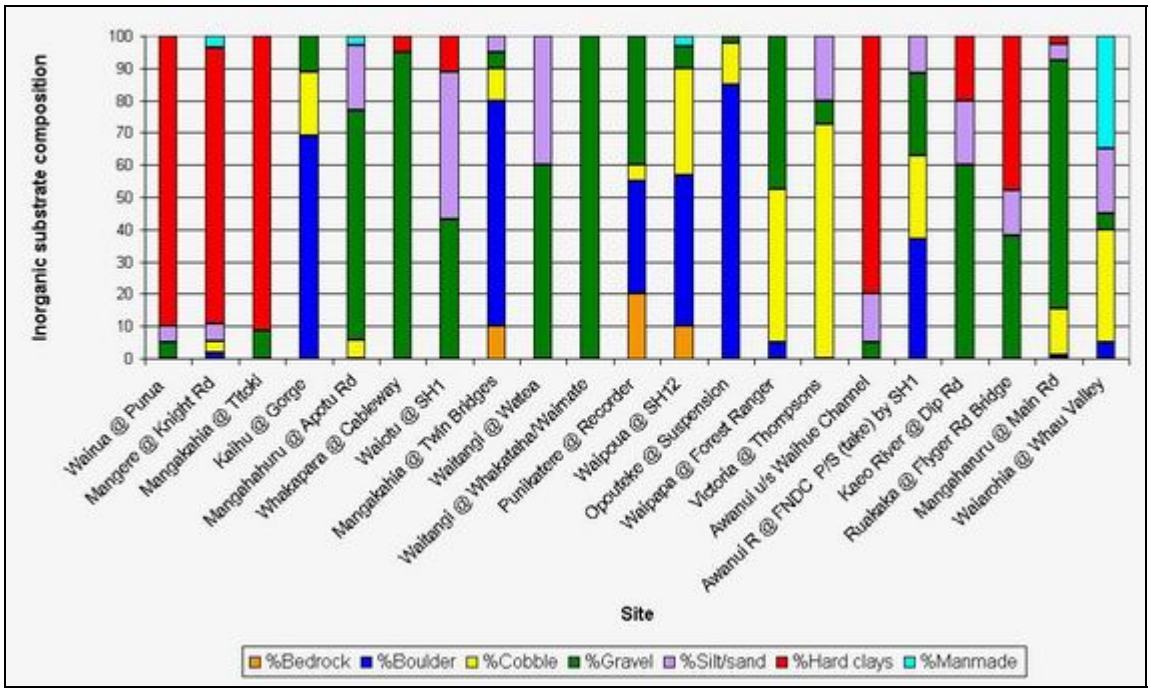

Figure 1: Inorganic substrate composition at 21 SOE sites in 2007.

Eight of the 21 sites have greater than 40% of their stream bed with none or very little organic material present, as shown in figure 2 (below). All other sites are dominated by either macrophytes or algae, which is most likely related to the lack of canopy cover or shading at all of these sites.

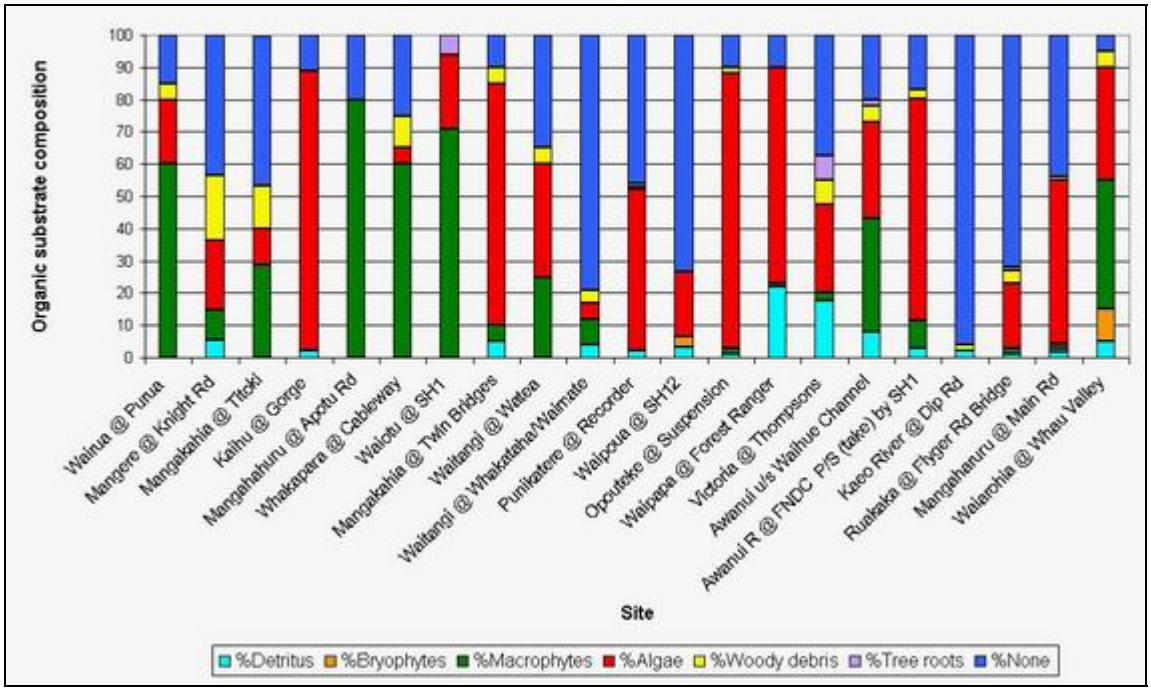

Figure 2: Organic substrate composition at 21 SOE sites in 2007.

3.1.3 Riparian vegetation

Riparian vegetation is important for stream health and good water quality for several reasons, including:

- the shade, cover and food resources it provides for fish and invertebrates;

- preventing excessive macrophyte and filamentous algal growth;
- reduced water temperatures;
- increased bank stability;
- and its ability to intercept nutrients and sediment from land runoff before it reaches the stream.

All of the SOE sites had 50% or less channel shading, as shown in table 3 in Appendix A. Interestingly the two native forest sites (Waipapa at Forest Ranger and Waipoua at SH12) were not the sites with the greatest channel shading. The sites with the highest percentage of the stream channel shaded were typically sites that had narrower stream channels such as Ruakaka River, Waiarohia Stream at Whau Valley and Mangahahuru Stream at Main Road, with 50, 40 and 40% channel shading respectively.

Only seven sites had their riparian canopy cover dominated by mature native trees, as shown in figure 3 (below).The majority of the SOE sites (15) had no canopy cover for 40% of their riparian margins.

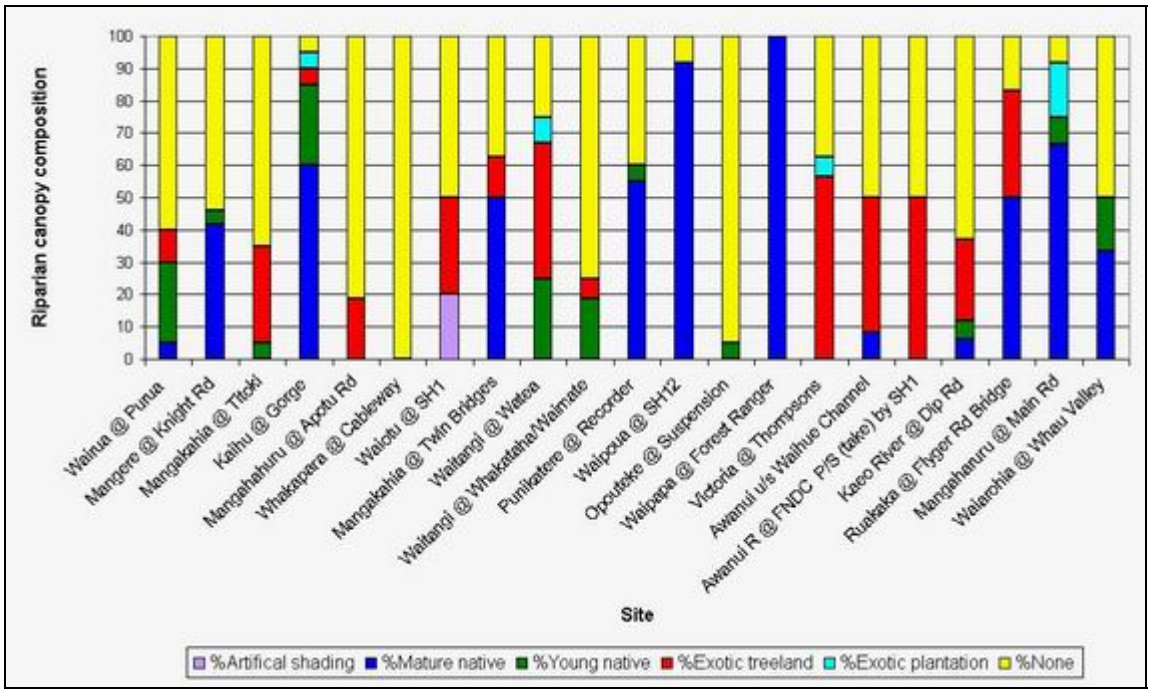

Figure 3: Riparian canopy vegetation composition at 21 SOE sites in 2007.

Sixteen of the 21 SOE sites were dominated by thin exotic understorey vegetation, which was mostly pasture and weeds, as shown in figure 4 (below). Exceptions include Awanui River at FNDC pump station where 94% of the understorey vegetation was dense exotic weeds, Waipoua River where 83% of the understorey was dense native and Waipapa River where 100% of the understorey was dense native vegetation.

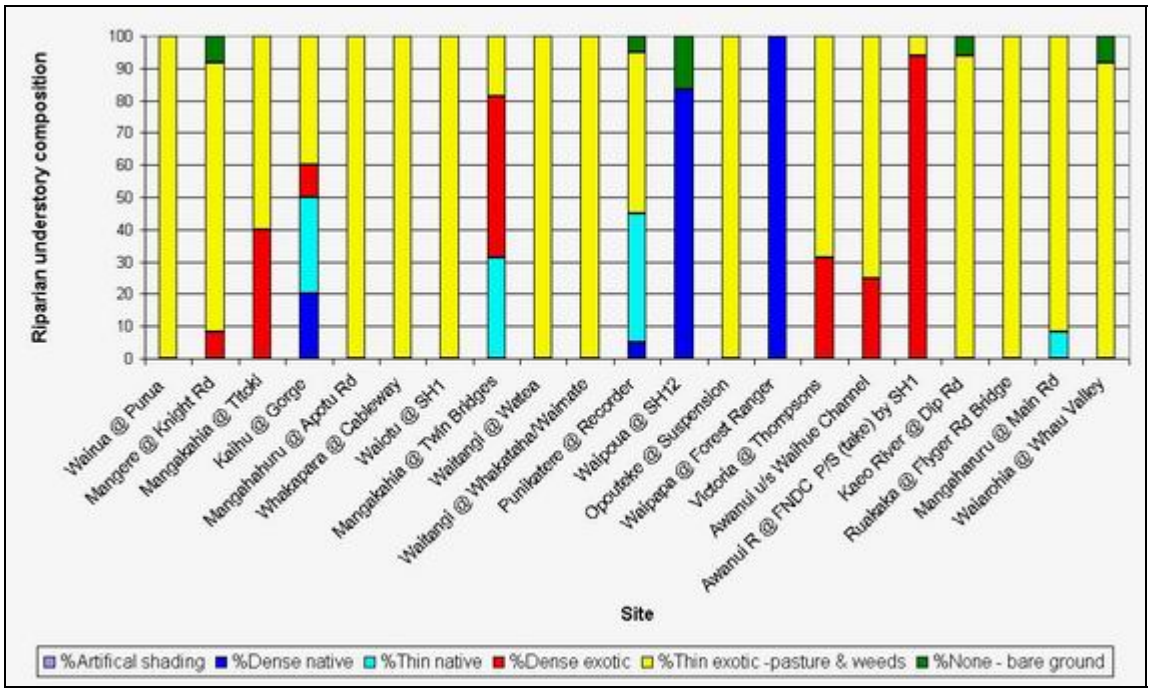

Figure 4: Riparian understorey vegetation composition at the 21 SOE sites in 2007.

3.1.4 Streambed and channel stability

There was a large variation in stream stability between all the SOE sites, as shown in figure 5 (below). Eight sites had a Pfankuch score of 100 or greater, which indicates a very unstable stream channel. Waipoua River at SH12 was the only site that had a score less than 60, indicating a more stable stream channel.

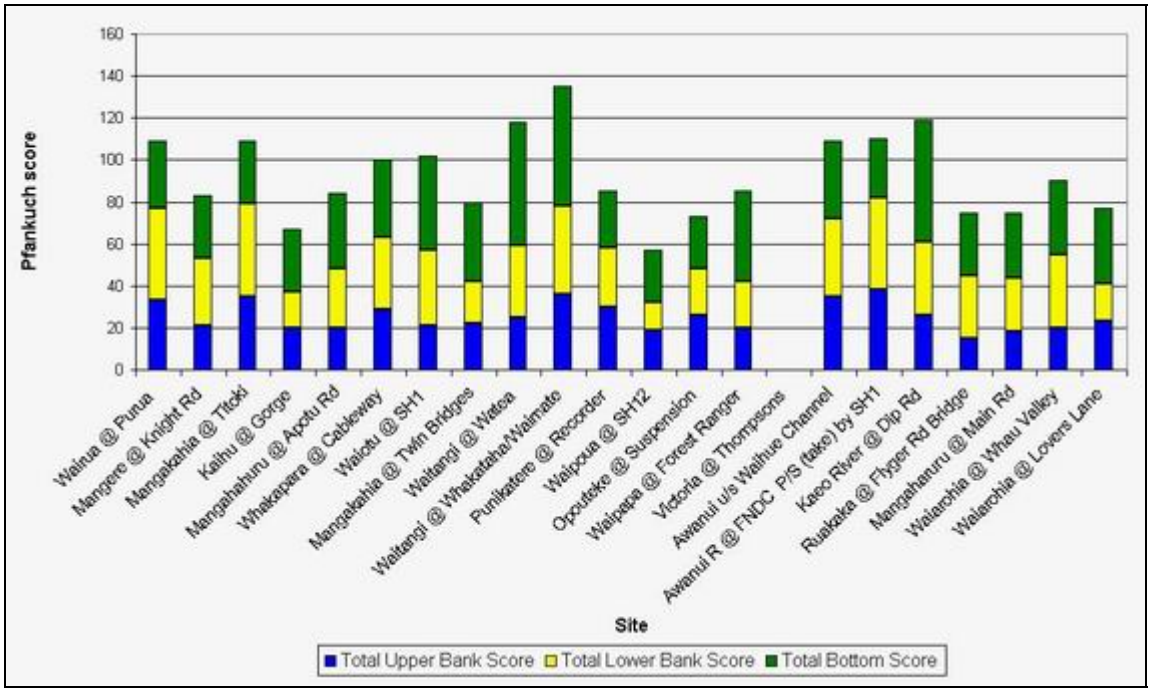

Figure 5: Pfankuch Stability Index scores for 21 SOE sites in 2007.

3.1.5 Stream habitat quality

Two sites had stream habitat quality scores greater than 105 indicating these sites had optimal habitat for fish and macroinvertebrate colonisation: Waipapa at Puketi Forest, and Waipoua at SH12, as shown in figure 6 (below). Eleven of the SOE sites had habitat quality scores between 70 and 105, indicating they have suboptimal habitat.

Nine of the 22 sites had habitat quality scores between 35 and 70 indicating they have marginal habitat for aquatic life. The low scores for most of these sites were as a result of limited channel shading. No sites had a total habitat quality score less than 35, which would suggest poor habitat quality.

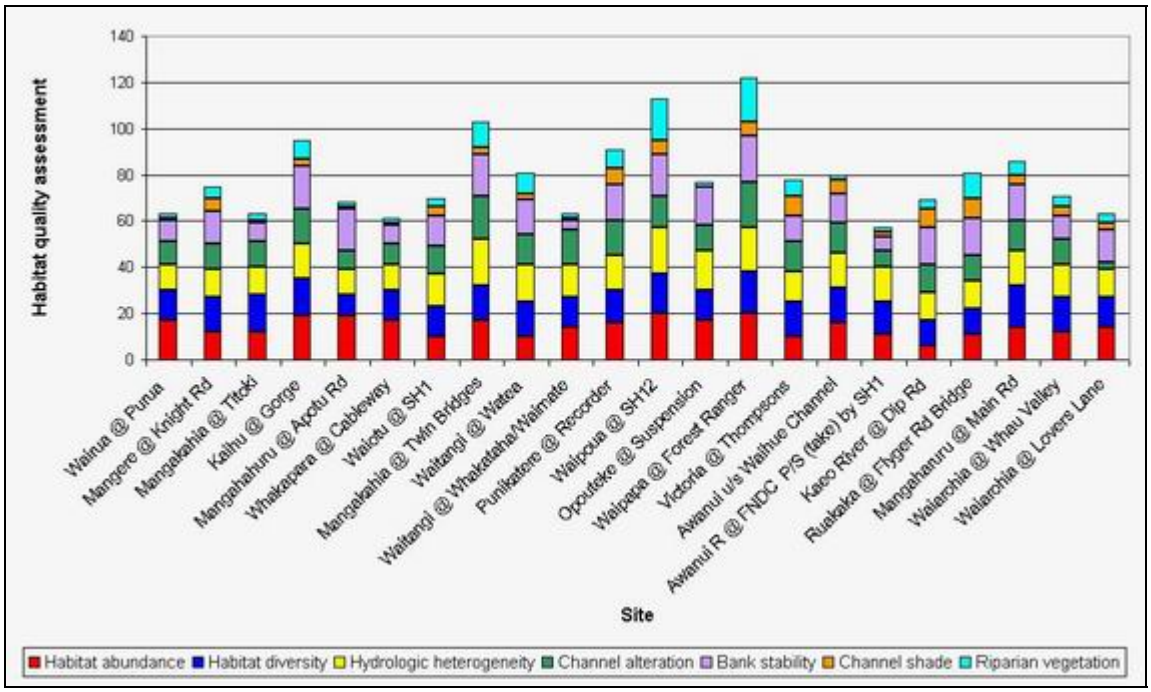

Figure 6: Habitat quality assessment scores for the 22 SOE sites in 2007.

3.2 Comparison between years for the SOE sites

3.2.1 Streambed and channel stability

The 2007 total Pfankuch scores were greater than the 2005 scores at five of the 18 sites, indicating a possible decrease in streambed and channel stability at these sites, as shown in figure 7 (below).

Five sites showed a decrease in their Pfankuch scores between 2005 and 2007 indicating a possible improvement in stream stability: Mangere at Knight Road, Mangahahuru at Apotu Road, Waipoua at SH12 rest area, Whakapara at cableway and Opouteke at Suspension Bridge. Eight sites showed no or little change in their Pfankuch stability scores between 2005 and 2007 i.e. the difference was less than 10.

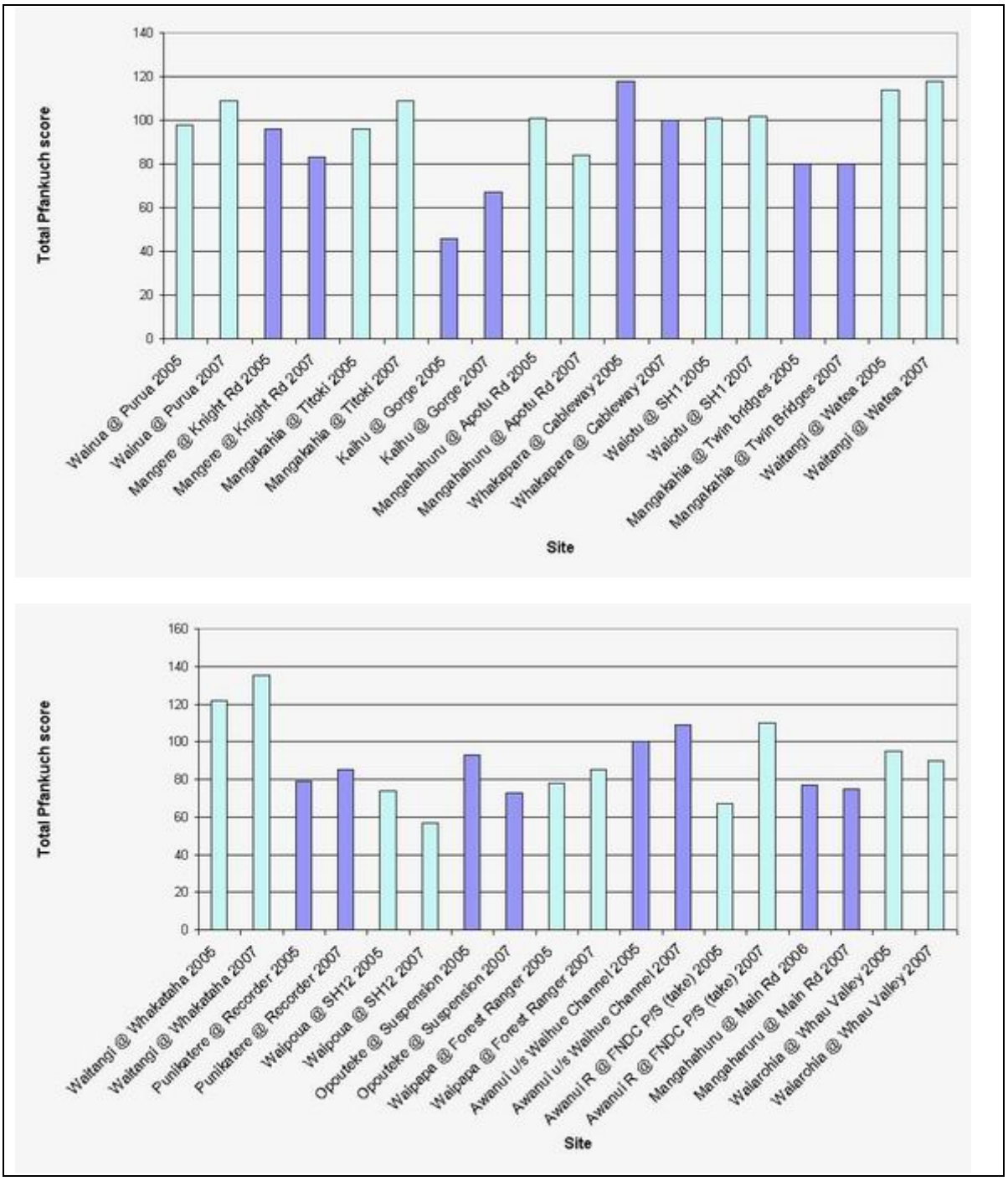

Figure 7: Total Pfankuch scores for 18 SOE sites in 2005 and 2007.

3.2.2 Stream habitat quality

Most of the SOE sites have shown little change in stream habitat quality over the last four years, as shown in figure 8 (below).

Stream habitat quality over the last four years has improved, i.e. increased by more than 20, at four sites; Wairua at Purua, Mangakahia at Titoki, Waitangi at Whakataha and Awanui upstream of Waihue Channel. This improvement is mostly as a result of an increase in habitat abundance and diversity at these sites.

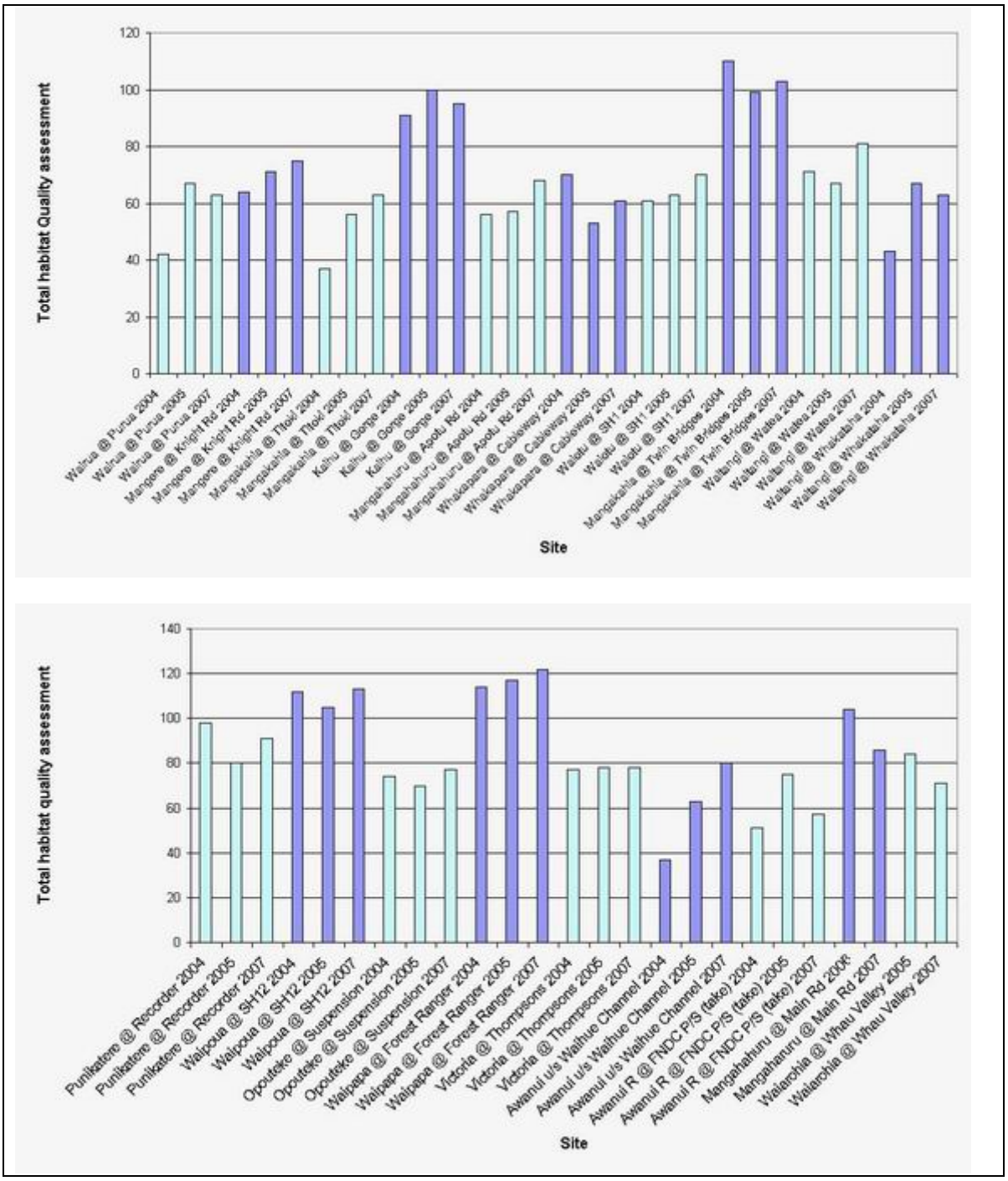

Figure 8: Total habitat quality assessment scores for 19 SOE sites in 2004, 2005 and 2007.

4 Results for the Resource Consent sites

4.1 Resource consent site results for 2007

As with the SOE sites, the surrounding catchment land use for the resource consent sites ranged from relatively pristine native forest, to agricultural land (Appendix B). The sites varied in river order, substrate type and size, stability and riparian vegetation.

4.1.1 Physico-chemical characteristics

Water temperature measurements taken during sampling ranged from 16.2 to 21.7 °C. Dissolved oxygen measurements ranged from 3.2 to 9.6 mg/L, as shown in table 4 in Appendix B. All the sites had a dissolved oxygen level within the safe range for aquatic life at the time of sampling, except for upstream and downstream of oxidation pond A, where dissolved oxygen was 5.4 and 3.2 mg/L respectively.

Water clarity varied from 0.9 m downstream of Dam A to 3.1 m upstream of the quarry. There was only a large reduction in water clarity downstream of one consent activity compared to upstream. This was at Dam A.

4.1.2 Streambed (substrate)

Like the SOE sites, half the sites for the resource consent activities are dominated by soft bottomed substrates such as hard clays, gravels and silt/sand, as shown in figure 9 (below).

There is a reasonable difference in the substrate of the upstream and downstream sites for most of the resource consent activities. For example, the substrate upstream of Dam A is dominated by bedrock, while the substrate downstream is predominately hard clays.

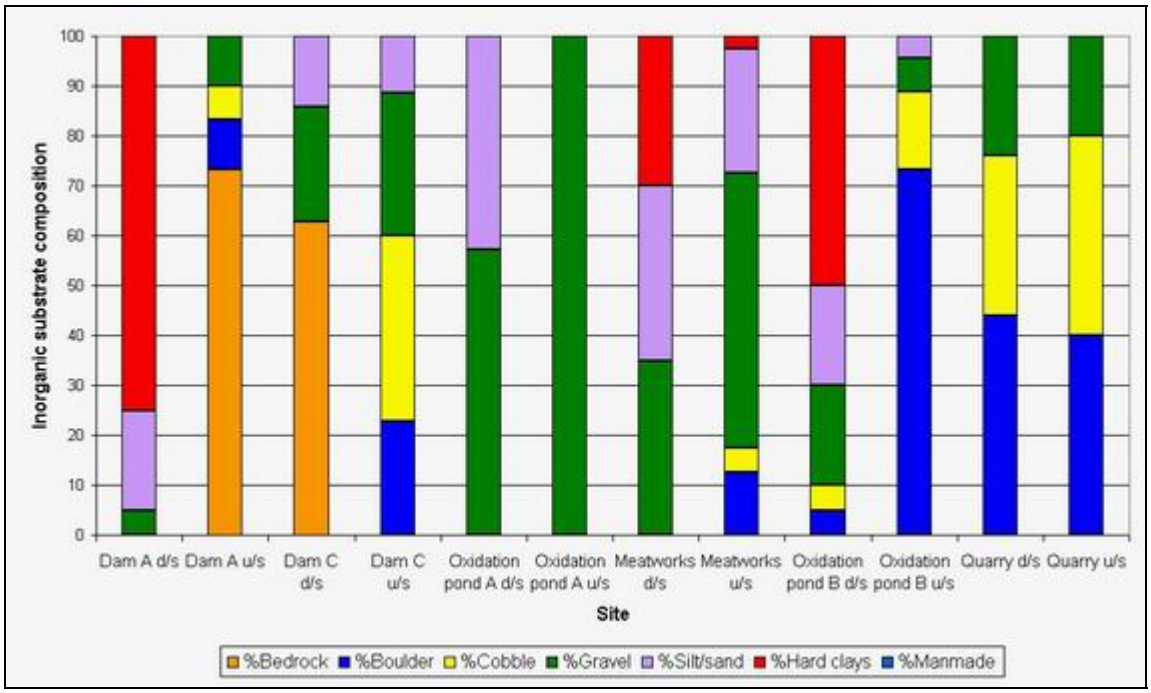

Figure 9: Inorganic substrate composition at resource consent sites in March 2007.

Similar to the SOE sites, the resource consent sites are dominated by algae, macrophytes or areas without organic material, as shown in figure 10 (below). However there tends to be higher proportions of detritus, bryophytes and woody debris at more of the resource consent sites, which is most likely related to the greater prevalence of mature trees as part of the riparian vegetation and being in closer vicinity to forested upper catchments.

The organic substrate data shows that there are slight differences in the organic substrate composition between the upstream and downstream sites for each consent activity. For example, Dam A has bryophytes present and a smaller proportion of algae at the upstream site compared to the downstream site.

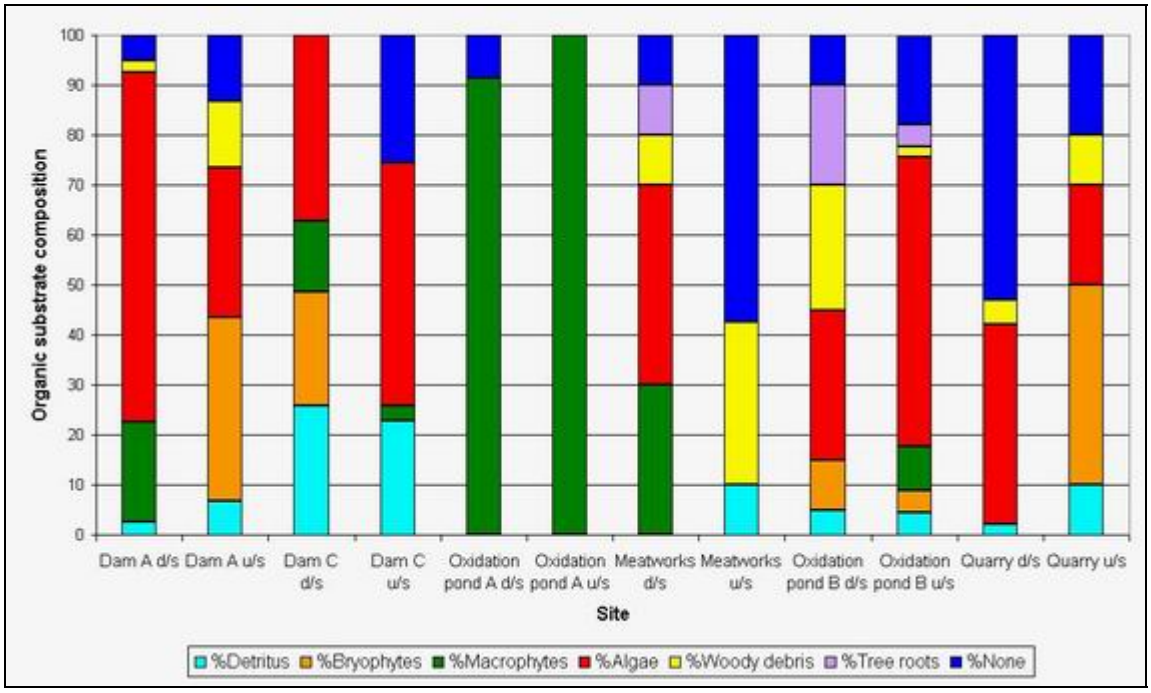

Figure 10: Organic substrate composition at Resource Consent sites in March 2007.

4.1.3 Riparian vegetation

There is much greater channel shading at the resource consent sites compared to the SOE sites, with eight of the 12 resource consent sites having more than 50% of their stream channel shaded (see table 4 in Appendix B). This is most likely related to the resource consent sites typically being higher up in their catchments than the SOE sites, meaning the streams are narrower and there is more mature riparian vegetation.

All resource consent activities assessed showed considerable difference in their riparian canopy composition between their upstream and downstream sites, as shown in figure 11 (below). For example, approximately 85% of the riparian margin for the downstream site for Dam A was lacking canopy vegetation, while 67% of the riparian margin for the upstream site is mature native canopy.

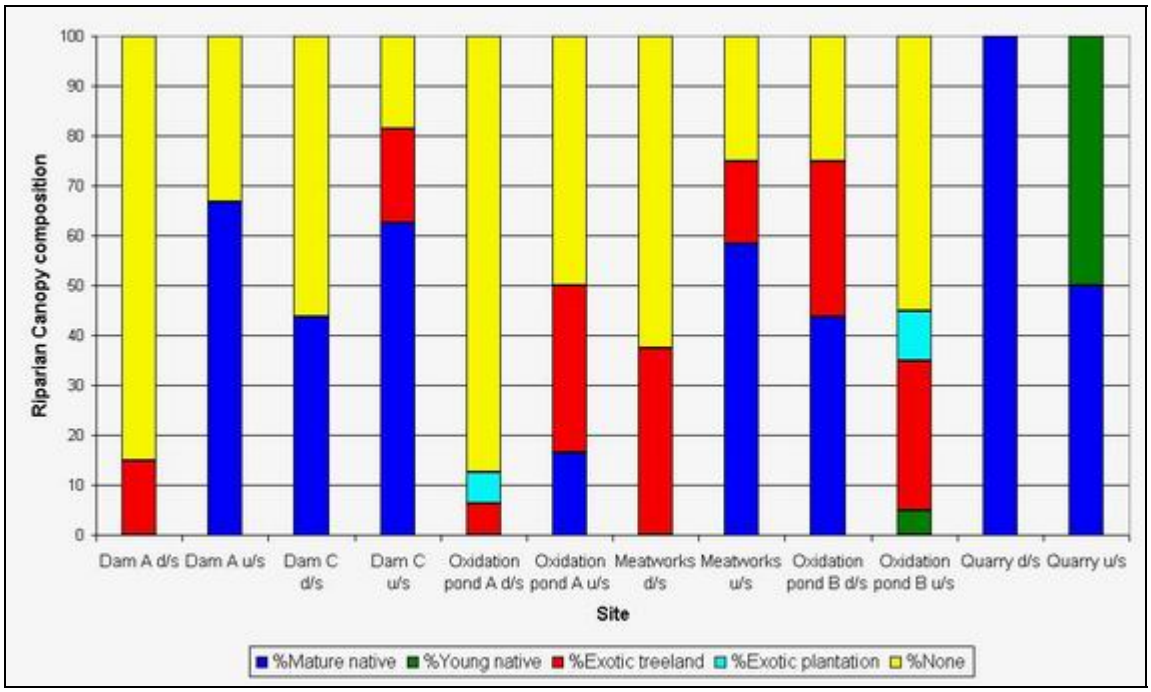

Figure 11: Riparian canopy vegetation composition at the resource consent sites in March 2007.

Understorey riparian vegetation is also an important influencing factor on water quality and macroinvertebrate communities in streams. Understorey vegetation was similar upstream and downstream of Dam C and Oxidation pond A, as shown in figure 12 (below).

The other four resource consent activities showed differences between their upstream and downstream understorey vegetation. For example, the meatworks was 50% native upstream compared to 100% weeds and pasture downstream, and the quarry was 50% exotic weeds upstream compared to 100% native downstream.

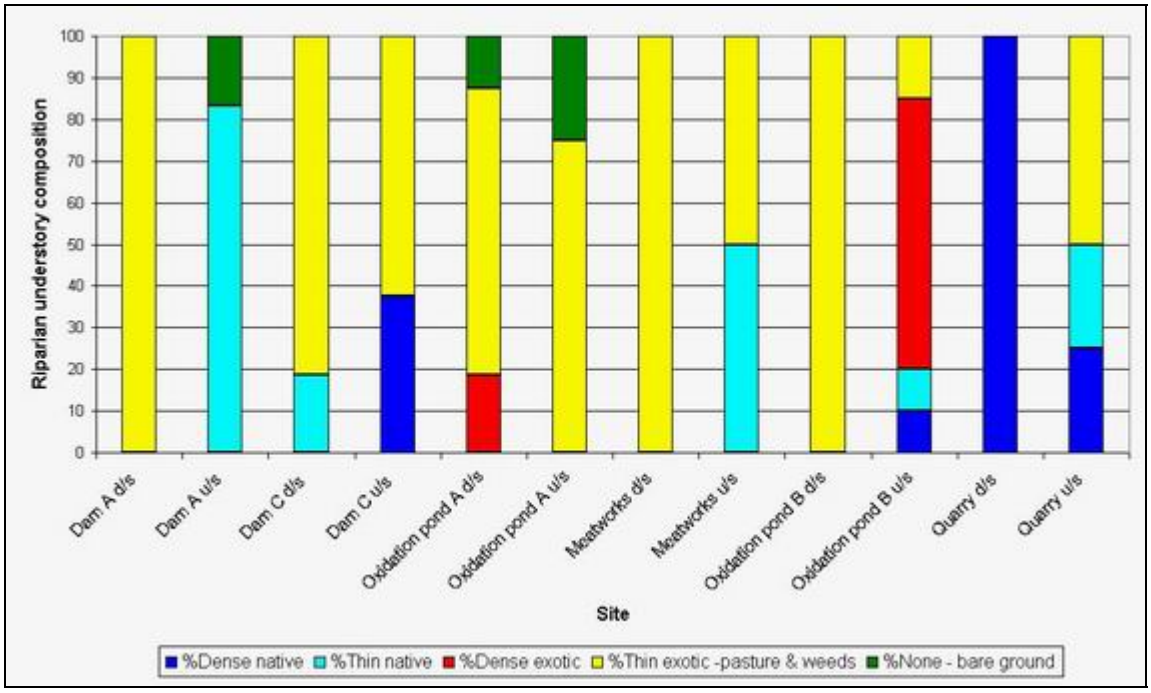

Figure 12: Riparian understorey vegetation composition at the resource consent sites in 2007.

4.1.4 Streambed and channel stability

The Pfankuch stability index scores, which are all 100 or less, indicate that the resource consent sites have reasonably good stream channel and bank stability, as shown in figure 13 (below).

The Pfankuch scores differed for the upstream and downstream sites for three of the resource consent activities. The upstream sites at the meatworks and Dam A were more stable than the downstream sites, while the downstream site was more stable at Dam C than the upstream site. There was little or no difference between the stability scores of the upstream and downstream sites for the other three resource consent activities.

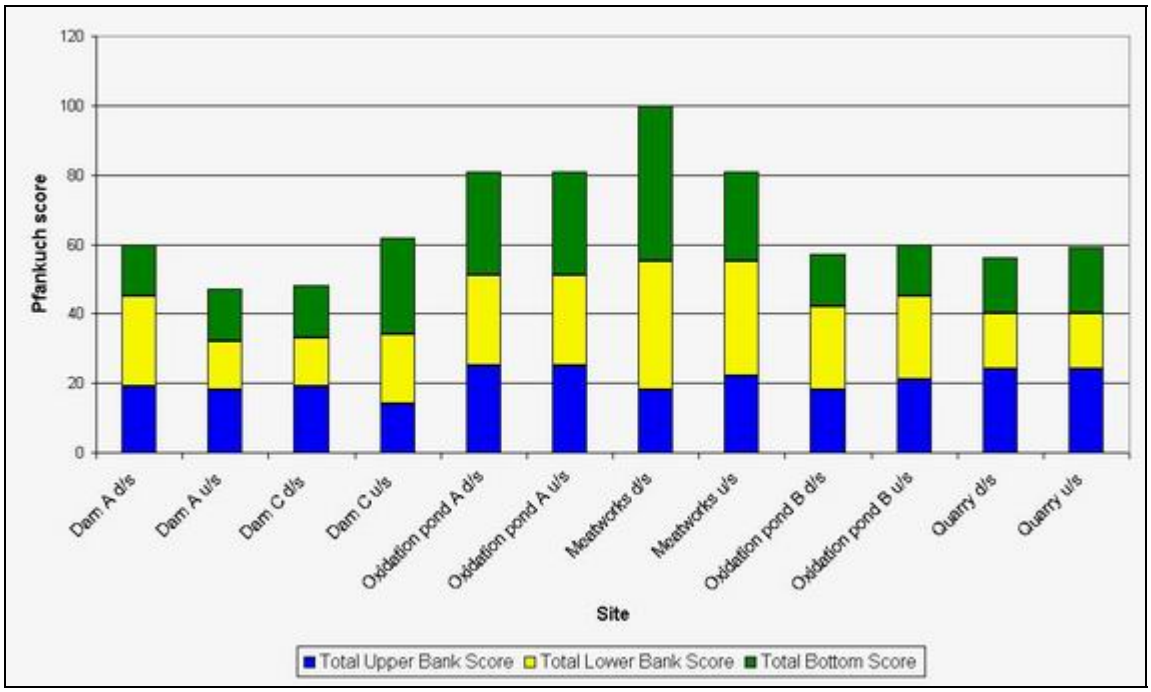

Figure 13: Pfankuch scores at the resource consent sites in March 2007.

4.1.5 Stream habitat quality

For the majority of the consent activities the upstream and downstream sites had similar stream habitat quality, with slightly better stream habitat quality upstream, as shown in figure 14 (below). The exception is Dam A and C where the upstream sites had much better stream habitat quality. For example, the downstream site for Dam A scored 49, indicating marginal habitat quality, while the upstream site scored 127, indicating optimal habitat quality.

Five of the 12 resource consent sites had stream habitat quality scores greater than 105 indicating they have optimal habitat quality for aquatic life. Four sites had scores between 70 and 105, indicating suboptimal habitat quality, while the other three sites scored between 35 and 70, indicating marginal habitat quality. None of the 12 sites had scores less than 35, which would suggest poor habitat quality.

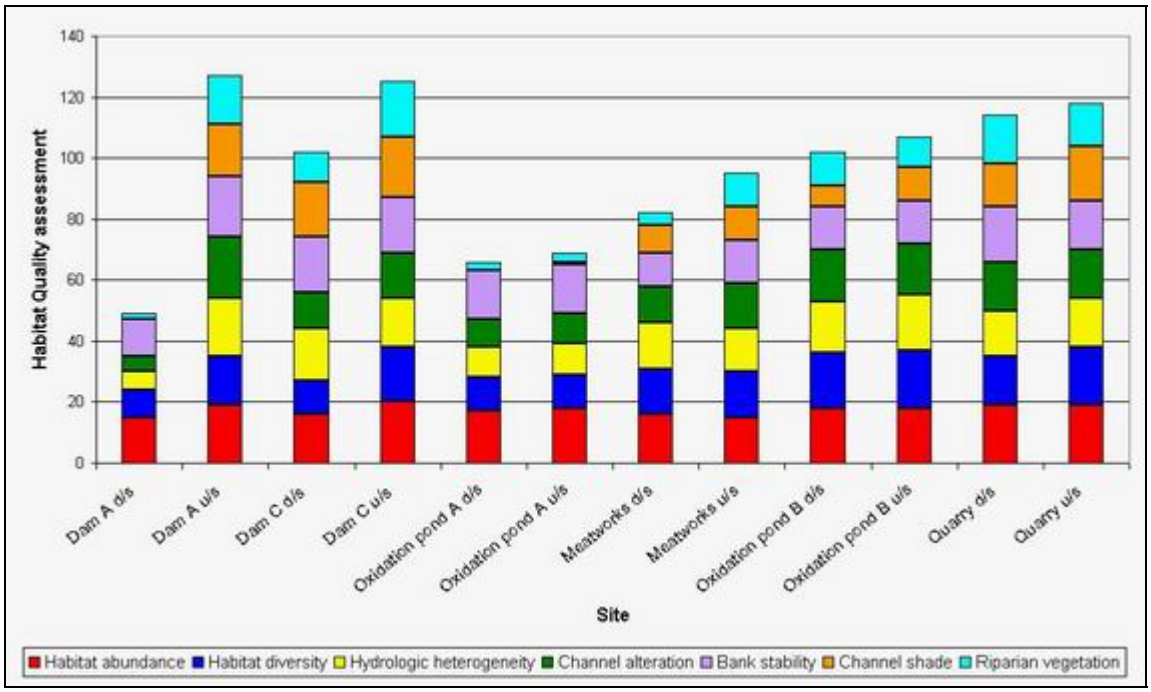

Figure 14: Habitat quality assessment at the resource consent sites in March 2007.

4.2 Comparison between years for resource consent sites

4.2.1 Streambed and channel stability

There was no or little change between the 2005 and 2007 Pfankuch scores for most of the resource consent sites, as shown in figure 15 (below). There was a slight decline in the Pfankuch scores downstream of Dam C and upstream of Dam A, indicating a possible increase in stability.

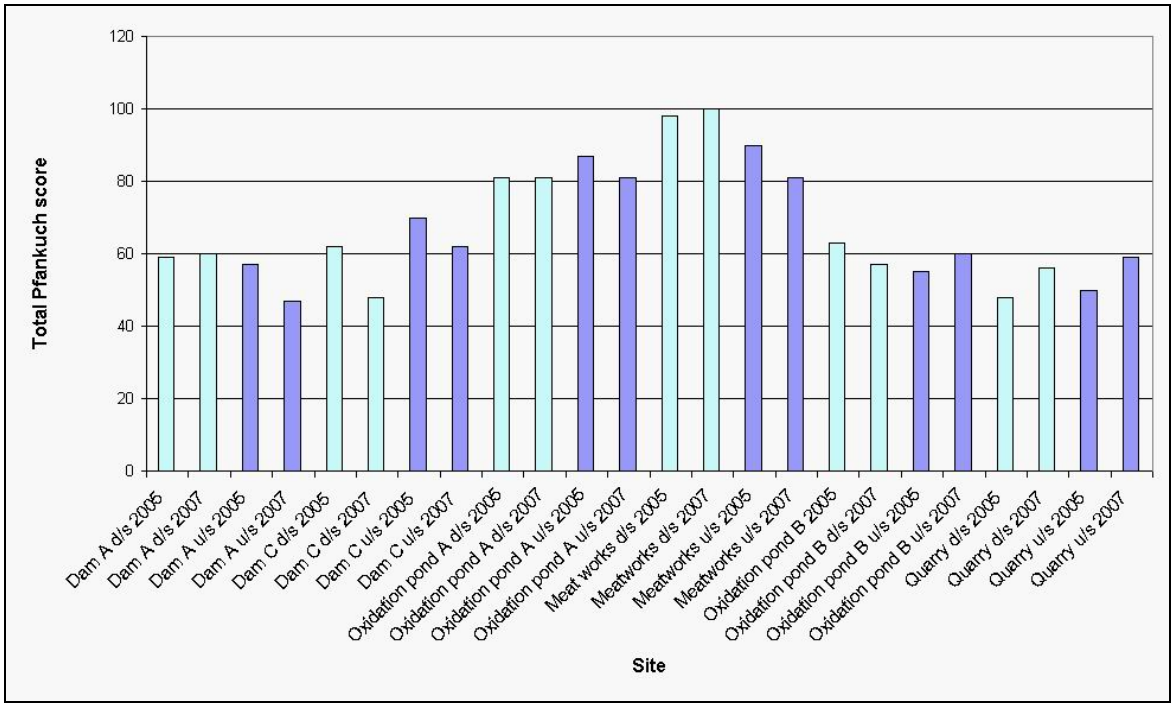

Figure 15: Total Pfankuch scores at resource consent sites in 2005 and 2007.

4.2.2 Stream habitat quality

There has been no or little change in the stream habitat quality scores over the last four years at most resource consent sites. Some sites have shown small changes in stream habitat quality but all of these differences are less than 20, as shown in figure 16 (below). There has been a decline in the habitat quality scores at the Dam C and Quarry downstream sites. This is a result of reduced instream habitat abundance and diversity and channel shading. The habitat quality scores have increased at the upstream sites for Dam C and the Quarry. This is due to increased instream habitat abundance and diversity, bank stability and riparian vegetation.

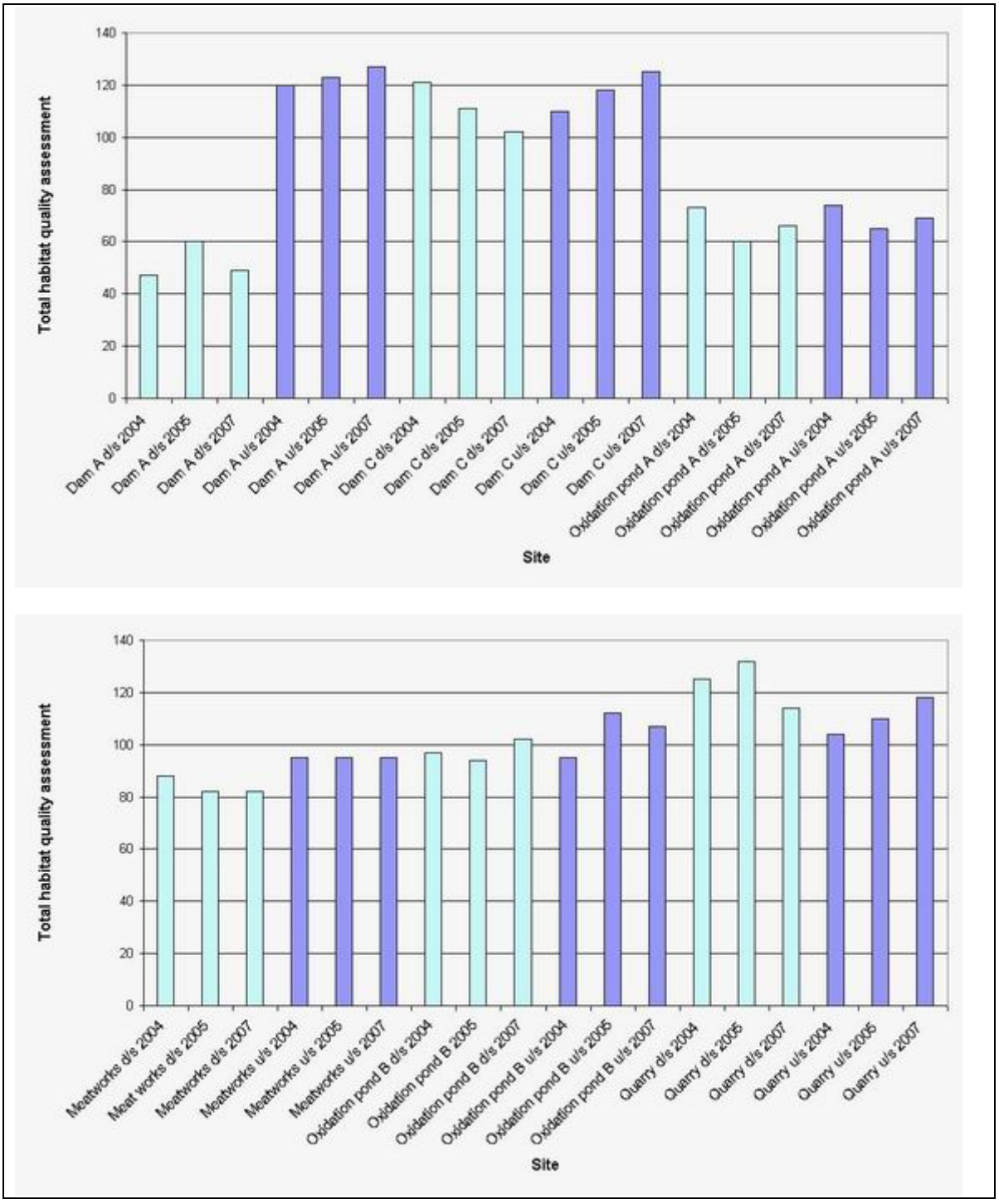

Figure 16: Total habitat quality assessments at resource consent sites for 2004, 2005 and 2007.

5 Periphyton results

Some sites did not have suitable substrate for sampling periphyton. Therefore there are only periphyton results for 18 of the RWQMN sites. The average chlorophyll α and taxa recorded at each site are presented in table 5 in appendix C.

5.1 Chlorophyll α

Chlorophyll α can be used as an indicator of algal biomass. The sites varied greatly in chlorophyll α levels, as shown in figure 17 (below). The native forest sites had very little chlorophyll α (low algal biomass), with samples often below detection levels, such as Waipapa at Puketi Forest. The sites in pastoral farming or urban catchments typically had much higher chlorophyll a levels (algal biomass) such as Mangakahia at Titoki, Punakitere at permanent recorder, Awanui at FNDC watertake and Waiarohia at Whau Valley and Lovers lane.

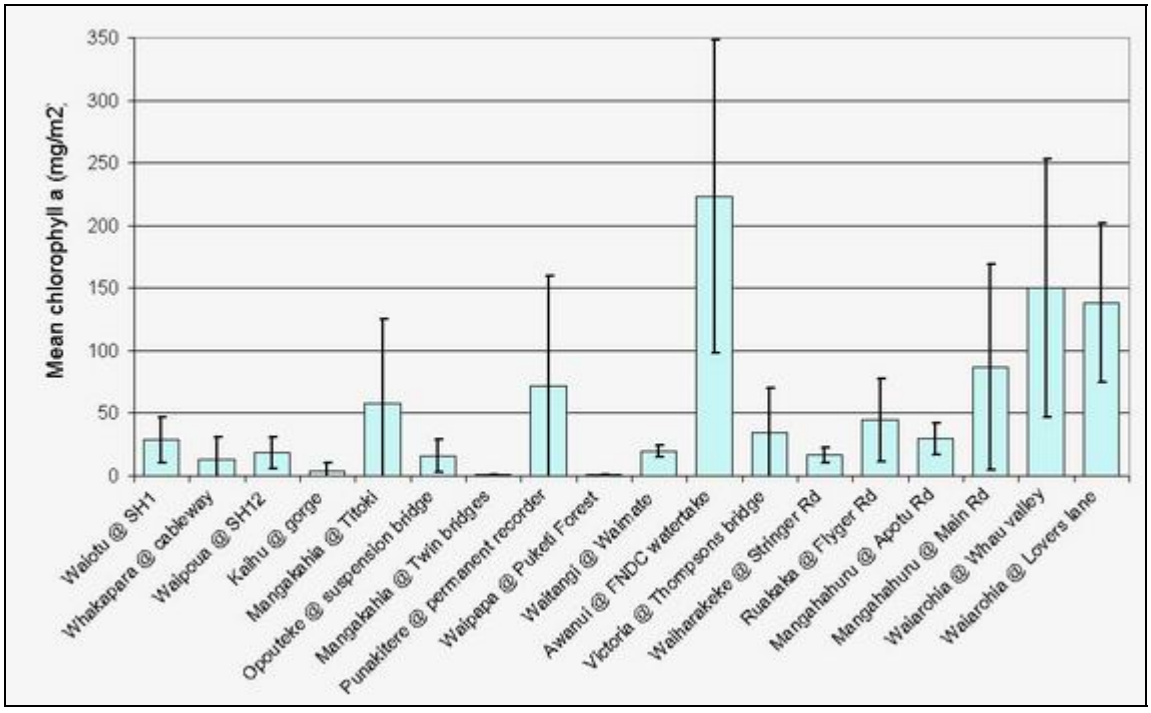

Figure 17: Mean chlorophyll α for each site with the standard deviation shown as error bars.

These levels can be compared to the recommended maximum level of chlorophyll α acceptable for aesthetics and contact recreation of 120 mg/m^2 and for 'clean water" macroinvertebrate fauna, such as stoneflies, of 20 mg/m^2 (Biggs 2000). Thirteen of the 18 sites meet the recommended level for aesthetics and contact recreation and three meet the recommended level for 'clean water' macroinvertebrate fauna.

5.2 Periphyton species

The number and types of periphyton taxon that were dominant, abundant or common at each site varied greatly, as shown in table 5 (appendix C). Three sites had a blue green algae, *Phormidium* sp. as the most dominant periphyton taxon: Waipoua, Mangakahia at Titoki and Punakitere. Otherwise most sites were dominated by diatoms and green algae species. Desmids were not recorded, rare or occasional.

6 Discussion

Typically, temperature and dissolved oxygen measurements were within a safe range for aquatic life for all SOE and resource consent sites assessed. Water clarity was above the ANZECC (2000) trigger value for the protection of aquatic ecosystems at all SOE and resource consent sites, except four of the SOE sites: Ruakaka, Mangere, Waiarohia at Whau valley and Victoria River. However, the low water clarity at the Waiarohia and Victoria sites was due to anomalies (algal bloom and river works respectively) on the day of sampling and is not indicative of the normal water clarity at these sites.

Half of the SOE and resource consent sites are dominated by soft bottomed substrate such as hard clays, gravel and sand or silt. This is a good representation of the proportion of soft sedimentary rivers in Northland, with 44% of Northland rivers included in the NZ River Environments Classification (Snelder et al. 2002) being classed as soft sedimentary (Hall 2003).

The SOE and resource consent sites with more mature riparian vegetation typically have better water quality and stream habitat for aquatic life. They typically:

- have higher proportions of their stream channel shaded, meaning lower water temperatures. Although this is not always the case for larger rivers in native forest catchments, such as Waipoua and Waipapa Rivers, which have relatively low proportions of their channel shaded because they are so wide.
- have lower nutrient levels, in combination with more shade means they are not dominated by macrophytes and algae like the majority of other sites.
- have more detritus (leaf litter) and woody debris in the stream channel, which provides important food and habitat resources for fish and macroinvertebrates.
- have better water clarity.

Only two of the 22 SOE sites, the two relatively pristine native forest sites, had habitat quality assessment scores indicative of optimal habitat for aquatic biota: Waipapa River at Forest Ranger and Waipoua River at SH12 rest area, while five of the 12 resource consent sites had scores indicative of optimal habitat for aquatic biota. This is most likely because more of the resource consent sites are on smaller streams near the catchment headwaters, which means they typically have more riparian vegetation and therefore more channel shading, woody debris and detritus. None of the SOE or resource consent sites had habitat quality assessment scores, indicative of poor habitat quality for aquatic life. However many sites had scores indicative of marginal habitat quality, most as a result of limited riparian vegetation and channel shading.

The Pfankuch scores for eight of the 21 SOE sites were greater than 100 indicating poor to moderate stream channel and bank stability, while all 12 resource consent sites had scores less than 100 indicating greater stream stability. Stream and bank stability is an important influencing factor of aquatic biota and water quality, i.e. overall stream health. The sites with greater stability (i.e. lower pfankuch scores) typically have higher habitat quality scores.

The different habitat characteristics discussed in this report such as channel stability, substrate type, riparian vegetation and habitat quality need to be considered when comparing the upstream and downstream sites to assess the effects of resource consent activities. If there is large differences in these habitat characteristics between the upstream and downstream sites it makes it difficult to determine whether any differences in water quality and stream health detected is as a result of the resource consent activity or an artefact of differences in stream habitat.

For example, differences in water clarity and macroinvertebrate communities (Pohe and Hall 2007) between the upstream and downstream sites of Dam A is more likely as a result of differences in substrate type, riparian vegetation and surrounding land use, than the dam structure and associated water take. For this reason this dam will no longer be monitored in the future.

For many of the other resource consent activities there are slight differences in stream habitat at the upstream and downstream sites such as proportions of inorganic and organic substrate and channel stability. These differences will be considered when assessing the effect of these resource consent activities on water quality and macroinvertebrate communities.

Five of the 18 SOE sites showed an improvement in stream stability over the last three years, while a further five showed a decrease in stream stability. There was only slight changes in stream stability at the resource consent sites over the last three years.

Fifteen of the 19 SOE sites showed fairly stable habitat quality assessment scores over the last four years. Scores indicate that stream habitat quality has improved at four sites. There has been little change over the past four years in the habitat quality at the 12 resource consent sites.

As this is the first year of periphyton sampling at the RWQMN sites, it would be premature to draw too many conclusions from the data. The most obvious observation at this stage is that the chlorophyll a levels at many sites were consistent with the water quality, macroinvertebrates and surrounding land use. For example, pastoral sites had typically higher periphyton biomass (chlorophyll α levels), higher nutrient levels and macroinvertebrate communities indicating probable organic pollution.

7 Acknowledgements

Thank you to John Maxted from Auckland Regional Council for providing advice and a template for carrying out the habitat assessments. Thank you to the following NRC staff; those that have assisted with assessments in the field over the last four years, Lisa Elphick, Megan McGregor and Emma Simpson for assisting with data entry, analysis and report preparation and Lesley Webb for proof reading this report.

8 References

ANZECC (2000). Australian Water Quality Guidelines for Fresh and Marine Waters. Australia and New Zealand Environment and Conservation Council (ANZECC).

Biggs, B.J.F. (2000). New Zealand Periphyton Guideline: Detecting, Monitoring and Managing Enrichment of Streams. Report published by Ministry for the Environment.

Biggs, B.J.F and Kilroy, C. (2000). Stream Periphyton Monitoring Manual. Report prepared by NIWA for Ministry for the Environment.

Boothroyd, I and Stark, J. (2000). Use of invertebrates in monitoring. *In:* Collier, K.J.; Winterbourn, M.J. *eds.* New Zealand stream invertebrates: ecology and implications for management. New Zealand Limnological Society, Christchurch. Pp 344 – 373.

Cook, T.L. (2004). Review of Water Quality Monitoring of Waiarohia Stream. Internal report, Northland Regional Council, Whangarei.

Hall, G. (2003). Freshwater Quality Monitoring Regional Monitoring Strategy. Internal report, Northland Regional Council, Whangarei.

MfE (1994). Water Quality guidelines No. 2 – guidelines for the Management of Water Colour and Clarity. Ministry for the Environment (MfE).

Pfankuch, D.J. (1975). Stream reach inventory and channel stability evaluation. U.S.D.A Forest Service, Region 1, Missoula, Montana.

Pohe, S. R and Hall, T. (2007). Northland Macroinvertebrate Monitoring Programme: 2007 Monitoring Report. Report produced by NorthTec for Northland Regional Council.

Quinn, J.M. and Hickey, C.W. (1990). Characterisation and classification of benthic invertebrate communities in 88 New Zealand rivers in relation to environmental factors. New Zealand Journal of Marine and Freshwater Research 24:387 – 409.

Snelder, T. Biggs, B. Weatherhead, M. (2002). New Zealand River Environment Classification: A guide to concepts and use. Prepared for Ministry for the Environment. NIWA Project: MFE02505.

Stark, J.D. (1985). A Macroinvertebrate Community Index of water quality for stony streams. Ministry of Works and Development, Water and Soil Miscellaneous Publication, No 87.

Stark, J.D.; Boothroyd, I.K.G.; Harding, J.S.; Maxted, J.R. and Scarsbrook, M.R. (2001). Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103, 57p.

Winterbourn, M.J.; Gregson, K.L.D. and Dolphin, C.H. (2000). Guide to the Aquatic Insects of New Zealand. Bulletin of the Entomological Society of New Zealand 13, 102p.

Appendix A: Habitat data for SOE sites

Table 3: Habitat data for 2007 including physiochemical, habitat information, stream habitat quality and Pfankuch stability index for the 22 State of Environment sites.

Site name	Wairua	Mangere	Mangakahia (Titoki)	Kaihu	Mangahahuru (Apotu Rd)	Whakapara	Waiotu	Mangakahia (Twin Bridges)	Waitangi (Watea)	Waitangi (Waimate)	Punikatere	Waipoua
Site Number	101753	101625	101038	102256	100281	102249	102248	103307	101752	103178	105231	103304
Date sampled	27/02/07	28/02/07	28/02/07	27/02/07	21/03/07	27/02/07	27/02/07	28/02/07	7/03/07	28/02/07	28/02/07	27/02/07
Physico-chemical data												
Temperature	21.3	18.2	21	21.2	16.2	19.2	19.2	21.3	21.4	21.6	21	18.7
Dissolved oxygen (mg/L)	7.87	6.2	7.3	9.31	7.42	7.28	7.14	8.3	7.76	9.4	9.35	9.3
Conductivity (uS)	149.9	136.4	152.2	114.5	152	86.6	97.4	114.3	129.3	100.8	126.9	90.8
Water clarity (m)	1.41	0.69	1.57	5.15	1.69	1.35	1.71	4.65	2.68	1.96	1.81	3.0
Pfankuch Stability Index												
Upper bank	33	21	35	20	20	29	21	22	25	36	30	19
Lower bank	44	32	44	17	28	34	36	20	34	42	28	13
Bottom (streambed)	32	30	30	30	36	37	45	38	59	57	27	25
Total	**109**	**83**	**109**	**67**	**84**	**100**	**102**	**80**	**118**	**135**	**85**	**57**
General habitat information												
Mean stream depth	3	1.5	~3	0.41	0.79	1.5	1.2	0.2	2.5	0.7	1.2	1
Mean stream width	7.9	4.8	8	7.6	4.07	13	8.6	1.5	25.4	4.75	16	12
Land use	Pasture	Pasture	Pasture	Scrub, forest, pasture	Pasture	Pasture	Pasture	Pasture	pasture	Pasture	Pasture	Native Forest
Livestock access	2	1	1	0	0	2	1	2	0	2	2	0
% Channel shading	<2	20	<2	10	10	0	10	<5	5	<2	30	20
% Filamentous algae	20		20	10		3	<2	5	40		15	<1
Macrophytes	A	R	R	R	A	A	C	R	R	R	R	R
Qualitative Assessment												
Habitat abundance	17	12	12	19	19	17	10	17	10	14	16	20
habitat diversity	13	15	16	16	9	13	13	15	15	13	14	17
Hydrologic heterogeneity	11	12	12	15	11	11	14	20	16	14	15	20
channel alteration	10	11	11	15	8	9	12	19	13	15	15	14
Bank stability	9	14	8	19	18	8	13	18	15	4	16	18
Channel shade	1	6	1	3	1	1	4	3	3	1	7	6
Riparian vegetation	2	5	3	8	2	2	4	11	9	2	8	18
Total	**63**	**75**	**63**	**95**	**68**	**61**	**70**	**103**	**81**	**63**	**91**	**113**
Flow type												
%Pool	0	0	0	0	14.3	0	0	42.3	40	0	0	16.7
%Riffle	0	0	0	55.5	0	0	0	7.1	0	0	33.3	16.7
%Run	100	100	100	44.4	85.7	100	100	35.7	60	100	66.6	33.3
%Waterfall/chute	0	0	0	0	0	0	0	14.3	0	0	0	33.3

Table 3 cont: Habitat data for 2007 including physiochemical, habitat information, stream habitat quality and Pfankuch stability index for the 22 State of Environment sites.

Site name	Wairua	Mangere	Mangakahia (Titoki)	Kaihu	Mangahahuru (Apotu Rd)	Whakapara	Waiotu	Mangakahia (Twin Bridges)	Waitangi (Watea)	Waitangi (Waimate)	Punikatere	Waipoua
Site Number	101753	101625	101038	102256	100281	102249	102248	103307	101752	103178	105231	103304
Inorganic substrate												
%Bedrock	0	0	0	0	0	0	0	10	0	0	20	10
%Boulder	0	1.8	0	68.9	0	0	0	70	0	0	35	46.7
%Cobble	0	3.6	0	20	5.7	0	0	10	0	0	5	33.3
%Gravel	5	0	8.8	11.1	71.4	95	43	5	60	100	40	6.6
%silt/sand	5	5.5	0	0	20	0	46	5	40	0	0	0
%Hard clays	90	85.5	91.1	0	0	5	11	0	0	0	0	0
%manmade	0	3.6	0	0	2.9	0	0	0	0	0	0	3.3
Organic substrate												
%detritus	0	5.5	0	2.2	0	0	0	5	0	4	2	3.3
%bryophytes	0	0	0	0	0	0	0	0	0	0	0	3.3
%macrophytes	60	9.1	28.8	0	80	60	71	5	25	8	0	0
%Algae	20	21.8	11.1	86.7	0	5	23	75	35	5	50	20
%Woody debris	5	20	13.3	0	0	10	0	5	5	4	1	0
%Tree roots	0	0	0	0	0	0	6	0	0	0	1	0
%None	15	43.6	46.6	11.1	20	25	0	10	35	79	46	73.3
Bank type												
%Earth	100	90.9	94.4	0	100	100	100	0	95	100	100	0
%Rock	0	0	0	0	0	0	0	0	5	0	0	0
%Mix	0	9.1	5.6	100	0	0	0	100	0	0	0	83.3
%manmade	0	0	0	0	0	0	0	0	0	0	0	16.7
Bank Stability												
%Stable	33.3	86.4	0	100	78.6	0	36	93	50	50	61.1	8.3
%Unstable	66.7	13.6	100	0	21.4	100	64	7	50	50	38.9	91.7
Riparian canopy												
%Artifical Shading	0	0	0	0	0	0	20	0	0	0	0	0
%Mature Native	5	41.7	0	60	0	0	0	50	0	0	55	91.7
%Young Native	25	4.2	5	25	0	0	0	0	25	18.75	5	0
%Exotic Treeland	10	0	30	5	18.8	0	30	12.5	42	6.25	0	0
%Exotic plantation	0	0	0	5	0	0	0	0	8	0	0	0
%None	60	54.2	65	5	81.3	100	50	37.5	25	75	40	8.3
Riparian understorey												
%Artifical Shading	0	0	0	0	0	0	0	0	0	0	0	0
%dense native	0	0	0	20	0	0	0	0	0	0	5	83.3
%thin native	0	0	0	30	0	0	0	31.2	0	0	40	0
%dense exotic	0	8.3	40	10	0	0	0	50	0	0	0	0
%thin exotic -pasture & weeds	100	83.3	60	40	100	100	100	18.8	100	100	50	0
%none - bare ground	0	8.3	0	0	0	0	0	0	0	0	5	16.7

Table 3 cont: Habitat data for 2007 including physiochemical, habitat information, stream habitat quality and Pfankuch stability index for the Resource Consent sites.

Site name	Opouteke	Waipapa (Puketi)	Victoria	Awanui (u/s waihue channel)	Awanui (FNDC take)	Kaeo	Ruakaka	Mangaharuru (Main Rd)	Waiarohia (Whau Valley)	Waiarohia (Lovers Lane)
Site number	102258	101751	105532	100370	100363	102674	105008	100237	107773	105672
Date sampled	28/02/07	28/02/07	5/03/07	5/03/07	5/03/07	5/03/07	21/03/07	21/03/07	21/03/07	21/03/07
Physico-chemical data										
Temperature	19.8	20.8	21.5	21.9	21.1	18.7	15.4	15.5	17	19.2
Dissolved oxygen (mg/L)	8.9	8.35	8.75	9.24	8.6	8.5	6.83	9	8.98	11.03
Conductivity (uS)	130	114.7	164.1	207.2	194.5	130.9	194.7	83.1	482	337
Black disc (m)	2.9	3.95	0.47	1.29	1.94	1.95	0.39	1.94	0.42	1.17
Pfankuch Stability Index										
Upper bank	26	20		35	38	26	15	18	20	23
Lower bank	22	22		37	44	35	30	26	35	18
Bottom (streambed)	25	43		37	28	58	30	31	35	36
Total	**73**	**85**	**0**	**109**	**110**	**119**	**75**	**75**	**90**	**77**
General habitat information										
Mean stream depth	0.66	0.6	0.5	1.5	0.74	1.2	0.6	0.44	32.5	N/A
Mean stream width	18	17	8.1	13.6	9	8	5	4.8	2.9	N/A
Predominant land use	Pasture, planted forest u/s	Native Forest		Pasture	Pasture	pasture, urban (minor u/s)	pasture	planted forest, pasture	Pasture	urban
Livestock access	2	0	1	2	2	0	0	2	2	0
% Channel shading	0	20	20	20	5	30	50	40	40	10
% Filamentous algae	95	<2	5	5	70	0	<10	10	40	50
Macrophytes	R	R	R	C	R	R	R	R	R	C
Stream habitat quality										
Habitat abundance	17	20	10	16	11	6	11	14	12	14
habitat diversity	13	18	15	15	14	11	11	18	15	13
Hydrologic heterogeneity	17	19	13	15	15	12	12	15	14	12
channel alteration	11	20	13	13	7	12	11	13	11	3
Bank stability	17	20	11	13	6	16	16	16	10	14
Channel shade	0	6	9	6	2	8	9	4	4	3
Riparian vegetation	2	19	7	2	2	4	11	6	5	4
Total	**77**	**122**	**78**	**80**	**57**	**69**	**81**	**86**	**71**	**63**
Flow type										
%Pool	0	50	0	20	0	0	25	0	25	N/A
%Riffle	100	37.5	37.5	0	14.3	0	25	40	62.5	N/A
%Run	0	12.5	62.5	80	85.7	100	50	60	12.5	N/A
%Waterfall/chute	0	0	0	0	0	0	0	0	0	N/A

Table 3 cont: Habitat data for 2007 including physiochemical, habitat information, stream habitat quality and Pfankuch stability index for the 22 State of Environment sites.

Site name	Opouteke	Waipapa (Puketi)	Victoria	Awanui (u/s waihue channel)	Awanui (FNDC take)	Kaeo	Ruakaka	Mangaharuru (Main Rd)	Waiarohia (Whau Valley)	Waiarohia (Lovers Lane)
Site number	102258	101751	105532	100370	100363	102674	105008	100237	107773	105672
Inorganic substrate										
%Bedrock	0	0	0	0	0	0	0	0	0	N/A
%Boulder	85	5	0	0	37.2	0	0	1	5	N/A
%Cobble	13	47.5	72.5	0	25.7	0	0	14.4	35	N/A
%Gravel	2	47.5	7.5	5	25.7	60	38	77	5	N/A
%silt/sand	0	0	20	15	11.4	20	14	5.1	20	N/A
%Hard clays	0	0	0	80	0	20	48	2.5	0	N/A
%manmade	0	0	0	0	0	0	0	0	35	N/A
Organic substrate										
%detritus	1	22	17.5	8	2.9	2	1	1.8	5	N/A
%bryophytes	0	0	0	0	0	0	0	1	10	N/A
%macrophytes	2	1	2.5	35	8.6	0	2	1.4	40	N/A
%Algae	85	67	27.5	30	68.6	0	20	51	35	N/A
%Woody debris	2	0	7.5	5	2.9	2	4	0.8	5	N/A
%Tree roots	0	0	7.5	2	0	0	1	0	0	N/A
%None	10	10	37.5	20	17.1	96	72	44	5	N/A
Bank type										
%Earth	0	100	62.5	100	64.3	100	100	100	100	N/A
%Rock	0	0	0	0	0	0	0	0	0	N/A
%Mix	1	0	37.5	0	35.7	0	0	0	0	N/A
%manmade	0	0	0	0	0	0	0	0	0	N/A
Bank Stability										
%Stable	44	100	56.3	60	78.6	70	50	80	100	N/A
%Unstable	56	0	43.7	40	21.4	30	50	20	0	N/A
Riparian canopy										
%Artifical Shading	0	0	0	0	0	0	0	0	0	N/A
%Mature Native	0	100	0	8.3	0	6	50	66.7	33.3	N/A
%Young Native	5	0	0	0	0	6	0	8.3	16.7	N/A
%Exotic Treeland	0	0	56.3	41.6	50	25	33	0	0	N/A
%Exotic plantation	0	0	6.3	0	0	0	0	16.7	0	N/A
%None	95	0	37.5	50	50	63	17	8.3	50	N/A
Riparian understorey										
%Artifical Shading	0	0	0	0	0	0	0	0	0	N/A
%dense native	0	100	0	0	0	0	0	0	0	N/A
%thin native	0	0	0	0	0	0	0	8.3	0	N/A
%dense exotic	0	0	31.3	25	93.75	0	0	0	0	N/A
%thin exotic -pasture & weeds	100	0	68.7	75	6.25	94	100	91.7	91.7	N/A
%none - bare ground	0	0	0	0	0	6	0	0	8.3	N/A

Appendix B: Habitat data for resource consent sites

Table 4: Habitat data for 2007 including physiochemical, habitat information, stream habitat quality and Pfankuch stability index for the resource consent sites.

Site name	Dam A d/s	Dam A u/s	Dam C d/s	Dam C u/s	Oxidation pond A d/s	Oxidation pond A u/s	Meatworks d/s	Meatworks u/s	Oxidation pond B d/s	Oxidation pond B u/s	Quarry d/s	Quarry u/s
Site number	105937	106114	106508	106509	100280	100279	100010	100007	103317	103316	103824	103823
Date	6/03/07	6/03/07	7/03/07	7/03/07	6/03/07	6/03/07	7/03/07	7/03/07	7/03/2007	7/03/07	5/03/07	5/03/07
Physico-chemical data												
Temperature	21.7	16.2	17.3	18.6	17.8	17.9	19.6	19.8	19.2	18.9	18.1	18.5
Dissolved oxygen (mg/L)	7	8.82	6.82	9.35	3.2	5.4	6.02	7.67	9.48	9.6	7.8	7.8
Conductivity (uS)	63	62.8	116.9	145.6	1064	1013	168.3	153	125.6	92.2	84.6	84.4
Black disc (m)	0.9	3	2	0.99	1.12	2.15	1.04	1.28	1.2	2.01	2.41	3.06
Pfankuch Stability Index												
Upper Bank	19	18	19	14	25	25	18	22	18	21	24	24
Lower Bank	26	14	14	20	26	26	37	33	24	24	16	16
Bottom (streambed)	15	15	15	28	30	30	45	26	15	15	16	19
Total	60	47	48	62	81	81	100	81	57	60	56	59
General habitat information												
Mean stream depth	0.8	0.75	0.5	0.34	1.2	1.2	0.92	1.1	1.09	0.61	0.62	0.15
Mean stream width	1.5	5.2	1.9	4.4	2.4	2.5	8	7.7	15.43	7.8	7.8	2
Predominant land use	pasture	forestry/ pasture.	pasture	forestry/ pasture	pasture	pasture	pasture	pasture	Forestry/ pasture	Forestry/ pasture	Native scrub	Scrub/ pasture
Livestock access	2	0	0	0	1	1	2	2	2	2	0	0
% channel shading	0	80	90	95	0	<2	50	60	30	60	70	90
% Filamentous algae	20	<2	<2	<2	40	45	<5	<2	60	10	<5	<5
Macrophytes	C	R	C	R	A	A	C	R	R	R	R	R
Stream habitat quality												
Habitat abundance	15	19	16	20	17	18	16	15	18	18	19	19
habitat diversity	9	16	11	18	11	11	15	15	18	19	16	19
Hydrologic heterogeneity	6	19	17	16	10	10	15	14	17	18	15	16
channel alteration	5	20	12	15	9	10	12	15	17	17	16	16
Bank stability	12	20	18	18	16	16	11	14	14	14	18	16
Channel shade	0	17	18	20	0	1	9	11	7	11	14	18
Riparian vegetation	2	16	10	18	3	3	4	11	11	10	16	14
Total	49	127	102	125	66	69	82	95	102	107	114	118
Flow type												
%Pool	0	33.3	28.6	28.6	0	0	0	62.5	0	22.2	40	25
%Riffle	10	16.7	0	57.1	0	0	0	0	28.6	44.4	60	50
%Run	90	33.3	42.8	14.3	100	100	100	37.5	71.4	33.3	0	25
%Waterfall/chute	0	16.7	28.6	0	0	0	0	0	0	0	0	0

Table 4 cont: Habitat data for 2007 including physiochemical, habitat information, stream habitat quality and Pfankuch stability index for the resource consent sites.

Site name	Dam A d/s	Dam A u/s	Dam C d/s	Dam C u/s	Oxidation pond A d/s	Oxidation pond A u/s	Meatworks d/s	Meatworks u/s	Oxidation pond B d/s	Oxidation pond B u/s	Quarry d/s	Quarry u/s
Site number	105937	106114	106508	106509	100280	100279	100010	100007	103317	103316	103824	103823
Inorganic substrate												
%Bedrock	0	73.3	62.9	0	0	0	0	0	0	0	0	0
%Boulder	0	10	0	22.9	0	0	0	12.5	5	73.3	44	40
%Cobble	0	6.7	0	37.1	0	0	0	5	5	15.6	32	40
%Gravel	5	10	22.9	28.6	57.1	100	35	55	20	6.6	24	20
%silt/sand	20	0	14.2	11.4	42.9	0	35	25	20	4.4	0	0
%Hard clays	75	0	0	0	0	0	30	2.5	50	0	0	0
%manmade	0	0	0	0	0	0	0	0	0	0	0	0
Organic substrate												
%detritus	2.5	6.7	25.7	22.9	0	0	0	10	5	4.4	2	10
%bryophytes	0	36.7	22.9	0	0	0	0	0	10	4.4	0	40
%macrophytes	20	0	14.2	2.9	91.4	100	30	0	0	8.9	0	0
%Algae	70	30	37.1	48.6	0	0	40	0	30	57.8	40	20
%Woody debris	2.5	13.3	0	0	0	0	10	32.5	25	2.2	5	10
%Tree roots	0	0	0	0	0	0	10	0	20	4.4	0	0
%None	5	13.3	0	25.7	8.6	0	10	57.5	10	17.7	53	20
Riparian canopy												
%Mature Native	0	66.7	43.75	62.5	0	16.6	0	58.3	43.8	0	100	50
%Young Native	0	0	0	0	0	0	0	0	0	5	0	50
%Exotic Treeland	15	0	0	18.8	6.3	33.3	37.5	16.7	31.2	30	0	0
%Exotic plantation	0	0	0	0	6.3	0	0	0	0	10	0	0
%None	85	33.3	56.25	18.8	87.5	50	62.5	25	25	55	0	0
Riparian understorey												
%dense native	0	0	0	37.5	0	0	0	0	0	10	100	25
%thin native	0	83.3	18.75	0	0	0	0	50	0	10	0	25
%dense exotic	0	0	0	0	18.8	0	0	0	0	65	0	0
%thin exotic -pasture & weeds	100	0	81.25	62.5	68.8	75	100	50	100	15	0	50
%none - bare ground	0	16.6	0	0	12.5	25	0	0	0	0	0	0

Appendix C: Periphyton data

Table 5: Relative abundance of periphyton taxon at 18 RWQMN sites and chlorophyll α levels. Note for ranked abundance codes: 8 = dominant, 7 = abundant, 5 = common, 3 = occasional and 1 = rare.

Site description		Waiotu @ SH1	Whakapara @ cableway	Waipoua @ SH12	Kaihu @ gorge	Mangakahia @ Titoki	Opouteke @ gorge	Mangakahia @ Twin bridges	Punakitere @ recorder	Waipapa @ Forest Ranger	Waitangi @ Waimate	Victoria @ Thompson bridge	Awanui @ FNDC take	Waiharakeke @ Stringer Rd	Ruakaka @ Flyger Rd	Mangahahuru @ Apotu Rd	Mangahahuru @ Main Rd	Waiarohia @ Whau Valley	Waiarohia @ Lovers Lane
NRC site no.		102248	102249	103304	102256	101038	102258	103307	105231	101751	103178	105532	100363	100007	105008	100281	100237	107773	108359
Date collected:		27-Feb	27-Feb	27-Feb	27-Feb	28-Feb	28-Feb	28-Feb	28-Feb	28-Feb	28-Feb	05-Mar	05-Mar	07-Mar	21-Mar	21-Mar	21-Mar	21-Mar	21-Mar
Chlorophyll α	Mean	28.5	12.9	18.2	3.8	57.4	16.2	0.7	71.8	0.7	19.5	34.3	223.3	16.4	44.6	29.5	86.9	149.9	138.3
	Standard deviation	17.8	18.1	12.6	6.2	68.1	13.0	0.0	87.6	0.0	4.6	35.9	125.1	5.9	33.1	12.4	82.0	103.2	63.2
Blue greens (Cyanophyceae)	*Chamaesiphon* sp.														2				
	Coleodesmium sp.			7															
	Homoeothrix sp.														4				
	Nostoc sp.												4						
	Oscillatoria sp.	5													5				
	Phormidium sp.			8		8			8					5	1		1	2	
Desmids (Mesotaeniaceae, Desmidiaceae)	*Closterium* sp.		4								3						2		
	Spirogyra sp.															2			
Diatoms (Bacillariophyceae)	*Cocconeis* sp.	4	3	4								3	3	3	1		1	1	2
	Cymbella sp.				5		3			3	7	3	5						
	Epithemia sp.							4											
	Eunotia sp.																		2
	Fragilariforma sp.											8	7						
	Gomphoneis sp.			3			3	5		7	5	4	3	8	6	5	1		3
	Gyrosigma sp.					3			3										
	Melosira sp.		5				8	3	4				6			3			8
	Navicula sp.								5								3	3	3
	Nitzschia sp.														2		2	2	
	Rhoicosphenia sp.	8							3					3	6	6	5	3	4
	Unident. diatom				4		3			3									
	Stauroneis sp.										5								
	Synedra sp.			3	7					5	8	5				1		5	6
Greens (Chlorophyceae)	*Cladophora* sp.		8													3			5
	Eudorina elegans																		1
	Miicrospora sp.																8		2
	Oedogonium sp.	7	7			7	6	5											
	Spirogyra sp.				5							6	8				5	8	
	Stigeoclonium sp.				8			8		8		6				6			
	Ulothrix sp.															2			
Red algae (Rhodophyta)	*Audouinella* sp.	6				5								5	8	5		4	
	Compsopogon sp.					5										8			
Number of taxon		5	5	5	5	5	5	5	5	5	5	7	7	5	9	10	9	8	10