Whanganui Catchment Ecological Health Assessment – Year One

Authors:

Miller, R.J[1], Death, R.G[2], Taylor, J[3]

[1] Freshwater Technical Advisor, Department of Conservation, Private Bag 3016, Whanganui.

[2] Freshwater Ecologist, River Research, RD14 Pohangina, 4844, Palmerston North

[3]River Restoration Ranger, Department of Conservation, Private Bag 3016, Whanganui.

Department of Conservation
Te Papa Atawhai

New Zealand Government

Cover: Upper Whanganui River site. Photo: Jane Taylor

DOCM-7529317

In the interest of forest conservation, we support paperless electronic publishing.

Contents

1 Summary

The primary aim of this work was for the Department of Conservation (DOC) to support hapū and iwi aspirations for improved ecological health in the Whanganui River by providing a practical opportunity to get into the river together, to build relationships, to start building capability and to increase understanding across all parties.

Both DOC and hapū are curious to better understand how healthy the river is. One of the best ways of determining that is by looking at the aquatic invertebrates (the small animals that live on rocks in the stream). While Horizons and NIWA do annual monitoring, this is only at 6 sites, and most are in the mainstem. A comprehensive one-off survey of aquatic invertebrate communities across the whole catchment was undertaken by Jonathan Horrox, a Master's student at Massey University in 1997 (Horrox, 1998). That study found that ecological health was high in both forested mudstone streams and forested hardstone streams but was lower in mudstone pasture streams than in hardstone pasture streams, suggesting that the soft geology streams were more susceptible to the impacts of agricultural development.

The other aim of this work was to re-survey those previously surveyed sites to determine how healthy they are today, and within the limitations of a one-off snapshot survey, see whether they had changed over the intervening 26 years. Re-surveying these sites was also an opportunity to assess whether the relationship between geology, land use and stream health detected by Horrox still held. This has implications for managing the catchment and for prioritising restoration efforts.

The purpose of this report is to present the results of the first year of survey work back to the hapū involved and to others interested in the health of the river. The prime consideration in selecting sites was the receptivity of hapū to the project and their capacity to be involved. As this took time and discussions to ensure we connected with the right people, only 10 of the original 53 sites were sampled in this first year.

The composition of the aquatic invertebrate community was used to evaluate ecological health at the sites and to compare it between the two surveys.

Ecological health across the 10 sites was found to be high in the more pristine (more native vegetation in the catchment) sites and average or low in the pasture sites. We observed lower ecological health than in the earlier study, particularly in the pasture sites. Horizons' monitoring has found ecological health at their annually monitored sites to be either stable or declining, which, combined with our results, albeit from a one-off snapshot, raises concerns about potential declining ecological health at these sites over the last few decades.

It is recommended that the remaining sites from the original survey are re-visited in partnership with hapū, that potential causes of decline are investigated and that management interventions such as riparian planting, sediment reduction measures or land-use change are implemented. We also recommend that it is timely to explore the development of a more comprehensive coordinated catchment wide monitoring programme that draws on both western science monitoring and mātauranga Māori.

2 Introduction

The makeup of stream invertebrate communities (animals such as snails, worms, and the juveniles of flies, dragon flies, mayflies, stoneflies, midges and caddisflies) reflects the ecological health of a stream. In just the same way human health is assessed by measuring blood pressure, kidney function, weight, lung capacity, blood sugar and more. Some of these animals can only live in places with good habitat and high water quality. Others can survive anywhere, and some are more typical of degraded habitat or poor water quality. They are sensitive to temperature, levels of oxygen available in the water and the effects of land-use.

In the Whanganui catchment the aquatic invertebrate community is also affected by the underlying catchment geology (e.g., hard geology or greywacke versus soft geology such as mudstone or papa).

Juvenile mayflies are indicators of good water quality.
Photo: Angus McIntosh, Uni of Canterbury

The last comprehensive survey of the instream ecological health of the Whanganui catchment was conducted by a Massey University student who sampled 53 sites throughout the catchment across two summers in 1996 and 1997 (Horrox, 1998). He found that the healthiest stream invertebrate communities were in forested areas, and those in farmed land were not as healthy, being less diverse with species more tolerant of pollution. This was most apparent in the mudstone catchments which he concluded were more vulnerable to land use impacts. Similar results have been found in Tairāwhiti in a study by Hunter *et al.* (in prep).

DOC is working with hapū to re-survey those same sites (see map in Appendix 1) to investigate how ecological health might have changed over the last 26 years, whether the stream invertebrate communities have changed in response to land-use changes, and whether hard or soft geology catchments have different types of ecological health depending on their land-uses.

Horizons Regional Council annually monitors the invertebrate community at six sites, four in the mainstem of the Whanganui (at Pipiriki, at Te Maire, at Cherry Grove and at Pipiriki) and in two tributaries (Manganui o te Ao at Ashford and Ongarue at Taringamotu) as part of their State of the Environment monitoring programme. NIWA also monitors the invertebrate community at two sites in the mainstem – at Te Maire, and at Paetawa. These annual monitoring programmes provide information on the state and trend of ecological health at these sites[1], and provide valuable context when attempting to compare the results from 1996/7 to 2021-22.

This interim report looks at the results from the first year of sampling (summer of 2021-22) which re-surveyed 10 of the original Horrox (1998) sites. It is proposed to re-survey the rest of the these sites over the next two summers. There is currently no plan for any future re-surveying of these

[1] Land, Air, Water Aotearoa (LAWA) - Whanganui

sites although if a comprehensive monitoring plan was developed for the catchment, it might be sensible to include some of these sites with historic data.

3 Methods

Site selection:

A key objective of this work was to undertake the work in partnership with hapū. Assessing stream health is a practical means for hapū to assert their kaitiaki and connection with their awa. Therefore, the prime consideration in selecting which of the Horrox sites to re-survey was the receptivity of hapū to the project and their capacity to be involved.

Field and laboratory methods:

Using the same methods as in the original study, rocks were scrubbed from a set area of stream bed (0.01 m^2) and the stream invertebrates caught in a net using a Surber sampler. Five samples were taken from each site. They were then sent to a specialist laboratory (Aquanet, Palmerston North) for processing (identifying what species had been caught and in what numbers) under microscope.

Periphyton is the slime that accumulates on rocks which is the source of food for stream invertebrates in moderate amounts but can become overly abundant and smother them in times of high nutrients, low flow and/or high temperatures. Samples of periphyton were taken from rocks and submitted to Hills laboratory for analysis.

Other instream habitat data gathered included a suite of water quality measurements (conductivity, temperature, dissolved oxygen, pH, turbidity, black disk (where conditions were suitable), habitat type (proportion of run, riffle, pool types of habitat), substrate size (proportion of different sized rocks making up the stream bottom) and Pfankuch stream bed stability.

The Stream Health Check, developed for Beef and Lamb[2] is a questionnaire that evaluates bank side vegetation, bank erosion, land drainage, and sediment deposition. The scores are totalled, and overall final scores can range from 50 to 500. A score greater than 250 indicates a healthy stream while a score of less than 120 indicates that there are aspects of the waterway contributing to low ecological health. The Stream Health Check scores have been shown to correlate strongly with MCI and QMCI measures (Death et al., in prep).

In addition to the data gathered at the site, a GIS assessment was made of the change in land-use above each of the sampling points by examining the proportion of land use identified through the Land Cover Database (LCDB) in 1996 and 2018.

For data analysis methodology see the Appendix I.

[2] Stream health | Beef + Lamb New Zealand (beeflambnz.com)

4 Results

4.1 Working with tangata whenua

DOC working alongside hapū in undertaking the stream health evaluation using technical assessments helped demystify these techniques and start the upskilling and building of hapū capacity. Working collaboratively on this survey provided both DOC and hapū an opportunity for relationship building and for connecting together in the river.

In addition, and significantly, hapū representatives provided knowledge they had of the cultural significance of the site and any known mātauranga Māori to complement the technical data. The mātauranga gathered at each site from hapū representatives will not be included in this report as it belongs to the hapū. Individual site reports have been prepared capturing that knowledge along with the site-specific technical results.

Two of the proposed sites were identified by hapū as wāhi tapu so they were excluded from the study out of respect for this additional information.

4.2 Stream health in 2022

The stream invertebrate community results were used to derive two measures of stream health:

- MCI or Macroinvertebrate Community Index which amalgamates the presence/absence of different species based on their sensitivity to pollution.
- QMCI or quantitative MCI which includes a measure of the total numbers of individual species.

These indices are used in the National Policy Statement for Freshwater Management (NPSFM) to assess ecological health within graded bands. An index in the A-band is indicative of pristine conditions and high ecological integrity or health. B-band indicates invertebrate communities with some loss of ecological health and more likely to include species sensitive to pollution. C-band indicates some moderate pollution while D-band is reserved for those sites below the National bottom line with poor ecological health.

The NPSFM bands are used here to place the results in a national context and to provide an indication of current ecological health. However, the bands are technically for repeat monitoring data (using the five-year-median score) as these metrices can vary between years.

Table 1 sets out the results for the 10 sites for each of these indices and their corresponding band. This helps answer the question of 'is this stream healthy', although the answer can depend on the index used. In our view the QMCI is the best indicator of overall health as it incorporates both the diversity of species and their respective abundances. Overall, the indices identified 2 of the 10 sites fall below the national bottom line for one metric and four were in the A band for at least two metrices.

Table 1: Stream invertebrate health results from summer 2022 survey

Site	Geology	Land use - % indigenous vegetation[3]	Stream health check	MCI	MCI NPS class	QMCI	QMCI NPS Band
Kaiwhakauka	soft	97	444	131	A	7.2	A
Pumice Creek	hard	100	438	130	A	6.5	A
Whakapapanui	hard	81	424	135	A	6.8	A
Whanganui	soft	96	460	146	A	7.5	A
Motuaruhe	soft	45	230	104	B	4.5	D
Kauarapaoa	soft	80	432	111	B	5.9	B
Operiki	soft	80	368	116	B	6.4	B
Stream X[4]	soft	27	320	98	B	4.9	C
Mangare	soft	39	188	113	B	5.9	B
Whangamomona	soft	37	168	98	C	4.4	D

The Stream Health Check is designed for farmers/citizens to assess the impact of surrounding land-use on their waterway to see if better management is required or if a more rigorous or technical assessment is required. It is also a useful way of quantifying some 'intuitive' aspects of stream health assessments'.

Seven of the sites scored over 250, indicating healthy conditions, and three sites scored between 120 and 250 indicating that these sites had potential but intermediate health (Table 1). No sites scored less than 120.

There was a strong correlation between the MCI and the stream health check scores (Figure 1), indicating that the stream health check could be a useful, and less expensive or technical means for assessing and reporting on stream health (Death *et al*, in prep).

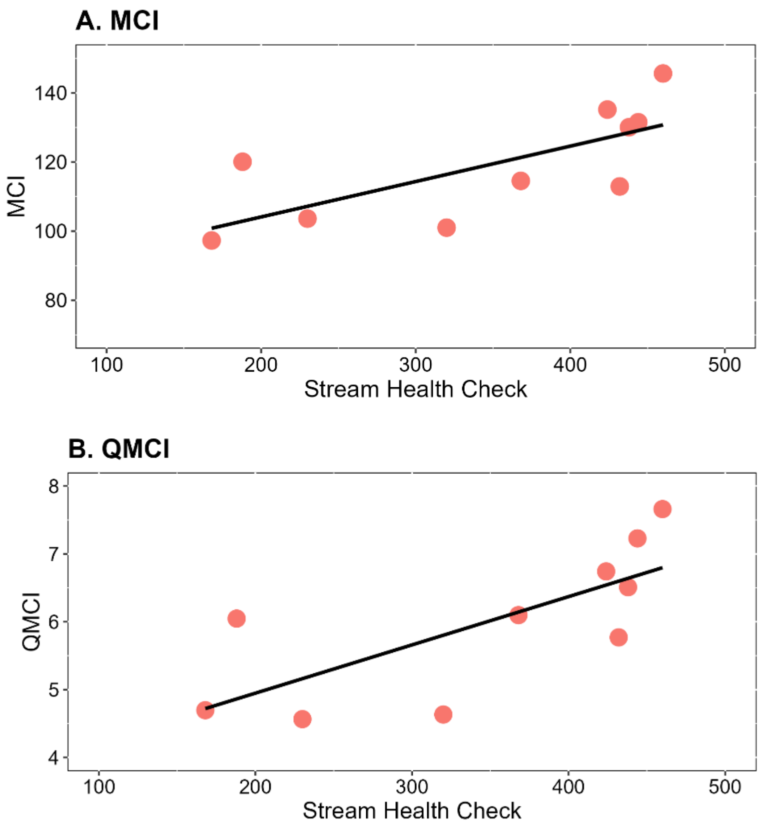


Figure 1: Stream health check scores compared with MCI and QMCI

[3] From LCDB from 2018: alpine grassland, broadleaved indigenous hardwood, indigenous forest, manuka or kanuka, sub alpine tussock and tall tussock.
[4] Site name withheld from wider publication on request from hapū

4.3 *Land use above the sites in 2022*

Many other studies have demonstrated a strong link between land-use and ecological health (e.g. Allan, 2004, MfE, 2017). The land-use above each sampling point was determined using the New Zealand Land Cover Database. The total size of the catchments ranged from very small (Pumice Creek, total size 150 ha dominated by alpine grass/herbfield) and Operiki (total size 460 ha dominated by native vegetation) to large (Whangamomona (7366 ha) dominated by pasture grass, the Whakapapanui (6864 ha) dominated by sub alpine and tall tussock and the Kauarapaoa (6110 ha), dominated by native vegetation (Figure 2).

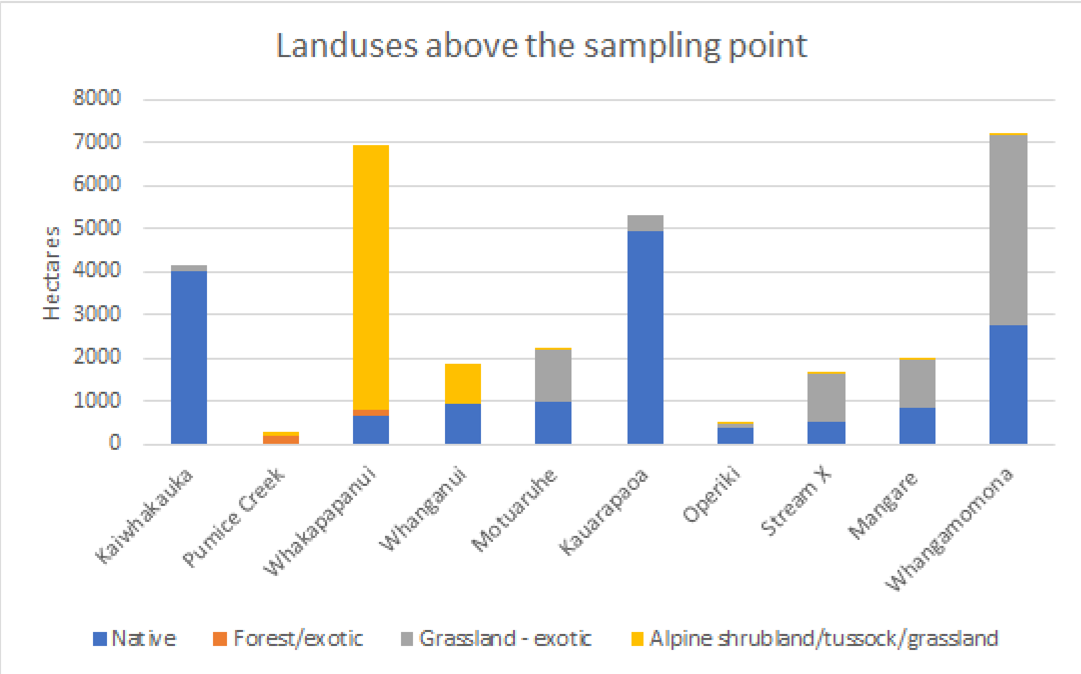


Figure 2: Size of catchment above each sampling point (total height of bar) and land use.

4.4 *Stream health changes since 1996*

Determining longer term temporal trends in ecological data is fraught with challenges given how variable conditions can be from year to year . Examining only two points in time isn't sufficient to understand whether real long term change has occurred between two surveys.

That said, we considered that revisiting historic sites was still worthwhile and helpful for the wider conversation around the ecological health of the river.

The same two indices were used to compare the ecological health between the two surveys – MCI and QMCI.

We followed the same methodology as in the Horrox study and collected five samples per site. This enabled us to calculate a median score per site and to graph that median along with the range to generate the following box plots. These are useful because where there is no overlap between the bars from the two surveys, then there

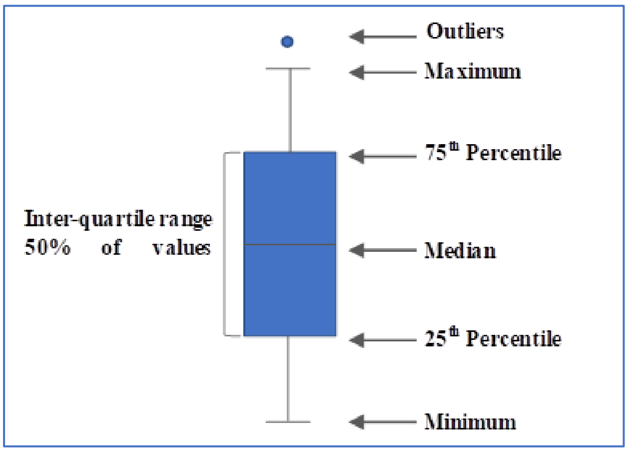


Figure 3: Box plots show the median (the middle line) and the range of data (the lines)

is a significant difference. For some sites, there was a drop in median value and the bars didn't overlap, although this didn't result in a drop in NPSFM band (e.g. the Pumice Creek site for MCI still remained in the A band even though the 2022 results were lower than the 1996/97 results).

Figures 4-5 illustrate for each site, which sites were in the A, B, C or C band in each year for both MCI and QMCI. They illustrate whether there has been a change, and whether this has resulted in a drop in NPSFM band.

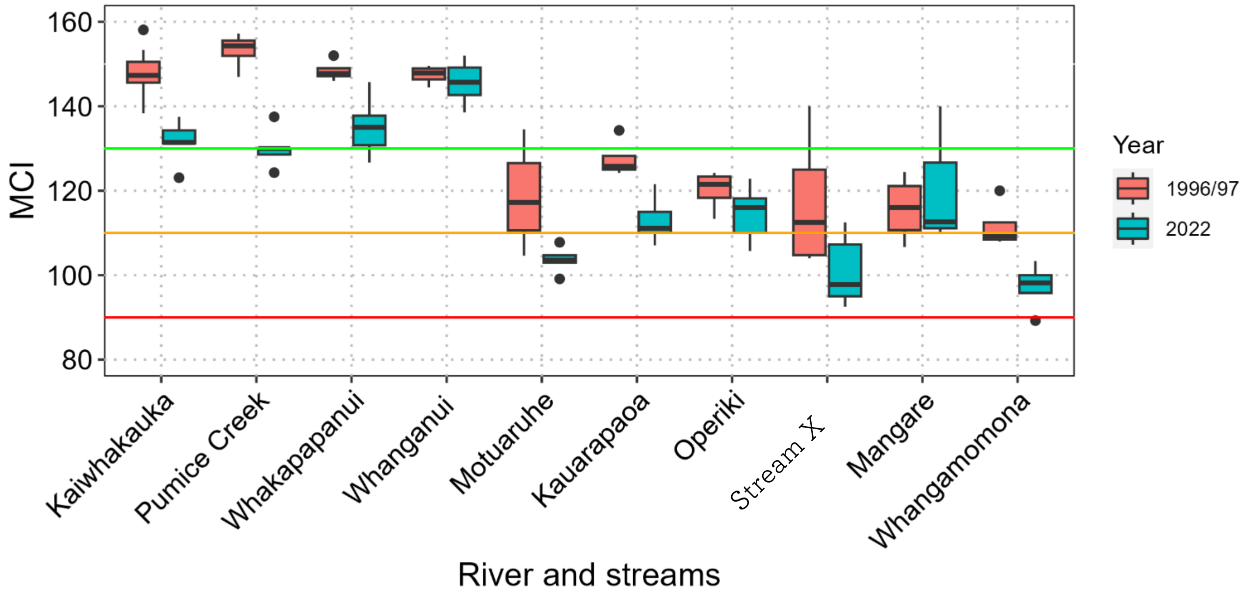


Figure 4: Change in MCI between 1996/97 and 2022. Above the green line is band A, above the orange line is band B, above the red line is band C and below the red line is D.

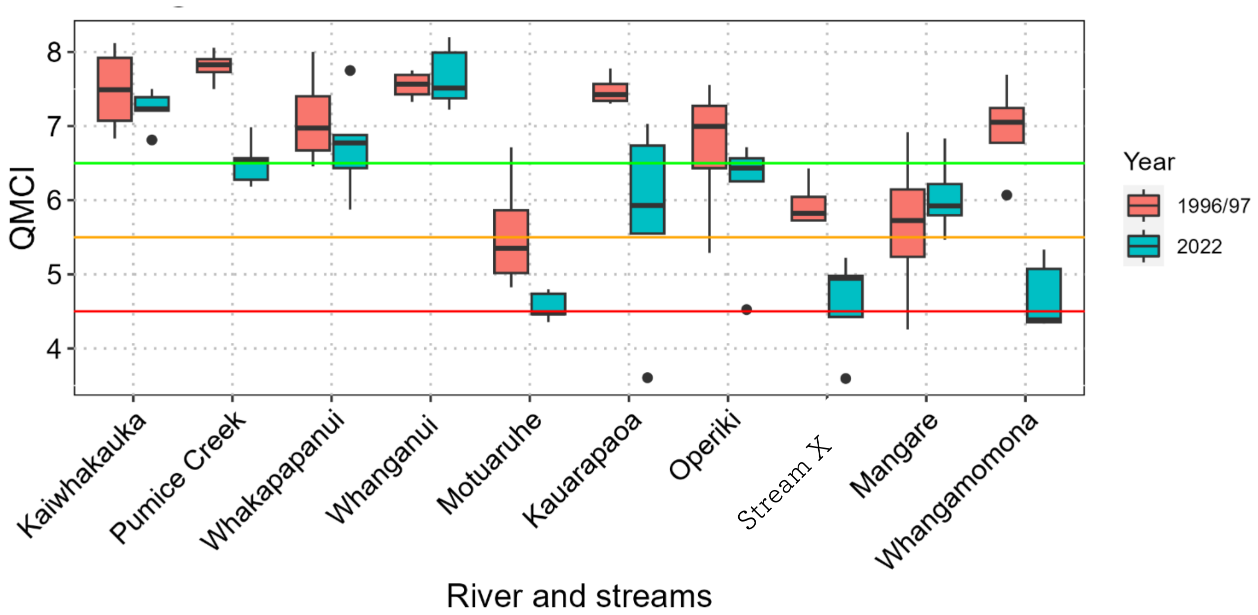


Figure 5: Changes in QMCI between 1996/97 and 2022. Above the green line is band A, above the orange line is band B, above the red line is band C and below the red line is D.

In summary, six sites demonstrated a decrease in MCI with two of those sites dropping down a band (from B to C). Five sites showed a decrease in QMCI, all large enough to result in a decrease in band – three sites dropping a band, one site dropping two bands, and one site dropping three bands (from an A to a D).

Sites which originally had a high ecological health had not changed band (Kaiwhakauka, Pumice Creek, Whakapapanui and the headwaters of the Whanganui). Those sites which had lower ecological health in the 1990s, were the ones where decreases in band were detected. Furthermore, sites with a significant amount of native vegetation in their catchment did not decrease in bands (Table 3).

For more technical detail on the results, and statistical tests of differences see Appendix II.

Table 3: Summary of NPSFM bands for each site for each sampling occasion.

- = no change ↓ = dropped one band, ↓ ↓ = dropped two bands ↓ ↓ ↓ = dropped three bands

	Geology	Land use - % indigenous vegetation[5]	MCI NPSFM band			QMCI NPSFM band		
			96/97	2022	Change	96/97	2022	Change
Kaiwhakauka	Soft	97	A	A	-	A	A	-
Pumice Creek	Hard	100	A	A	-	A	A	-
Whakapapanui	Hard	81	A	A	-	A	A	-
Whanganui	Soft	96	A	A	-	A	A	-
Motuaruhe	Soft	45	B	C	↓	B	D	↓ ↓
Kauarapaoa	Soft	80	B	B	-	A	B	↓
Operiki	Soft	80	B	B	-	A	B	↓
Stream X	Soft	27	B	C	↓	B	C	↓
Mangare	Soft	39	B	B	-	B	B	-
Whangamomona	Soft	37	C	C	-	A	D	↓ ↓ ↓

4.5 *Changes in invertebrate community composition*

The biological indices (MCI, QMCI) described above summarise the collective response of individual species based on their sensitivity to environmental stressors such as high nutrients. For example, *Stenoperla*, a stonefly larvae, has an MCI score of 10 because it needs exceptionally clean water to survive, whereas *Chironomus*, a midge larvae, has an MCI score of 1 because this species can live in habitats with very low oxygen levels. Biological indices are very useful for summarising information into a single number that can be compared to national standards for the maintenance of water quality as we have done above with reference to the NPSFM bands, however they do obscure a lot of information on how the species have actually responded to their environments.

[5] From LCDB from 2018: alpine grassland, broadleaved indigenous hardwood, indigenous forest, manuka or kanuka, sub alpine tussock and tall tussock.

It is often useful to look at changes in the overall composition of the invertebrate communities to see whether some species may be responding differently to particular stresses at each site that might be lost when data is summarised in a single index number. Multivariate statistics (further explained in Appendix II) can be used to compare the communities according to all the species that make them up. Communities are then graphed – those that are very similar are closer together in the graph whereas those that are very different are further apart. The further away from each other they are the more different they are in composition (refer resulting graph in Appendix II).

This analysis showed that the invertebrate communities at the Mangare and the Kaiwhakauka sites were very similar in 2022 as they had been in 1996/97, whereas the make-up of the invertebrate communities from Stream X and Whangamomona had changed the most suggesting that the overall composition of invertebrates had changed at these sites.

To explore why the invertebrate communities at some sites are more similar we examined how the habitat variables differed between the sites (again, detail on this in Appendix II). We did this for just the 2022 data. We found that the invertebrate communities from Whanganui, Kaiwhakauka and Pumice Creek were associated with measurements of low conductivity, low temperature and high Stream Health Check scores, i.e. the more pristine habitats. Whereas invertebrate communities from Whangamomona, Motuaruhe and Stream X are correlated with having high conductivity and temperature (indicators of more impaired conditions).

Finally, we looked at what individual species were associated with these patterns. We found that the more impacted sites featured beetle larvae and worms which often prefer habitats with high levels of fine sediment and/or lower water quality. We can conclude that the Operiki site probably had good water quality (because of where it appeared on the graph) but reasonable levels of periphyton as the caddisfly *Pycnocentria* found there feed on algae in moderately good water quality sites. The more pristine sites featured species known to prefer good water quality and habitat such as stoneflies (*Stenoperla* and *Austroperla*), a mayfly (*Ameletopsis*), a beetle (*Scritidae*) and a caddisfly (*Hydrochorema*).

Cased caddisfly (*Pycnocentrodes* sp.) grazing on algal covered rock. Photo credit: A McIntosh.

4.6 Changes in land use since 1996

The proportions of the catchments covered by the key land-uses of interest (native vegetation, forestry and grassland) were examined to see how these had changed between the landcover database in 1996 and the landcover database in 2018 (the most recent land cover database). For example, in the Operiki sub-catchment, 15% more of the catchment was in native vegetation in 2022 (using the 2018 landcover database information) than in 1996 and there was 15% less grassland (Figure 6). Four sub-catchments showed some change in land use: Motuaruhe (more grassland less native vegetation), Operiki (more native vegetation, less grassland), Kauarapaoa (more forestry, less grassland) and Mangare (more forestry and less grassland and native vegetation). This also illustrates the catchments where there has been little or no change in land use – Whakapapanui, Whanganui headwaters and Pumice Creek.

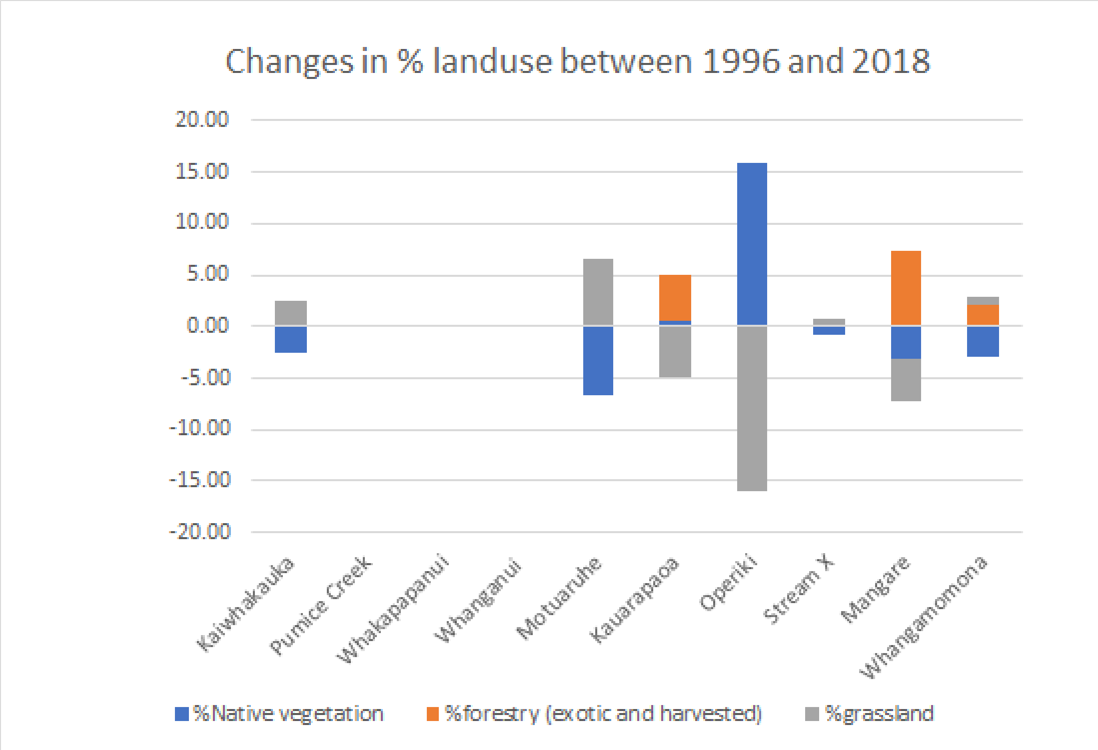


Figure 6: Changes in the proportion of each catchment between the 1996 and 2018.

4.7 *Drivers of observed changes*

Overall decline in ecological health at these sites could not be directly attributed to land-use change, although some of the changes at individual sites may be related to land use change.

For example, Motuaruhe had more grassland and less native vegetation and showed drops in NPSFM band for both indices; Operiki had more native vegetation, less grassland yet still showed a drop in band for one index and Kauarapaoa had more forestry and less grassland and showed a drop in band for one index.

Photos and observations in the field highlighted that in some sites, particularly Whangamomona and Motuaruhe there was a considerable amount of deposited fine sediment. Large amounts of deposited sediment could be from landslides close to the river or land disturbance activities further up the catchment. These sites were characterised by low ecological health.

Sediment covered rocks at the Whangamomona site, a soft geology site

5 Discussion

5.1 Ecological health varies according to land-use and geology

Of the ten sites re-surveyed, two were of hard geology, and both had a high percentage of native vegetation in their catchments and so, unsurprisingly, had good ecological health. Of the eight streams from soft geology, four had over 80% indigenous vegetation in their catchment, scored in either the A or B bands indicating good or a reasonable level of ecological health irrespective of their geology.

Sites from catchments with less than 50% indigenous vegetation had much poorer ecological health. Again, this is unsurprising as many studies have found similar results when comparing pasture sites with native vegetation sites. One of our sites, the Mangare stream, had reasonable health (in the B-band) which we attributed to our observation of increased planting with redwood pines.

Although it can weaken the statistical power of conclusions we can make about the state of entire Whanganui catchment by resampling specific sites rather than those selected at random our results still support the importance of revegetation programmes in the catchment to improve instream ecological health. Re-surveying the remaining sites throughout the catchment in both soft and hard geologies, and in catchments dominated by native vegetation and those dominated by pasture will enable us to further explore if streams in soft geologies are indeed more vulnerable to land-use.

5.2 State of Environment monitoring of invertebrate communities

This study is a snapshot in time from only two occasions and thus has some limitations. To put our results in a wider context where monitoring on a more regular basis has occurred, we examined the results and trends from the Horizons' State of Environment (SOE) data. Horizons Regional Council has been annually monitoring the invertebrate community at six sites, four in the mainstem of the Whanganui (at Pipiriki, at Te Maire, at Cherry Grove and at Pipiriki) and in two tributaries (Manganui o te Ao at Ashford and Ongarue at Taringamotu) as part of their State of the Environment monitoring programme for 25 years. NIWA also monitors the invertebrate community at two sites in the mainstem – at Te Maire, and at Paetawa with data dating back to 1989. These annual monitoring programmes provide information on the state and trend of ecological health at these sites[6], and provide valuable context when attempting to compare the results from 1996/7 to 2021-22.

Making sense of long-term trends can be complicated. LAWA (Land and Water Aotearoa) is the national website that presents the results from all regional council state of environment monitoring. The trends over the last 10 years from the Whanganui catchment are summarised in Table 5 below. Horizons has found that some of these trends, when considered over a 20-year period are not declining. Thus, we think it is fair to say that the ecological health at these sites is either declining or staying the same, certainly there is no suggestion that the health of the awa is improving. This is consistent with our observations.

[6] Land, Air, Water Aotearoa (LAWA) - Whanganui

Table 5: Bands and trends in stream health from Horizons SOE monitoring as shown on LAWA for 10 year trends.

Site	MCI band	MCI Trend	QMCI band	QMCI Trend
Ongarue at Taringamotu	B	[likely degrading]	B	[likely improving]
Whanganui at Cherry Grove	C	[likely degrading]	C	[very likely degrading]
Whanganui at Te Maire (NIWA)	B	[very likely degrading]	D	[likely degrading]
Whanganui at Te Maire (Horizons)	C	[likely degrading]	C	[indeterminant]
Whanganui at Wades Landing	C	[very likely degrading]	D	[likely degrading]
Manganui o te Ao at Ashworth	C	[very likely degrading]	D	[very likely degrading]
Whanganui at Pipiriki	C	[likely degrading]	D	[likely degrading]
Whanganui at Paetawa	C	[very likely degrading]	D	[likely improving]

Key:

[icon] = likely degrading	[icon] = very likely degrading	[icon] Likely improving	[icon] Indeterminant

5.3 *Ecological health at these sites looks to have declined.*

In our opinion it is concerning that none of the sites surveyed had better ecological health than they had 26 years ago in 1997/97, and that many had poorer ecological health; some sites much worse. Granted our abilities to make firm conclusions is limited but our results provide a strong weight of evidence that there is an overall decline in ecological health at many sites and that this is generally consistent with Horizons' long-term annual monitoring.

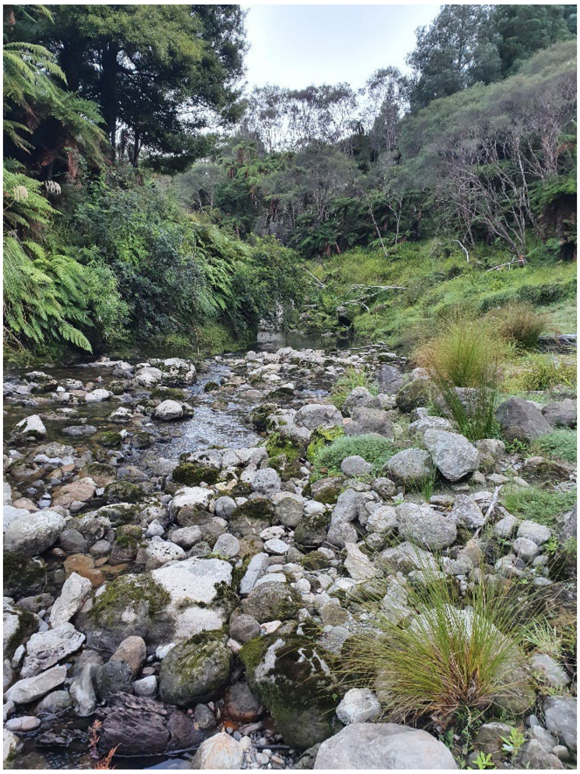
The MCI metric is based on the presence/absence of particular taxa weighted according to their sensitivities to pollution. It takes quite a significant change in the invertebrate community for a change in MCI to occur – species need to be completely absent or swapped out for a species with a lower pollution tolerance before a decline in MCI is registered. Yet in this study we observed quite large decreases in MCI.

Equally, it requires quite dramatic changes in ecological health to register shifts in NPSFM band, and yet we detected drops in bands at several sites. This might be explainable at the site scale, for example at the Whangamomona site the ecological health had gone from an A to a D for QMCI, a drop in 3 bands. This site was observed to be very muddy and degraded with stock crossing in the immediate vicinity of the sampling so perhaps this wasn't too surprising.

The National Policy Statement for Freshwater Management (NPSFM) seeks to have freshwater managed to ensure that the health and well-being of degraded water bodies is improved, and the well-being of other water bodies maintained (policy 5). Where regional councils detect degradation, the NPSFM requires them to take action to halt or reverse the degradation through changing a regional plan or preparing an action plan (policy 3.20).

In the Whanganui catchment the Te Awa Tupua Legislation 2017 requires a strategy (Te Heke Ngahuru) for the catchment to be developed by the strategy group Te Kōpuka nā Te Awa Tupua. Our results indicate impacts on the health and well-being of Te Awa Tupua that should be a prompt for action.

Although there have been some land-use changes in the catchments above the sampling sites, they were not directly correlated with changes in ecological health which may instead have been the result of small-scale site changes such as an increase in deposited fine sediment. It would be worth investigating further whether there have been any changes to pasture management (perhaps increased fertiliser application and/or stock densities), which may have changed over the last 30 years in largely sheep and beef land use.



Another potential explanation worthy of further exploration is the possibility that there have been adverse weather events which have contributed to increased erosion and increased fine sediment load to these streams.

It may be that hapū or the local landowners might have insights into what changes have occurred that could be causing these declines.

The Horrox study was notable in that a large amount of the catchment was surveyed. He found that the softer geology streams had poorer ecological health. The same land-use practices on soft geology has been found to be a third more impactful than similar land-use practices on hard rock geologies. (Hunter *et al*, in prep) also found that the impact of plantation forestry is greater in soft geologies than agriculture in hard geologies.

Therefore, the declines observed could be related to the underlying geology and the greater sensitivity of soft geologies to specific land uses. In 2022, the bulk of sites sampled were from soft geologies, so sampling more sites will enable us to assess whether this relationship still holds.

5.4 The Stream Health Check is a useful tool for assessing stream health

It is not always logistically or financially feasible to undertake detailed technical assessments of stream health by analysing the composition of the stream invertebrates. This study has highlighted the value of the Stream Health Check as a means to empower hapū or land managers to be informed about what to look for in the waterways. It is relatively easy to use, can quantify a more intuitive assessment of stream health and seems to correlate well with the more technical MCI.

As deposited fine sediment is a potential important determinant of ecological health, the stream health check may be a useful and easy means of getting more information on its spatial and temporal trends with citizen science.

5.5 Undertaking this work in partnership with hapū

One significant difference between undertaking this survey in 2022 compared to the 1990s is the Te Awa Tupua legislation and commitment of DOC to work in partnership with hapū to support their aspirations as kaitiaki. Undertaking this re-survey of the Horrox sites has enabled DOC to connect with the right people for each site, demystify the western science stream health assessment methods, build hapū capacity and connections back to the awa and incorporate, where appropriate, local mātauranga into the work.

5.6 Actions to address declining ecological health

The key aspects of the Stream Health Check that were linked to poor ecological health were lack of shade from riparian vegetation, and presence of sediment.

Projects such as Mouri Turoa and Horizons' freshwater programmes are focused on re-establishing riparian vegetation. This is particularly challenging in Whanganui tributaries given their steep riparian margins. Our results suggest that where successful, restored riparian vegetation will lead to improved instream ecological health. Horizons' sustainable land use programme along with modelling work undertaken by Maanaki Whenua are steps towards starting to address sediment issues in the catchment.

6 Recommendations

1. While re-surveying sites last surveyed 26 years ago may have some statistical limitations, we consider there is huge benefit in DOC and hapū continuing to re-survey the remaining sites together as a means of getting to know the current state of ecological health collaboratively.

2. Recognising the likely role of deposited sediment in driving ecological change, it is recommended that future sampling should include a measure of deposited fine sediment at each site and a photo of the underwater conditions (Clapcott et al, 2011)

3. Once the majority of sites have been re-sampled, it is recommended that the whole dataset is analysed, including an evaluation of underlying geology and land-use to see if the findings of Horrox around the increased vulnerability to soft geologies to land-use still hold.

4. We believe further investigation with hapū and landowners is warranted at the site scale to explore what changes in land-use practices may be contributing to changes in ecological health we have observed.

5. There is potential for further modelling work to be done using the results from this survey, understanding the type of sites that have remained unchanged and those that have changed, along with maps of land use, geology and deposited sediment to characterise the reaches of the river most at risk of declining ecological health. This

might help target future monitoring of stream health and/or areas where riparian planting or land-use change should be prioritised.

6. It is also recommended that once ecological health objectives have been set for either the whole catchment or for specific restoration programmes, that it would be timely to explore how to develop a comprehensive coordinated and integrated monitoring programme (as recommended in Dewson, 2022). This would require bringing all the forms of monitoring and knowledge together (both western science, mātauranga Māori and citizen science), statistical design, and legacy sites such as Horizons and NIWA State of Environment monitoring and this historic data set and its revisit.

7 Acknowledgements:

This study would not be feasible without the collaboration from hapū partners, in particular those that helped in the field including Ngāti Pamoana whānau at Operiki (Alaina, Jula and Da), Hone Albert from Ngāti Hikairo in the Whanganui headwaters and Whakapapanui Stream, Kimmy Ranginui (Motuaruhe Stream) and whānau at Whātaumū Stream (Zena, Shayna and Zion). The valuable support of others who participated in the field work was also much appreciated, particularly Raiha from Te Atawhai o Te Ao, Francis Ponga and Tanea Tangaroa.

Permission to access sites was provided by Jenny Tamekehu and Kimmy Ranginui (Matahiwi), Rawiri Tinirau (Ranana), Alaina Teki-Clark (Koriniti), Donald Tweedle (Kauarapaoa Stream), Wayne Hudson, Hone Albert and Te Rūnanganui o Ngāti Hikairo (Whakapapanui and Whanganui headwaters), and Di and Maki Ngarongo (Owhango).

Support from other DOC staff is acknowledged, particularly Aroha Greenhalgh, DOC Ranger, who was a critical member of the field team for most of the sites and also supported the engagement work and Denny Kumeroa (Pou Tairangahau) who provided engagement support. Ashley Alberto and Stephanie Davis from DOC's National Freshwater Monitoring Team provided valuable assistance in the survey preparation, in-field training, loan of field gear and data management.

The support and assistance of Aquanet, particularly Fiona Death, for processing the samples is gratefully acknowledged.

This report benefited from helpful peer review from Alex James, Zoe Dewson from EOS Ecology and Michael Patterson from Horizons.

8 References:

Allan, J. D. (2004). Landscapes and riverscapes: The influence of land use on stream ecosystems. *Annual Review of Ecology Evolution and Systematics, 35*, 257-284.

Beef and Lamb 2021? Farm Plan. Beef + Lamb New Zealand Farm Planning | Beef + Lamb New Zealand (beeflambnz.com)

Death et al, in prep. Stream Health Check: A farmer self-assessment method to link waterway evaluation with farm environment plans.

Dewson, Z. 2021. A Review of Fisheries & Aquatic Biodiversity Information for Te Awa Tupua/Whanganui River. EOS Ecology Report No. DEP01-21005. 31 p. fisheries-aquatic-biodiversity-whanganui-review-2021.pdf (doc.govt.nz)

Clapcott, Joanne, Roger Young, Jon Harding, Christoph Matthaei, John Quinn, and Russell Death. *Sediment Assessment Methods: Protocols and Guidelines for Assessing the Effects of Deposited Fine Sediment on in-Stream Values*. Cawthron Institute (Nelson: 2011).

Horizons Regional Council. Land, Air, Water Aotearoa (LAWA) - River Quality

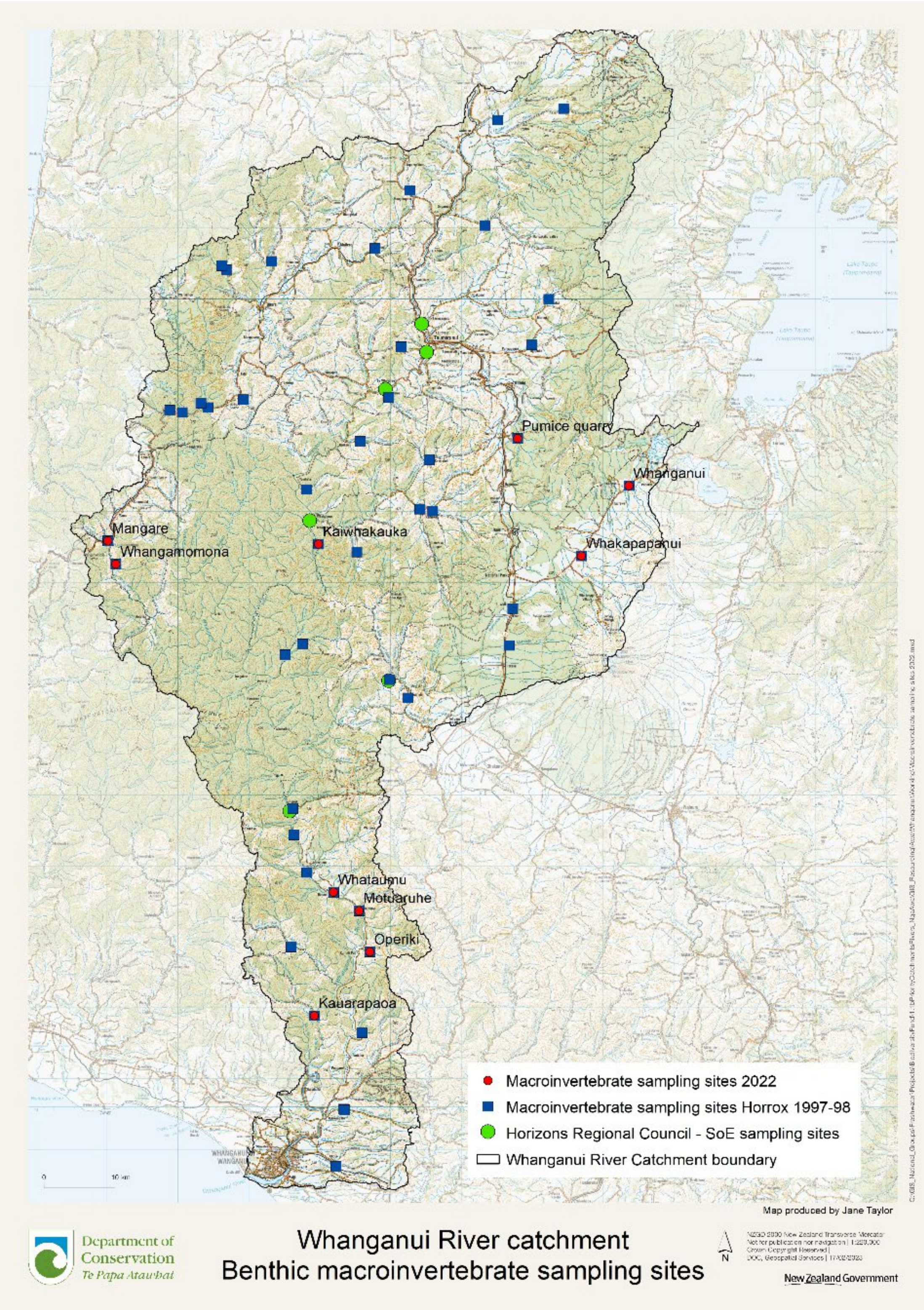
Horrox, J.V. 1998. Benthic communities of the Whanganui River catchment: the effects of land use and geology. Unpublished thesis, Massey University, Palmerston North, New Zealand. 92 p.

Hunter, H. A., Fuller, I. C., & Death, R. G. (submitted 24 Jan 2023). Does geology influence the effect of land use on stream macroinvertebrate communities? *Journal of Applied Ecology*.

Ministry for the Environment (MfE) and Stats NZ. (2017). *Our fresh water 2017: Data to 2016* (Vol. Publication number: ME 1305). Wellington: Ministry for the Environment & Stats NZ.

Ministry for the Environment (2023) The National Policy Statement for Freshwater Management. National policy statement for freshwater management | Ministry for the Environment

Appendix I: Map of sites



Appendix II: Technical analysis.

A. Determining statistical significance between sites

Analysis of Variance was used to assess significant differences in biological metrics collected in 1996/97 and 2022. The F values from this analysis and whether there is a statistically significant differences are presented in table IIb. A P value less than 0.05 signifies a significant difference.

Table: MCI, QMCI and ASPM results from the 1996/97 survey and the 2022 survey in relation to NPS bands

	Median MCI			MCI NPS class				Median QMCI			MCI NPS class			Change
	1996	1997	2022	1996	1997	2022	Change[7]	1996	1997	2022	1996	1997	2022	
Kaiwhakauka	148	147	131	A	A	A	no	8.0	7.1	7.2	A	A	A	no
Pumice Creek	154		130	A		A	no	7.8		6.5	A		A	no
Whakapapanui	148		135	A		A	no	7.0		6.8	A		A	no
Whanganui	148		146	A		A	no	7.6		7.5	A		A	no
Motuaruhe	129	110	104	B	B	C	yes	6.1	5.1	4.5	B	C	D	yes
Kauarapaoa	126		111	B		B	no	7.4		5.9	A		B	yes
Operiki		122	116		B	B	no		7.0	6.4		A	B	yes
Stream X	113		98	B		C	yes	5.8		4.9	B		C	yes
Mangare		116	113		B	B	no		5.7	5.9		B	B	no
Whangamomona		109	98		C	C	no		7.1	4.4		A	D	yes

[7] The 'change' assessment came from an assessment of the statistical significance, see Appendix III

Table IIb: Table of statistical significance:

		MCI			QMCI		
			F	P		F	P
3	Motuaruhe	96/97/22	19.32	**<0.001**	diff 1996 AND (1997/2022)	9.25	**0.005**
12	Kaiwhakauka	96/97/22	11.63	**0.002**	only diff 2022 and 96/97	3.05	0.09
15	Kauarapaoa	96/22	17.52	**0.004**		6.15	**0.04**
27	Pumice Creek	96/22	55.61	**<0.001**		47.53	**<0.001**
31	Whakapapanui	96/22	11.8	**0.01**		0.62	0.46
32	Whanganui	96/22	0.4	0.55		0.22	0.65
36	Whangamomona	97/22	15.44	**<0.001**		33.75	**<0.001**
38	Operiki	97/22	1.92	0.21		0.94	0.37
42	Stream X	96/22	3.6	0.1		13.29	**<0.001**
58	Mangare	97/22	0.33	0.58		0.51	0.5

B. How overall composition of invertebrate communities was compared

It is often useful to look at changes in the overall composition of the invertebrate communities to see whether some taxa may be responding differently to alternate stresses at particular sites that might be lost when data is summarised in a single index number. We can do this using multivariate ordination (technically Nonmetric multidimensional scaling (NMDS)), it places the invertebrate communities in ordination space depending on how similar they are in the types and abundance of taxa present. Communities that are very similar are closer together in the graph whereas those that are very different are further apart. The further away from each other they are the more different they are in composition.

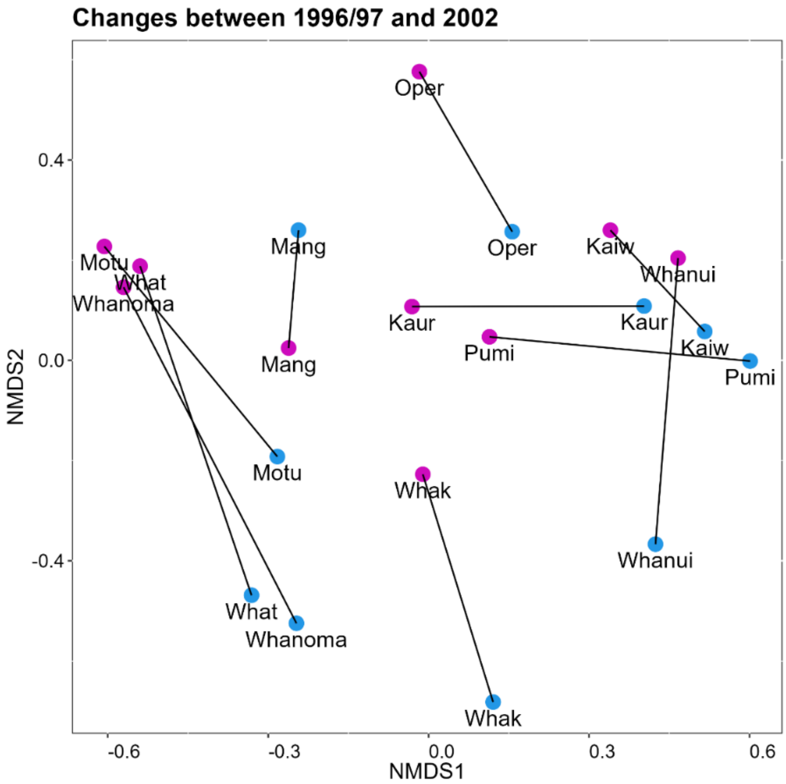


Figure 7: NMDs of invertebrate communities from 10 sites between 1996/97 and 2022. Blue is 1996/97 and purple is 2022.

To explore why the invertebrate communities at some sites are more similar we examined how the habitat variables differed between the sites. measured at each site against the long those ordination axes. We did this for just the 2022 data.

In Figure 8, the sites to the left of axis one (Whangamomona, Motuaruhe and Whataumu) are identified as having high conductivity and temperature whereas sites to the right (Whanganui, Kaiwhakauka and Pumice Creek) have low conductivity, low temperature and high Stream Health Check scores. This seems to broadly correspond to sites with healthy ecological conditions on the right and more impaired conditions on the left.

We can also look at what particular taxa are associated with the patterns in the same way. Sites to the left of axis one of Figure 9 are characterised by *Elmidae*, *Berosus* (both beetle larvae), and Oligochaetes (worms) which often prefer habitats with high levels of fine sediment and/or lower water quality. Operiki in the top right probably had good water quality but reasonable levels of periphyton as the caddisfly *Pycnocentria* feed on algae in moderately good water quality sites (and was aligned with the top of axis 2). The stoneflies (*Stenoperla, Austroperla*), mayfly *Ameletopsis*, beetle *Scritidae* and caddis *Hydrochorema* all like high water quality forested streams and were aligned more to the right of axis 1.

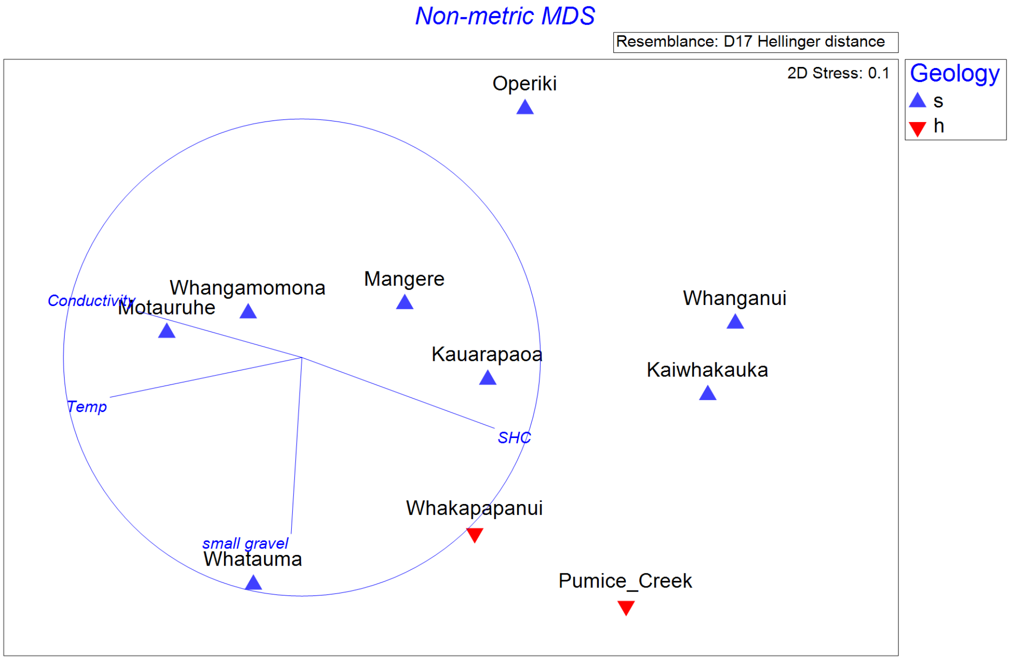


Figure 8: The invertebrate community data from the 2022 survey showing correlations between sites and water quality. Blue symbols are from hard substrate streams and red from mudstone streams.

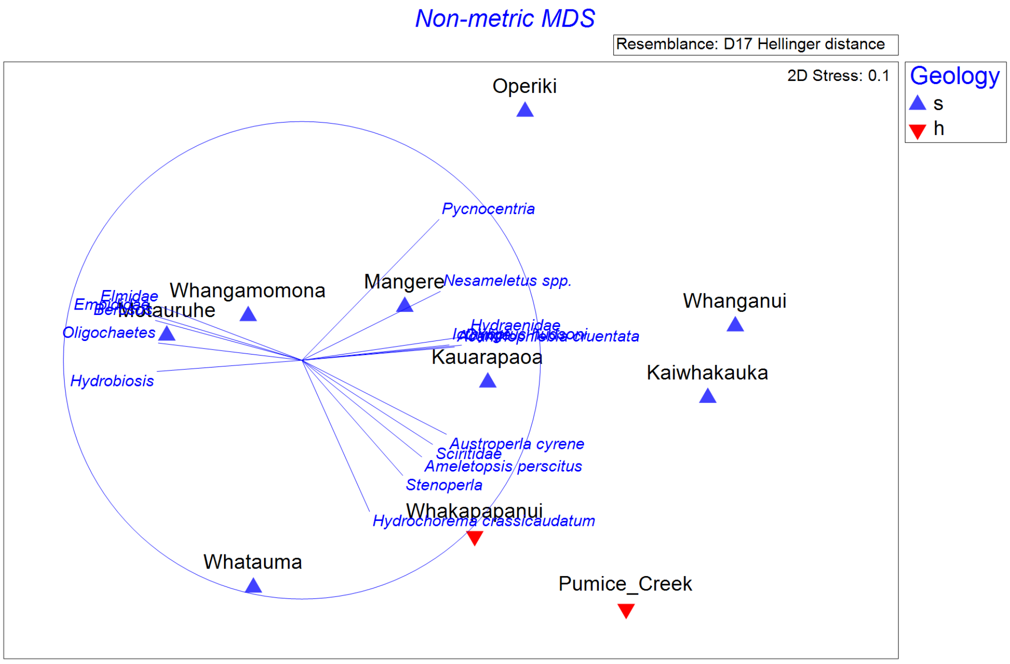


Figure 9: The invertebrate community data from the 2022 survey showing correlations between sites and individual taxa. Blue symbols are from hard substrate streams and red from mudstone streams.

Appendix III: Summary of reviewers' comments

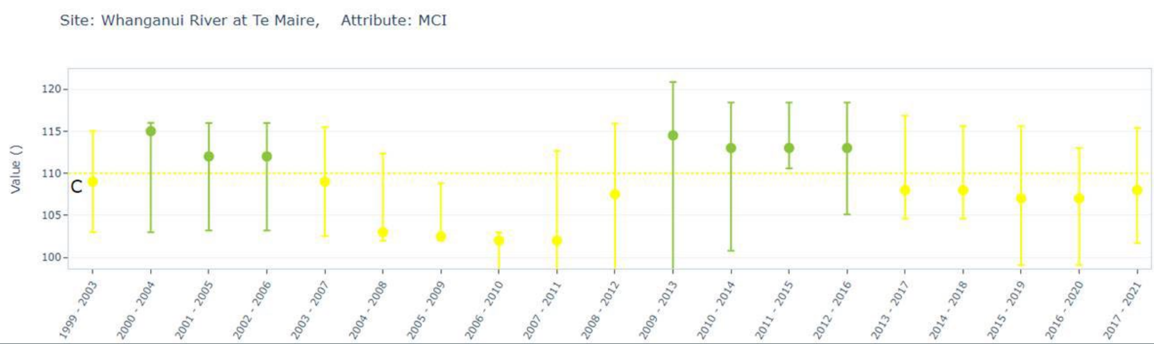
A draft of this report was peer reviewed by three freshwater ecologists. This helped improve the final report. However, they also raised a number of more technical comments that on evaluation we felt added unnecessary complexity if we had attempted to incorporate them into the report. For those curious or for the more technical audience, their key comments and our response are summarised here:

1. The problem with making statements about changes between 96/97:

The reviewers expressed concern about on relying on two points in time to categorically state there is a decline in water quality through time, particularly where we were attributing a statistical significance to the differences found. Although one reviewer did not disagree with the general conclusion that water quality as represented by macroinvertebrate metrics appear to be getting generally worse through time in the Whanganui.

The main issue with making statements about changes between the 96/97 Horrox and 2022 data is our inability to know things have tracked in the intervening years, so according to the reviewers, we can't say whether what we have observed in 2022 is a real change or just within the range of natural variability at these sites. Smoothing this variability is one reason the NPS-FM bands are based on five-year medians.

The reviewer from Horizons helpfully provided the following information by way of context which are the rolling, five year analysis of median MCI scores at Whanganui at Te Maire. i.e. each point is the median of 5 years of data, and with each step to the right, we take the oldest year off and add the newest year. The whiskers are the 95% confidence intervals (two sided so 90% confidence) on each of those points.



What is most evident is the long term sinusoidal pattern. It appears this is most likely attributable to long term weather patterns. Horizons has noted this for all sorts of attributes, particularly DRP and visual clarity, and have found it more evident at the reference sites than the impacted sites, attributing this to the weather having a greater impact where there are less other factors. Interestingly, in a study of national invertebrate monitoring sites Russell Death has found that reference sites are those less variable in time.

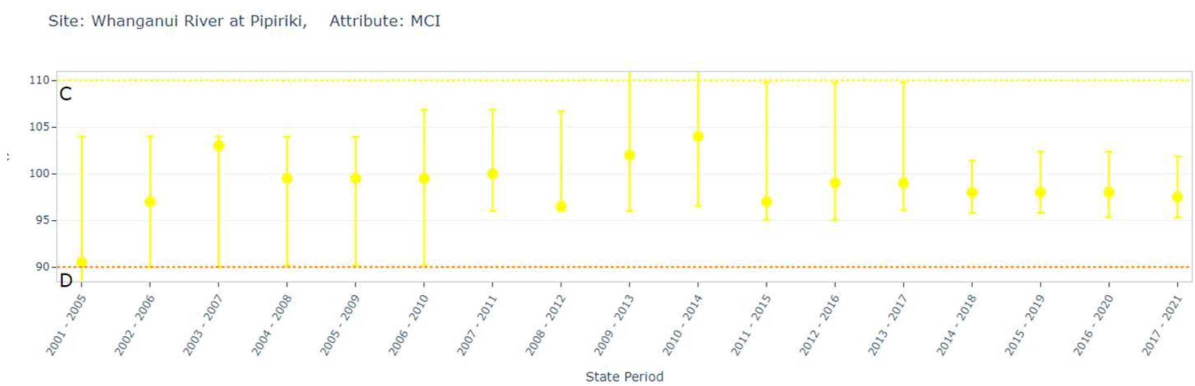
This reviewer concluded by noting that by undertaking five replicate Surber samples we were able to account for spatial variability at the site scale, and the same site accounts for spatial variability in the catchment scale but identified that we were unable to account for any temporal variability relating to short or long term weather patterns.

2. The problem with trends

The Horizons reviewer highlighted the complexity with understanding trends, noting that the 20 year trend for the Te Maire site is completely flat. For the last 10 years (2012 until 2021 inclusive) it is declining. A 10 year trend from 2005 – 2014 (incl) for example would be a significant improvement. Judging by the cycle there should be an improvement over the next 10ish years (the 2022 data point is an MCI of 120 replacing 107 from 2017, so certainly the next datapoint in this sequence is higher than that seen for 2017 - 2021). For some sites (those with the 15 year trend) this can be evident on the LAWA website where the 10 year trend is likely declining, while the 15 year trend is likely improving.

Another way of thinking about this is, if there is a long term cycle, unless the trend period is exactly in phase with the cycle (e.g. for a 9 year cycle; a 9, 18, 27, etc. year trend period), then the trend will be to some degree masked by that cycling. There is currently no way of reliably normalising trend for this cycle, so we are unsure whether the trend we are seeing is driven by the cycle or a true long term change.

These statements are exactly the same for Pipiriki (20 year trend is flat), and the rolling MCI is as below, though the sinusoidal pattern is far less evident:



This is a difficult subject that we (as a sector) have been working on heavily over the last six months. Horizons actually instigated a envirolink funded report that NIWA lead on this subject. I am expecting the report any day so will send it through if you like.

Response – the 15 year trend for the Te Maire site does show on LAWA as v.likely improving, but for the rest of the Whanganui catchment SOE sites the 15 year trend on LAWA was either the same as the 10 year trend, indeterminate or not assessed.

3. Suggestions for further analysis

One reviewer suggested finding out what taxa were responsible for any differences between 96/79 and 2022, particularly at sites where a decline in metrics have been observed. Have some sensitive taxa been lost? Have tolerant taxa increased? In response – this could be something we look into when analysing the next suite of re-surveyed sites.

4. Recommendations for more regular monitoring

The reviewers felt that the data will be really useful over time, especially if we were able to go back to some of these sites annually, to get an idea of any variability. In response – whilst we aren't proposing this at this stage, it would make sense to incorporate such historic sites into a well designed comprehensive catchment monitoring plan.

5. 'Naturally lower' ecological health in soft geology streams?

One reviewer noted that the ecological health from soft geology streams may be just poorer based on comparison to our metrics which are largely intended for use on hard bottomed stony streams, and that perhaps these streams just have a different general fauna - so are slightly different rather than being necessarily "poorer"?

Response – the fact that some soft geology sites, the ones with significant amounts of their catchment in native vegetation, met the A band for MCI and QMCI suggests to us that they are just as capable of having healthy ecological conditions, it more depends on the associated land-use.