Freshwater Macroinvertebrate Fauna Biological Monitoring Programme Annual State of the Environment Monitoring Report 2018-2019

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Executive summary

Section 35 of the Resource Management Act requires local authorities to undertake monitoring of the region's environment, including land, air, and fresh and marine water quality. The Taranaki Regional Council initiated the freshwater macroinvertebrate State of Environment Monitoring (SEM) programme for Taranaki in the 1995-1996 monitoring year.

Freshwater macroinvertebrates comprise a range of aquatic species including insects, crustacea, molluscs and worms. They have a crucial role in freshwater ecology and respond to changes in a variety of factors including water quality, hydrology and habitat. While a water sample will reveal water chemistry at the time of sampling, and thus give an indication of pressures on stream ecology, assessing the state of the freshwater macroinvertebrate communities will show the cumulative influences of these factors over the recent past as well as being a primary indicator of whether a stream is healthy or otherwise. The Macroinvertebrate Community Index (MCI) is a New Zealand version of an approach that is used internationally. Each taxa found at a stream monitoring site is scored according to its sensitivity or tolerance to the overall stream habitat, and the cumulative score then provides an index of stream health. The *Government's National Policy Statement for Freshwater Management 2017* requires every regional council to monitor and report on stream health using the MCI.

This report covers the 2018-2019 monitoring year. Biological surveys were performed in spring (October to November 2018) and summer (February to March 2019). Each seasonal survey assessed the macroinvertebrate communities at 59 sites in 26 rivers and streams.

For sites located in lower reaches of catchments the proportion of 'sensitive' taxa in the macroinvertebrate communities generally have been lower in summer than in spring, coincident with lower flows, higher water temperatures, less scouring, and increased smothering of habitats by more widespread algal growth within rivers and streams in summer. While this is a generic pattern, in the 2018-2019 summer surveys the pattern was exacerbated by extended periods of higher than usual stream temperatures, a significant increase in the proportion of more extreme temperatures, and prolonged low flow periods. The summer period was particularly dry with some sites recording new records for time elapsed since a significant fresh, which was likely to be a significant factor in the lower than normal summer scores. In the 2018-2019 monitoring year the median spring MCI score (102 units) was eight units higher than the median summer score (94 units), while the mean (average) spring score (106 units) was nine units higher than the mean summer score (97 units). The seasonal difference in scores was highly statistically significant. The spring median score was three units higher than the historical spring median, while the summer median was two units lower than the historic summer median. Overall, the median for the current year (99 units) across both surveys was one unit higher than the historical median, indicating that the current monitoring year result was slightly better than previous years.

The proportion of 'sensitive' taxa in the macroinvertebrate communities usually decreased down the length of the waterways, which was reflected in the deterioration in generic stream 'health' from 'very good' in the upper reaches to 'good' through to 'fair' in mid-reaches to 'fair' in the lower reaches.

There were three new maxima and eight new minima MCI scores recorded during the 2018-2019 period. This result contrasts with the seven new maxima and one new minima recorded in the preceding 2017-2018 period. One of the three new maxima and one of the eight new minima were from one of the two relatively new sites established in the 2015-2016 period and hence was of little comparative significance.

There were six sites on five streams/rivers that had 'poor' scores and one site with a 'very poor' score. Of particular note was the Mangati Stream that had 'poor' scores for both spring and summer, which is known to have a variety of water quality issues, the lower Huatoki Stream site summer score of only 56 units, the lower Waiwhakaiho River site at Constance St summer score of 60 units, and the lower Waitara River site summer score of 64 units. The latter three sites had scores that were either new minima, or equalled historic

minima. The low summer scores at the Huatoki, Waiwhakaiho and Waitara Rivers were possibly caused by the dry and warm summer causing unusually low flows, elevated in-stream temperatures, and a lack of significant freshes over atypically extended periods.

Temporal trend analysis was undertaken for sites with sufficient data. Taking into account the full historical record for each site, there are 57 sites with sufficient data, (at least 10 years' monitoring data), to perform a statistical analysis.

Forty-six sites display positive trends, with 25 of those sites having statistically significant improvements (after application of FDR tests[1]). Only ten sites had negative trends and only one of these was statistically significant. That site, along with two other sites with negative trends, were adversely affected by natural headwater erosion inside the National Park. However, the LOWESS graphs indicate several sites have unimodal trendlines, indicating that sites had improved in condition, had then plateaued, and now within the last couple of years are declining. There was one site with no trend either positive or negative.

There was little evidence of trends in macroinvertebrate health at sites in the upper reaches of catchments, which generally already had good macroinvertebrate health, while two-thirds of middle reach sites had significant improvement and nearly half the sites located in the lower reaches of catchments showed significant improvement. Generally, in lower catchment sites the macroinvertebrate communities tend to be 'tolerant' of the cumulative impacts of nutrient enrichment. Significant improvement of (predominantly 'fair') biological stream 'health' at the lower reach sites is unlikely to be detected until habitat improvements occur by way of substantial catchment-wide initiatives such as riparian planting and diversion of point source discharges and in urban and industrial areas better stormwater and wastewater management. It is noted that the Council is promoting these interventions with implementation by the regional community.

For the most recent ten-year data set, there were no sites that had a significant trend once FDR adjustment was applied. Prior to FDR adjustment being applied, there were no sites that showed a significant improvement and ten sites showed a significant decline. In total 20 sites had a positive trend, 36 sites had a negative trend, and one site had an indeterminate trend.

Trends have plateaued recently at some sites that have shown longterm improvements. This could be due to a variety of reasons. In some catchments riparian management initiatives have largely been completed and therefore stream health will likely have stabilised at monitoring sites. Some sites have shown step change improvements due to the removal of point source discharges such as wastewater treatment plant removal, with these improvements now resulting in a new baseline at those sites. There are also other factors that could be counteracting improvements such as increased agricultural inputs and/or warmer/drier weather. A specific analysis of the data for summer 2019 indicates that stream health, as measured by MCI scores, was negatively correlated with the time between sampling and the last significant fresh. This is likely due to periphyton accrual and possibly fine sediment deposition though in some cases a significant interval between sampling and the last significant fresh may also be an indication of very low flows. A significant fresh that mobilises the streambed will remove the majority of periphyton and fine, deposited sediment and thus provide better habitat for macroinvertebrates. Other factors such as nutrients and temperature can have important interactive and antagonistic effects and therefore the importance of the preceding hydrological regime will vary at the site level. An additional analysis indicates that the time between sampling and the last significant fresh has been increasing, which might be influencing long-term trends at some sites.

[1] FDR= False Discovery Rate, one of several tests applied to the results to increase confidence in the results by eliminating apparent trends that are the results of coincidence and random distributions rather than genuine change.

The recommendations for the 2019-2020 monitoring year are for the freshwater biological component of the SEM monitoring to be maintained by way of the same macroinvertebrate faunal programme, and expanded by the inclusion of five Eastern Hill Country sites. One site is recommended to be removed as it is considered to have poor site-specific habitat that is not representative of the stream or catchment.

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1 Introduction

1.1 General

The *Resource Management Act 1991* (RMA) established new requirements for local authorities to undertake environmental monitoring. Section 35 of the RMA requires local authorities to monitor, among other things, the state of the environment of their region or district, to the extent that is appropriate to enable them to effectively carry out their functions under the Act.

To this effect, the Taranaki Regional Council (the Council) has established a state of the environment monitoring (SEM) programme for the region. This programme is outlined in the Council's 'State of the Environment Monitoring Procedures Document', which was prepared in 1997. The monitoring programme is based on the significant resource management issues that were identified in the *Council's Regional Policy Statement for Taranaki (1994)*.

The SEM programme is made up of a number of individual monitoring activities, many of which are undertaken and managed on an annual basis (from 1 July to 30 June). For these annual monitoring activities, summary reports are produced following the end of each monitoring year (i.e., after 30 June). Where possible, individual consent monitoring programmes have been integrated within the SEM programme to save duplication of effort and minimise costs. The purpose of annual SEM reports is to summarise regional environmental monitoring activity results for the year, and provide an interpretation of these results, together with an update of trends in the data.

Annual SEM reports act as 'building blocks' towards the preparation of the regional state of the environment report every five years. The Council's first, or baseline, state of the environment report was prepared in 1996 (TRC, 1996c), summarising the region's progress in improving environmental quality in Taranaki over the past two decades. The second report (for the period 1995-2000) was published in 2003 (TRC, 2003). Data spanning the ten-year period 1995 to 2005 have been used in the preparation of a trend report (TRC, 2006). The third State of the Environment report (for the period 1995 to 2007) was published (TRC, 2009a) and included trend reporting and the fourth report (for the 1995 to 2014 period) has been published (TRC, 2015a). The provision of appropriate computer software statistical procedures allows regular reporting on trends in the environmental quality over time, in relation to Council's ongoing monitoring activities, now that there has been an accumulation of a comprehensive dataset of sufficient duration to permit a meaningful analysis of trends (i.e. minimum of 10 years).

This report summarises the results for the sites surveyed in the freshwater macroinvertebrate SEM programme over the 2018-2019 monitoring year, the twenty-fourth year of this programme.

1.2 Background

Freshwater macroinvertebrates are a range of aquatic species that have a crucial role in freshwater ecology and that respond to changes in water quality or hydrological patterns or habitat. While a grab sample of water collected from a waterbody will reveal the water chemistry at the time of sampling, and thus give an indication of any contemporaneous pressures on the ecology of the stream, the alternative of directly assessing the state of the freshwater communities themselves will show the cumulative influences of these factors over the recent past as well as being a primary indicator of whether a stream can be considered healthy or otherwise. The Macroinvertebrate Community Index (MCI) is a New Zealand version of an approach that is used internationally. Each species found at a stream monitoring site is scored according to its sensitivity or tolerance, and the cumulative score then provides an index of stream health. The *Government's National Policy Statement for Freshwater Management 2017* made it compulsory for every regional council to monitor and report on stream health using the MCI.

The Cawthron Institute notes: Benthic macroinvertebrates are used worldwide as sub-indicators of stream ecosystem health as they respond to human pressures, are taxonomically diverse and easy to sample. The MCI is responsive to multiple stressors, but not all stressors, and as such provides a good indicator of the overall condition of the macroinvertebrate component of stream ecosystem health[2].

[2] Cawthron Institute Report 3073

2 Monitoring methodology

2.1 Programme design

The Council commenced the freshwater biological SEM programme in spring 1995. The 2018-2019 monitoring year was therefore the twenty-fourth year in which this SEM programme was undertaken. This report presents the results from the sites surveyed in the 2018-2019 monitoring year. Full details of the methodology for the programme can be found in TRC (1997b).

2.2 Site locations

A map of all sites monitored in the Taranaki freshwater biological SEM programme is shown in Figure 1, with site meta data given in Table 1. Various additions of sites have been implemented throughout the 24 years of the SEM programme, with details of site selections given in Appendix I.

The biological programme for the 2018-2019 period involved the continuation of a riparian vegetation monitoring component which incorporated five sites in the Kaupokonui River (see Table 1) and five sites in western Taranaki ring plain streams (Katikara Stream and Kapoaiaia Stream).

Most recently, the addition of further Eastern Hill country sites has been undertaken, in the light of the requirement of the National Policy Statement on Fresh Water that the Council undertakes representative monitoring across all Freshwater Management Units (FMUs) within the region. The Council has identified prospective FMUs and has adjusted its monitoring programmes in anticipation of these being confirmed in due course within the forthcoming *Regional Water and Land Plan* (in prep).

Table 1 Freshwater biological monitoring sites in the State of the Environment Monitoring programme

River/stream	Site	Site code	GPS location		Spring date	Summer date
			E	N		
Hangatahua (Stony) R	Mangatete Road	STY000300	1677460	5657823	25-Oct-18	18-Feb-19
Hangatahua (Stony) R	SH45	STY000400	1674632	5661558	25-Oct-18	18-Feb-19
Herekawe S	Centennial Drive	HRK000085	1688283	5674972	10-Oct-18	14-Feb-19
Huatoki S	Hadley Drive	HTK000350	1693349	5671486	10-Oct-18	14-Feb-19
Huatoki S	Huatoki Domain	HTK000425	1693041	5673404	10-Oct-18	14-Feb-19
Huatoki S	Molesworth St	HTK000745	1692800	5676424	10-Oct-18	14-Feb-19
Kapoaiaia S	Wiremu Road	KPA000250	1678009	5652025	26-Oct-18	18-Feb-19
Kapoaiaia S	Wataroa Road	KPA000700	1672739	5652272	26-Oct-18	18-Feb-19
Kapoaiaia S	Cape Egmont	KPA000950	1665690	5652452	26-Oct-18	18-Feb-19
Katikara S	Carrington Road	KTK000150	1683566	5657855	25-Oct-18	18-Feb-19
Katikara S	Beach	KTK000248	1676597	5667473	25-Oct-18	18-Feb-19
Kaupokonui R	Opunake Road	KPK000250	1698088	5639231	5-Oct-18	5-Mar-19
Kaupokonui R	U/s Kaponga oxi ponds	KPK000500	1698609	5634423	5-Oct-18	5-Mar-19
Kaupokonui R	U/s Lactose Co.	KPK000660	1697613	5629791	5-Oct-18	5-Mar-19
Kaupokonui R	Upper Glenn Road	KPK000880	1693026	5622705	5-Oct-18	5-Mar-19
Kaupokonui R	Near mouth	KPK000990	1691209	5620444	5-Oct-18	5-Mar-19
Kurapete S	U/s Inglewood WWTP	KRP000300	1705087	5665510	10-Oct-18	26-Feb-19
Kurapete S	D/s Inglewood WWTP	KRP000660	1709239	5667481	10-Oct-18	26-Feb-19
Maketawa S	Opp Derby Road	MKW000200	1702192	5656304	20-Nov-18	18-Feb-19
Maketawa S	Tarata Road	MKW000300	1708784	5665231	20-Nov-18	18-Feb-19
Mangaehu R	Raupuha Rd	MGH000950	1726300	5639062	8-Oct-18	11-Feb-19
Manganui R	SH3	MGN000195	1708871	5651282	20-Nov-18	18-Feb-19
Manganui R	Bristol Road	MGN000427	1711210	5667887	20-Nov-18	18-Feb-19
Mangaoraka S	Corbett Road	MRK000420	1702538	5676320	10-Oct-18	15-Feb-19
Mangati S	D/s railway line	MGT000488	1700095	5678043	21-Nov-18	20-Feb-19
Mangati S	Te Rima Pl, Bell Block	MGT000520	1699385	5679103	21-Nov-18	20-Feb-19
Mangawhero S	U/s Eltham WWTP	MWH000380	1712475	5633431	16-Oct-18	6-Mar-19
Mangawhero S	D/s Mangawharawhara S	MWH000490	1710795	5632738	16-Oct-18	6-Mar-19
Mangorei S	SH3	MGE000970	1696094	5671500	20-Nov-18	8-Feb-19
Patea R	Barclay Rd	PAT000200	1702620	5646598	7-Nov-18	4-Mar-19
Patea R	Swansea Rd	PAT000315	1711801	5644382	7-Nov-18	4-Mar-19
Patea R	Skinner Rd	PAT000360	1715919	5644681	7-Nov-18	4-Mar-19
Punehu S	Wiremu Rd	PNH000200	1687323	5637020	11-Oct-18	5-Mar-19
Punehu S	SH45	PNH000900	1677946	5627786	11-Oct-18	5-Mar-19
Tangahoe R	Upper Valley	TNH000090	1725340	5626101	4-Oct-18	7-Mar-19
Tangahoe R	Tangahoe Vly Rd bridge	TNH000200	1719126	5622681	4-Oct-18	7-Mar-19
Tangahoe R	d/s rail bridge	TNH000515	1715751	5612470	4-Oct-18	7-Mar-19
Timaru S	Carrington Road	TMR000150	1684423	5659634	25-Oct-18	18-Feb-19
Timaru S	SH45	TMR000375	1679509	5665554	25-Oct-18	18-Feb-19
Waiau S	Inland North Road	WAI000110	1714587	5680018	10-Oct-18	15-Feb-19
Waimoku S	Lucy's Gully	WMK000100	1681324	5666240	25-Oct-18	14-Feb-19
Waimoku S	Beach	WMK000298	1681725	5669851	25-Oct-18	14-Feb-19

River/stream	Site	Site code	GPS location		Spring date	Summer date
			E	N		
Waingongoro R	700m d/s Nat Park	WGG000115	1700835	5645086	16-Oct-18	6-Mar-19
Waingongoro R	Opunake Rd	WGG000150	1705692	5642523	16-Oct-18	6-Mar-19
Waingongoro R	Eltham Rd	WGG000500	1710576	5634824	16-Oct-18	6-Mar-19
Waingongoro R	Stuart Rd	WGG000665	1709784	5632049	16-Oct-18	6-Mar-19
Waingongoro R	SH45	WGG000895	1704042	5618667	16-Oct-18	6-Mar-19
Waingongoro R	Ohawe Beach	WGG000995	1702531	5617624	16-Oct-18	6-Mar-19
Waiokura S	Skeet Rd	WKR000500	1698807	5628892	5-Oct-18	5-Mar-19
Waiokura S	Manaia Golf Course	WKR000700	1697636	5622019	5-Oct-18	5-Mar-19
Waiongana S	SH3a	WGA000260	1705159	5669554	21-Nov-18	14-Feb-19
Waiongana S	Devon Road	WGA000450	1704063	5680381	21-Nov-18	14-Feb-19
Waitara R	Autawa Road	WTR000540	1720719	5663669	22-Nov-18	14-Feb-19
Waitara R	Mamaku Road	WTR000850	1708384	5678739	22-Nov-18	14-Feb-19
Waiwhakaiho R	National Park	WKH000100	1696096	5658351	20-Nov-18	8-Feb-19
Waiwhakaiho R	SH3 (Egmont Village)	WKH000500	1698297	5666893	20-Nov-18	8-Feb-19
Waiwhakaiho R	Constance St (NP)	WKH000920	1695827	2677271	20-Nov-18	8-Feb-19
Waiwhakaiho R	Adjacent to L Rotomanu	WKH000950	1696587	2678336	20-Nov-18	8-Feb-19
Whenuakura R	Nicholson Rd	WNR000450	1732757	5598479	4-Oct-18	7-Mar-19

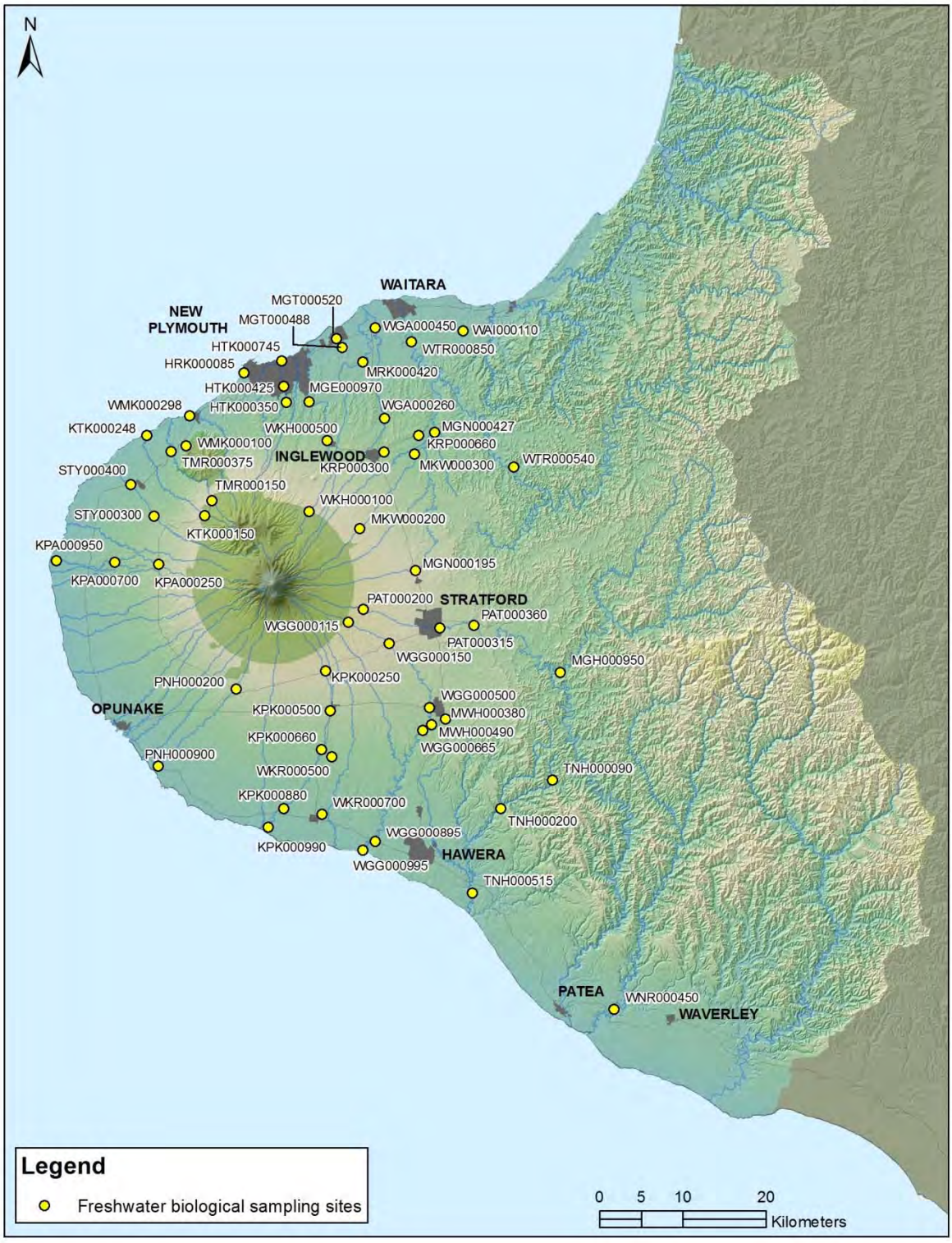


Figure 1 Location of macroinvertebrate fauna sampling sites for the 2018-2019 SEM programme

2.3 Sample collection and analysis

The standard '400 ml kick-sampling' and occasionally the '400 ml sweep-net- sampling' techniques were used to collect streambed (benthic) macroinvertebrates from various sampling sites in selected catchments in the Taranaki region (detailed in section 2.4 and TRC, 1997b). The 'kick-sampling' technique is very similar to Protocol C1 (hard-bottomed, semi-quantitative) and the 'sweep-net- sampling' technique is very similar

to Protocol C2 of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark et al, 2001). Surveys of all sites are normally performed twice during the monitoring year, once during spring (October to December) and once during summer (February and March). An audit of the macroinvertebrate samples used for SEM purposes was undertaken this monitoring year, as it had been noted that some surveys in the database did not appear to be for SEM purposes. A very small number of surveys were found to be wrongly assigned as SEM surveys and have since been removed from the analysis. Further information outlining this can be found at TRC, 2019. Sampling dates for each site are detailed in Table 1.

Samples were preserved using Kahle's Fluid, for later sorting and identification. This was carried out using a stereomicroscope, and following Taranaki Regional Council methodology, using protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001). Macroinvertebrate taxa were placed in abundance categories for each sample (Table 2).

Table 2 Macroinvertebrate abundance categories

Abundance category	Number of individuals
R (rare)	1-4
C (common)	5-19
A (abundant)	20-99
VA (very abundant)	100-499
XA (extremely abundant)	500+

2.4 Environmental parameters and indicators

2.4.1 Taxonomic richness

The number of macroinvertebrate taxa found in each sample is used as an indicator of the richness of the community at each site. However, a high taxonomic richness does not necessarily mean a pristine, healthy community. Sites with mild nutrient enrichment will often have higher taxonomic richness than pristine sites, and therefore caution is required when evaluating sites based on taxonomic richness (Stark and Maxted, 2007).

2.4.2 Macroinvertebrate Community Index (MCI)

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa are assigned the highest scores of 9 or 10, while the most 'tolerant' forms score 1. For studies undertaken in the Taranaki, the sensitivity scores for certain taxa have been modified in accordance with Taranaki experience (see TRC, 1997b). The Macroinvertebrate Community Index (MCI) value is calculated by averaging the scores obtained from a list of taxa taken from one site, and multiplying by a scaling factor of 20. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. Communities that are more 'sensitive' inhabit less polluted waterways.

2.4.3 Semi Quantitative MCI (SQMCI)

A semi-quantitative MCI value (SQMCI) (Stark 1998 & 1999) is also calculated from the taxa present at each site. The SQMCI is calculated by multiplying each taxon score by a loading factor (related to its abundance), summing these products, and dividing by the sum of the loading factors (Stark, 1998, 1999). The loading factors are 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the SQMCI is not multiplied by a scaling factor of 20. As a result, its corresponding range of values is 20x lower than MCI. A difference in SQMCI of more than 0.83 units is considered as statistically significant. However, Stark and Maxted (2007) considered the MCI to be a more appropriate index than the SQMCI for State of the Environment monitoring and discussion, and in this report, emphasis is placed on the MCI.

2.4.4 MCI Classification

A refinement of Stark's classification (Stark, 1985, Boothroyd and Stark, 2000; and Stark and Maxted, 2007) has been made in order to grade the biological 'health' based upon MCI and SQMCI ranges. This classification system is presented in Table 3.

Table 3 Generic MCI gradation of biological water quality conditions adapted for Taranaki streams and rivers

TRC Grading	MCI	SQMCI	Colour Code	Stark's classification
Excellent	≥140	≥7.00		Excellent
Very Good	120-139	6.00-6.99		
Good	100-119	5.00-5.99		Good
Fair	80-99	4.00-4.99		Fair
Poor	60-79	3.00-3.99		Poor
Very Poor	<60	<3.00		

This adapted system is considered to provide more resolution of stream 'health', in the context of more precise upper and lower MCI and SQMCI score bands, than the earlier grading classification (Stark and Fowles, 2015). Despite the acknowledgement that the boundaries between grades may be fuzzy (Stark and Maxted, 2007), classifying the data into grades can assist with the assessment of trends in long term temporal data.

When the same number of replicate samples are collected per site, it is possible to use the detectable difference method to assess the significance of MCI score differences. Stark (1998) provides statistically significant detectable differences for the protocols used by TRC (10.8 MCI units). Therefore, if the difference between MCI scores is greater than ten units, then the scores can be considered significantly different. In practice, this means a result more than 10 units above a score is regarded as significantly higher, and a result more than 10 units below a score is significantly lower. Between-season and long-term median MCI scores and/or taxa richness may also be compared using t-tests (Stark and Maxted, 2007).

2.4.5 Predictive measures using the MCI

Measured MCI values at each site are compared against two separate predictive models.

The first model establishes a relationship between MCI scores and the distance of ringplain sites from the National Park boundary. The resulting empirical model for MCI in ringplain streams/rivers is:

MCI = 131.717 – 25.825 $\log_{10}$ D [where D = distance from source (km)]

This model is based upon more than 2400 TRC surveys, including around 300 ringplain 'control' sites, with data collected over the period 1980 to 2008. This generic predictive relationship has a margin of error of ±10 units (Stark and Fowles, 2009).

Leathwick et al. (2009) has also developed a model for predicting MCI scores, based upon the River Environmental Classification (REC) system for New Zealand rivers and streams (Snelder et al, 2004). The REC classifies and maps river and stream environments in a spatial framework for management purposes. It provides a context for inventories of river/stream resources and a spatial framework for effects assessment, policy development, developing monitoring programmes, and interpretations of state of the environment reporting.

2.5 Trend analysis

State of the environment (SEM) macroinvertebrate data collected under standard TRC programme protocols, over the full twenty-four year (1995-2019), and last ten-year (2009-2019), periods, are analysed for trends over time. The MCI, a surrogate for stream health, is used as the most appropriate index for the assessment of time trends (following Stark and Maxted, 2007).

MCI trend data is first visually inspected using a scatter plot of MCI data vs time, with a LOWESS [Locally Weighted Scatterplot] fit (tension of 0.4) implemented to create a smoothed, moving average trend line.

The MCI data, for sites that have a minimum of ten-years continuous data, is then statistically analysed for trends over time using a Mann-Kendall test, followed by false discovery rate (FDR) analysis (Stark and Fowles, 2006). The significance of a site's trend (i.e. the strength of the trend) is assessed according to the statistical probability of occurrence (p-value), with comparisons between sites valid so long as similar numbers of samples have been collected for analysis at each site. This has been the case with the TRC programme. A Kendall tau coefficient is also produced, which indicates whether the trend is positive or negative, and gives a measure of the magnitude of the trend.

A trend may be statistically significant but have no ecological importance, or vice versa. The assessment of ecological importance may be made using the best professional judgment (BPJ) of a freshwater ecologist who has knowledge of the region's rivers and streams. However, it is likely that the strongest trends (lowest p-values) also have the greatest ecological importance.

To place these trends in perspective, each site may be categorised into graduations (bands of MCI values) of stream health. In this instance, Stark's (1985) categories have been refined (using BPJ), as illustrated in Table 3 in Section 2.2.1.2 (Stark & Fowles, 2015).

3 Results and discussion

3.1 Flows

Hydrological flow recorders continuously monitor water levels in the Mangaoraka, Waiongana, Punehu, and Kapoaiaia, Waiokura Streams, and the Waiwhakaiho, Manganui, Patea, Mangaehu, Waingongoro, Kaupokonui, Waitara, and Whenuakura Rivers. The proximity of previous freshes (elevated flows), for each site surveyed, are summarised in Table 4. Flow assessments are extrapolated from nearby catchments for sites where flow recorders do not exist.

Table 4 Duration since freshes at sampling sites in the 2018-2019 SEM biomonitoring programme

River/stream	Site	Spring survey (days after flow above)		Summer survey (days after flow above)	
		3 x median	7 x median	3 x median	7 x median
Hangatahua (Stony) R	Mangatete Road	(13)	(13)	(25)	(74)
Hangatahua (Stony) R	SH45	(13)	(13)	(25)	(74)
Herekawe S	Centennial Drive	(9)	(51)	(97)	(97)
Huatoki S	Hadley Drive	(9)	(51)	(97)	(97)
Huatoki S	Huatoki Domain	(9)	(51)	(97)	(97)
Huatoki S	Molesworth St	(9)	(51)	(97)	(97)
Kapoaiaia S	Wiremu Road	13	13	63	63
Kapoaiaia S	Wataroa Road	13	13	63	63
Kapoaiaia S	Near coast	13	13	63	63
Katikara S	Carrington Road	(13)	(13)	(25)	(74)
Katikara S	Near mouth	(13)	(13)	(25)	(74)
Kaupokonui R	Opunake Rd	17	31	49	182
Kaupokonui R	U/s Kaponga oxi ponds	17	31	49	182
Kaupokonui R	U/s Lactose Co.	19	31	49	182
Kaupokonui R	Glenn Rd	19	31	49	182
Kaupokonui R	Beach	17	31	49	182
Kurapete S	U/s Inglewood WWTP	(9)	(51)	(172)	(172)
Kurapete S	6 km d/s Inglewood WWTP	(9)	(51)	(172)	(172)
Maketawa S	Opp Derby Road	(10)	(11)	(34)	(76)
Maketawa S	Tarata Road	(10)	(11)	(34)	(76)
Mangaehu R	Raupuha Road	45	90	93	162
Manganui R	SH3	10	10	34	34
Manganui R	Bristol Road	10	10	55	76
Mangaoraka S	Corbett Road	9	51	161	161
Mangati S	D/s railway line	(11)	(12)	(100)	(101)
Mangati S	Te Rima Pl, Bell Block	(11)	(12)	(100)	(101)
Mangawhero S	U/s Eltham WWT Plant	(27)	(129)	(50)	(260)
Mangawhero S	D/s Mangawharawhara S	(27)	(129)	(50)	(260)
Mangorei S	SH3	(10)	(11)	(161)	(161)
Patea R	Barclay Rd	10	11	90	127
Patea R	Swansea Rd	10	11	90	127
Patea R	Skinner Rd	10	11	90	127
Punehu S	Wiremu Rd	9	35	65	65
Punehu S	SH45	9	35	65	65

River/stream	Site	Spring survey (days after flow above)		Summer survey (days after flow above)	
		3 x median	7 x median	3 x median	7 x median
Tangahoe R	Upper Valley	(29)	(42)	(51)	(117)
Tangahoe R	Tangahoe Valley Road	(29)	(42)	(51)	(117)
Tangahoe R	D/s railbridge	(29)	(42)	(51)	(117)
Timaru S	Carrington Road	(13)	(13)	(25)	(74)
Timaru S	SH45	(13)	(13)	(25)	(74)
Waiau S	Inland North Road	(9)	(51)	(161)	(161)
Waimoku S	Lucy's Gully	(13)	(13)	(97)	(97)
Waimoku S	Beach	(13)	(13)	(97)	(97)
Waingongoro R	900m d/s Nat Park	28	44	119	187
Waingongoro R	Opunake Rd	28	44	119	187
Waingongoro R	Eltham Rd	28	44	119	182
Waingongoro R	Stuart Rd	28	44	119	182
Waingongoro R	SH45	28	44	124	129
Waingongoro R	Ohawe Beach	28	44	124	129
Waiokura S	Skeet Road	(17)	(360)	(98)	(511)
Waiokura S	Manaia Golf-Course	(17)	(360)	(98)	(511)
Waiongana S	SH3a	11	11	31	72
Waiongana S	Devon Road	11	11	31	72
Waitara	Autawa Road	11	90	55	174
Waitara	Mamaku Road	11	12	95	97
Waiwhakaiho R	National Park	10	10	15	64
Waiwhakaiho R	SH3 (Egmont Village)	10	10	15	64
Waiwhakaiho R	Constance St (NP)	10	11	16	82
Waiwhakaiho R	Adjacent Lake Rotomanu	10	11	16	82
Whenuakura R	Nicholson Road	29	42	51	117

NB: ( ) = extrapolation from nearby catchment

Flow protocols prevent sampling within seven days after a 3x median fresh or ten days after a 7x median fresh, as higher flows disturb community composition and abundance. For this monitoring period, spring surveys were performed 9 to 45 days after a moderate fresh (> 3x median flow), while the summer 2019 surveys were undertaken 15-172 days after a moderate fresh.

3.2 Macroinvertebrate communities

Lists of the taxa found during spring 2018 and summer 2019 surveys, together with taxa richness, MCI scores and other appropriate indices for each site can be found in Appendix II. These results are discussed below, on a stream-by-stream basis, for the sites and seasons (spring and summer) in which the surveys were conducted. The data from previous surveys is also presented for each site, and results to date are illustrated as appropriate.

3.2.1 Hangatahua (Stony) River

The Hangatahua (Stony) River is a ringplain river whose source is located within Egmont National Park. The lower part of the river has a very narrow catchment and generally good water quality. There are two sites monitored for SEM purposes on the Hangatahua (Stony) River.

In the winter of 1996 a massive drift of sand moved down the Hangatahua River, following a major erosion event in the headwaters of the river. This devastated macroinvertebrate communities, with few macroinvertebrate taxa found in the river in the spring of 1996 (Figure 2 and Figure 4). Since then sand has continued to affect the macroinvertebrate communities of the river, although some recovery was observed in the communities in March and November 1997, January and February 1999, late 2000, and again in 2002-2003. At these times greater numbers and varieties of macroinvertebrates were recorded on the riverbed. The very high MCI score of 160 recorded at SH45 in November 1998 (Figure 2) was the result of a community consisting of only one taxon (and just a single individual) which was highly sensitive to pollution. The MCI is not a good indicator of water quality when only a small number of taxa are present and is not typically the index used to assess the impacts of sedimentation in stony streams. However, the MCI has some value in the assessment of recovery of the faunal community with time and has some value in trend evaluation.

A further massive sand drift moved down the river following very heavy February 2004 rainfall and significant flood flows in late February, some three weeks prior to the summer 2004 survey. An additional survey was performed in late winter 2004 to document the continuing effects of sand/sediment drift (see Figures 2 and 3), some three months prior to the late spring survey. Further erosion effects occurred in late 2006 delaying the spring 2006 survey and during the latter months of 2007 while significant sand and scoria bed scouring and sedimentation occurred down the river in mid-year and again in spring 2008 delaying the 'spring' survey until early in 2009. No large-scale significant headwater erosion events were recorded between spring 2009 and summer 2014 but there was a headwater erosion event in February 2014. There have been no major headwater erosion events since February 2014 though minor bed scouring and sedimentation effects continued to impact during the 2018-2019 period.

3.2.1.1 Mangatete Road site (STY000300)

3.2.1.1.1 Taxa richness and MCI

Forty-four SEM surveys have been undertaken in the Stony River at this mid-reach site between October 1995 and February 2019. These results are summarised in Table 5, together with results from the current period, and illustrated in Figure 2.

Table 5 Results from SEM surveys performed in the Stony River at Mangatete Road together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
STY000300	44	1-21	10	64-140	112	13	109	16	108

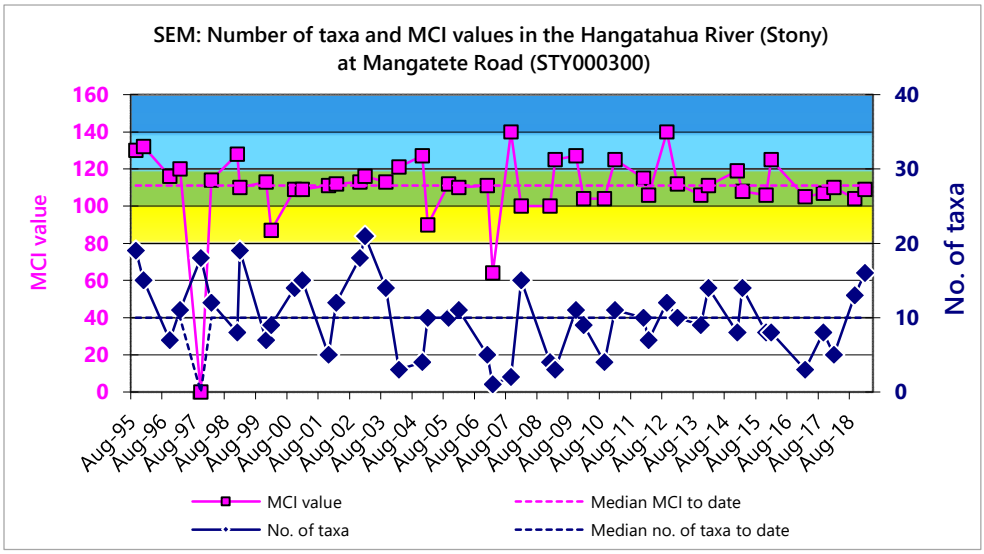


Figure 2 Numbers of taxa and MCI values in the Hangatahua (Stony) River at Mangatete Road

A wide range of richness (1 to 21 taxa) has been recorded as a consequence of extensive headwater erosion impacts on the river's communities with a historical median richness of only 10 taxa, far fewer than might be expected for a ringplain river site at this altitude (160 masl). In the 2018-2019 period, richness was higher than the median, indicative of lessening erosion impacts of scouring, finer sediment deposition, and bed movement.

There are significant limitations when using the MCI for community compositions affected by sedimentation and erosion events (e.g. scores show considerable significant variability when relatively few taxa are present). Values at this site have ranged widely between 64 and 140 units with a historical median MCI value of 112 units. The spring and summer scores were not significantly lower than the historical median. The summer score categorised this site as having 'good' health (Table 3). The median MCI score placed this site's river health in the 'good' category. The paucity of the communities in terms of richness in particular must be taken into account at the site, where headwater erosion effects have been very pronounced and the substrate remains relatively mobile and well scoured.

3.2.1.1.2 Predicted river 'health'

The Stony River at Mangatete Road is 7.3 km downstream of the National Park boundary at an altitude of 160 masl. A relationship for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 109 for this site. The historical site median was not significantly different (Stark and Fowles, 2009) to the predictive value. The spring 2018 and summer 2019 survey scores were also not significantly different to the predictive value. The REC predicted MCI value (Leathwick, et al. 2009) was 128 units. The historical site median was significantly lower than this value but the scores recorded in the year under review were both not significantly different.

3.2.1.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced for the full dataset (Figure 3). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 24 years of SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Stony River at Mangatete Road.

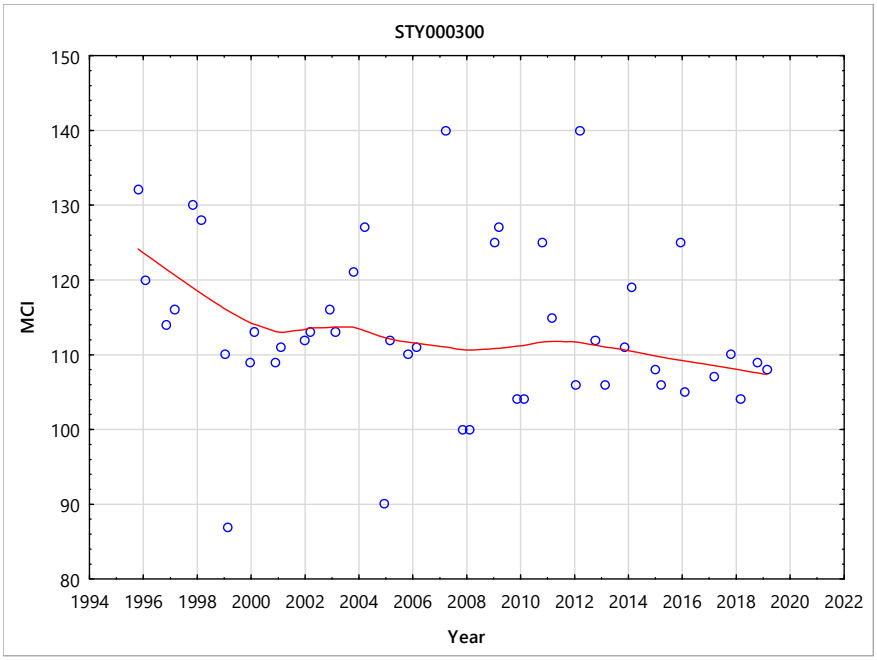


Figure 3 LOWESS trend plot of MCI data at Mangatete Road site for the full dataset with a Mann-Kendall test for the full and ten-year dataset

Although a decreasing trend in MCI scores has been found for the full dataset, particularly over the first six years, this trend was close to being statistically significant after FDR application and continued deterioration in the future will likely produce a statistically significant trend. The trendline at this site has a range of MCI scores of about 15 units indicative of some important ecological variability over the period, not surprisingly given the erosion effect documented earlier and further emphasised by the wide range of individual scores, particularly since 2004. Overall, the trendline shows 'good' generic river 'health'; deteriorating slightly from 'very good' (prior to 1997). However, the majority of the variability was caused by severe headwater erosion events at varying intervals over the period.

A slight negative trend in MCI scores has been found at this site for the ten-year dataset. However, this has not been statistically significant. Overall, the ten-year trendline shows 'good' generic river 'health'.

3.2.1.2 SH 45 site (STY000400)

3.2.1.2.1 Taxa richness and MCI

Forty-four surveys have been undertaken in the Stony River at this lower reach site between October 1995 and February 2018. These results are summarised in Table 6, together with results from the current period, and illustrated in Figure 4.

Table 6 Results from SEM surveys performed in the Stony River at SH 45 together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2019		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
STY000400	44	0-18	9	0-150	108	13	118	16	110

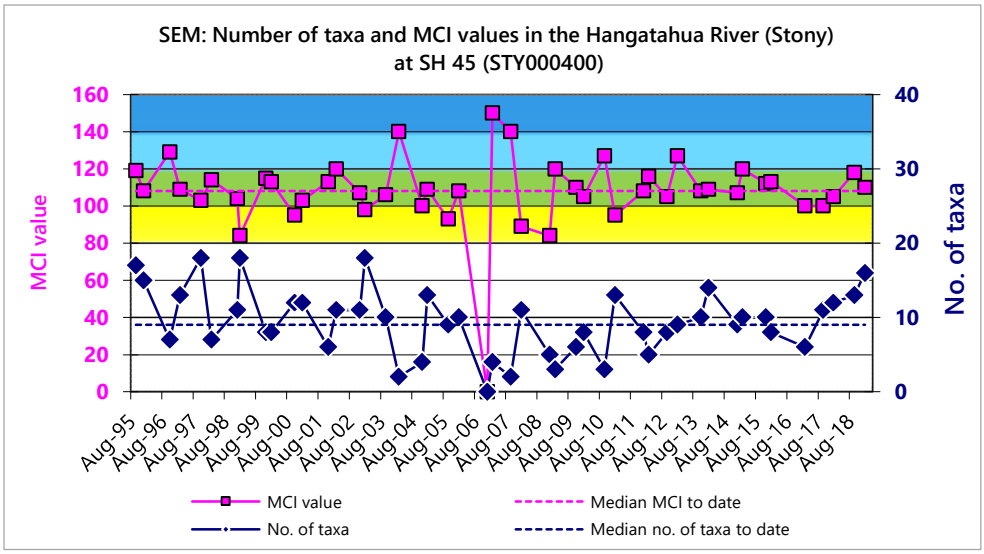


Figure 4 Numbers of taxa and MCI values in the Hangatahua (Stony) River at SH 45

A wide range of richness (0 to 18 taxa) has been recorded mainly as a consequence of extensive headwater erosion impacts on the river's communities, with a median richness of only nine taxa, far fewer than would be expected for a ringplain river site at this altitude (70 m asl). In the 2018-2019 period richness was moderately low with only 13 and 16 taxa recorded in spring and summer respectively suggestive of continuing but not severe erosion impacts of scouring, finer sediment deposition, and bed movement at this site.

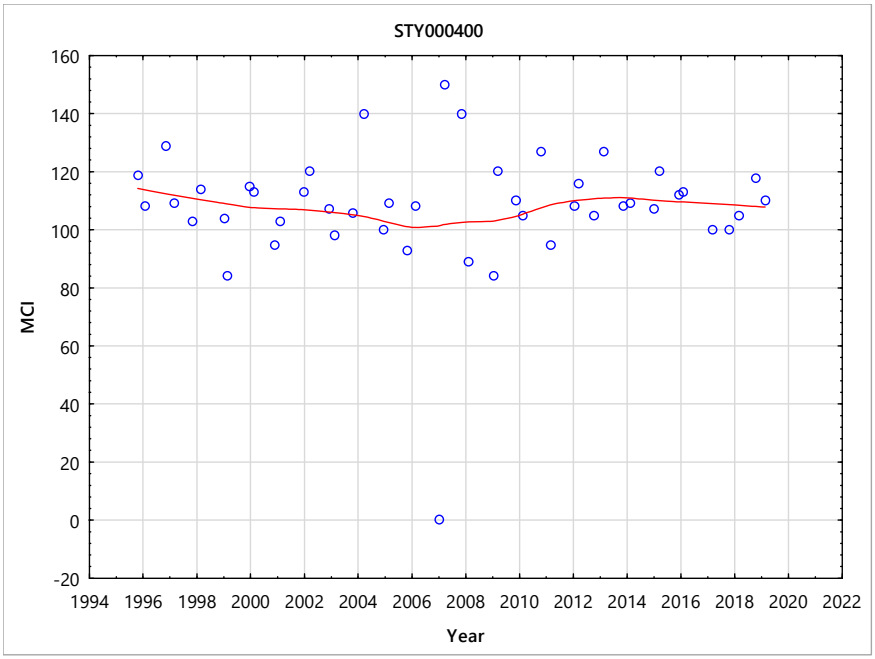
There are significant limitations when using the MCI for community compositions affected by sedimentation and erosion events (e.g. scores show considerable variability when relatively few taxa are present). Values at this site have ranged widely between 0 and 150 units with a median MCI value of 110 units. The MCI scores for the spring 2018 survey (118 units) and summer 2019 survey (110 units) were not significantly higher than the historical median (Figure 4). The score categorised this site as having 'good' health (Table 3). However, the paucity of numbers and richness should be recognised in this assessment given the historical impacts of headwater erosion effects along the length of the river channel and the persistently high rainfall that occurred preceding this survey.

3.2.1.2.2 Predicted river 'health'

The Stony River at SH 45 is 12.5 km downstream of the National Park boundary at an altitude of 70 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict an MCI value of 103 for this site. The spring score was significantly higher than (Stark, 1998) the distance predictive value. The historical median, spring and summer scores were not significantly different to the REC predicted score (Leathwick, et al. 2009) of 115 units.

3.2.1.2.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced using the full dataset (Figure 5). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 24 years of SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Stony River at SH 45.



N = 47
Kendall tau = 0.07
p level = 0.95
FDR p = 0.95

N = 19
Kendall tau = - 0.01
p level = 0.94
FDR p = 0.96

Figure 5 LOWESS trend plot of MCI data at SH 45 site for the full dataset with a Mann-Kendall test for the full and ten-year dataset

A slightly increasing trend in MCI scores over the period has not been statistically significant. The trendline at the site has a MCI range of about 16 units indicative of some important ecological variability over the period for the same reasons as those responsible for variability at the upstream site (Mangatete Rd). This was a similar trend to that found at the upstream mid-reach (Mangatete Road) site. Greater variability in scores has been apparent since 2004 with the majority of the variability in MCI scores associated with headwater erosion events. Overall, the trendline shows 'good' generic river 'health'.

There has been a minor negative trend in MCI scores over the ten-year period which was not statistically significant. Overall, the trend line shows 'good' generic river 'health'.

3.2.1.3 Discussion

Due to the major influence of historical and relatively frequent headwater erosion events, scouring, and instability of the river bed; seasonal and spatial differences in macroinvertebrate communities in the Stony River often have not been as abundant or diverse as elsewhere in ringplain streams.

Taxa richness at both sites were moderately low but slightly higher than historic medians. This was likely due to continuing but less severe erosion events impacting on the macroinvertebrate communities.

MCI scores indicted that macroinvertebrate communities were in 'good' health for both sites and were not significantly different to historical medians. There was a non-significant increase in MCI scores at the downstream site indicating little change in macroinvertebrate health in a downstream direction.

3.2.2 Herekawe Stream

One site in this small lowland coastal ringplain stream on the western perimeter of New Plymouth City was incorporated into the SEM programme in 2008 for the purpose of monitoring a newly-developed walkway and associated riparian planting initiatives in the lower reaches of the stream. Consent monitoring has been performed at this 'control' site in spring and summer throughout the period from 1995 to 2019 (and dates back to 1986).

3.2.2.1 Centennial Drive site (HRK000085)

3.2.2.1.1 Taxa richness and MCI

Forty-five surveys have been undertaken between February 1995 and February 2018 in this lower-reach site in the Herekawe Stream. These results are summarised in Table 7, together with the results from the current period, and illustrated in Figure 6.

Table 7 Results of previous surveys performed in Herekawe Stream at Centennial Drive, together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
HRK000085	45	13-29	19	68-100	89	20	92	18	96

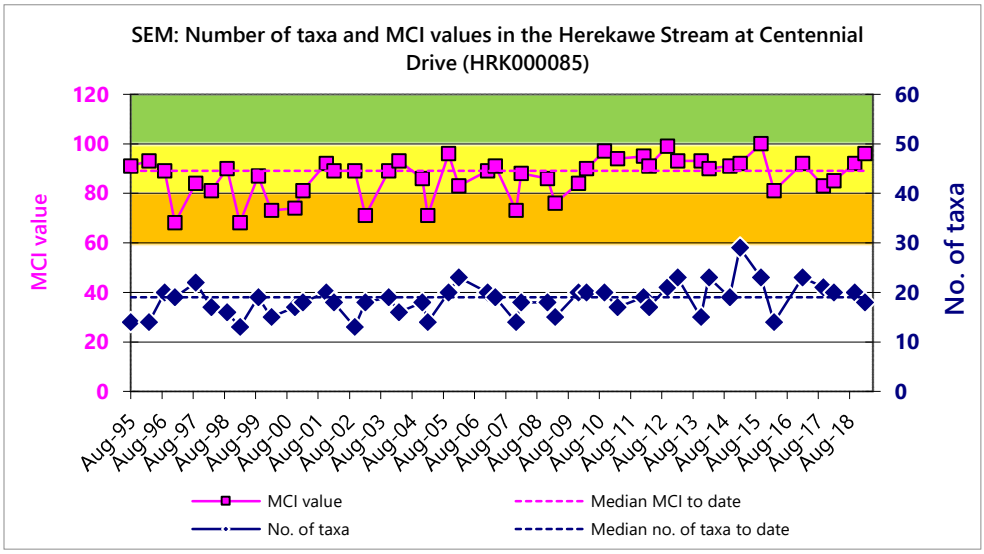


Figure 6 Numbers of taxa and MCI values in the Herekawe Stream upstream of Centennial Drive

A moderate range of richness (13 to 29 taxa) had been found, with a median richness of 19 taxa which has been more representative of typical richness in small lowland coastal streams. During the current period, spring (20 taxa) and summer (18 taxa) richness were similar to the median richness for the site. MCI values have had a relatively wide range (32 units) at this site. The historical median value (89 units) is above scores typical of lower reach sites elsewhere in small lowland coastal streams. The spring (92 units) and summer (96 units) scores were not significantly different (Stark, 1998) to the historical median. These scores categorised this site as having 'fair' health generically (Table 3). The historical median score (89 units) placed this site in the 'fair' category.

3.2.2.1.2 Predicted stream 'health'

The Herekawe Stream rises as seepage near the coast on the ringplain and the site at Centennial Drive, Omata is in the lower reaches near the mouth at an altitude of 5 m asl. The REC predicted MCI value (Leathwick, et al. 2009) was 89 units. The historical median, and spring and summer scores were not significantly different (Stark, 1998) to this value.

3.2.2.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 7). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was performed on 24 years of SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from Herekawe Stream at Centennial Drive.

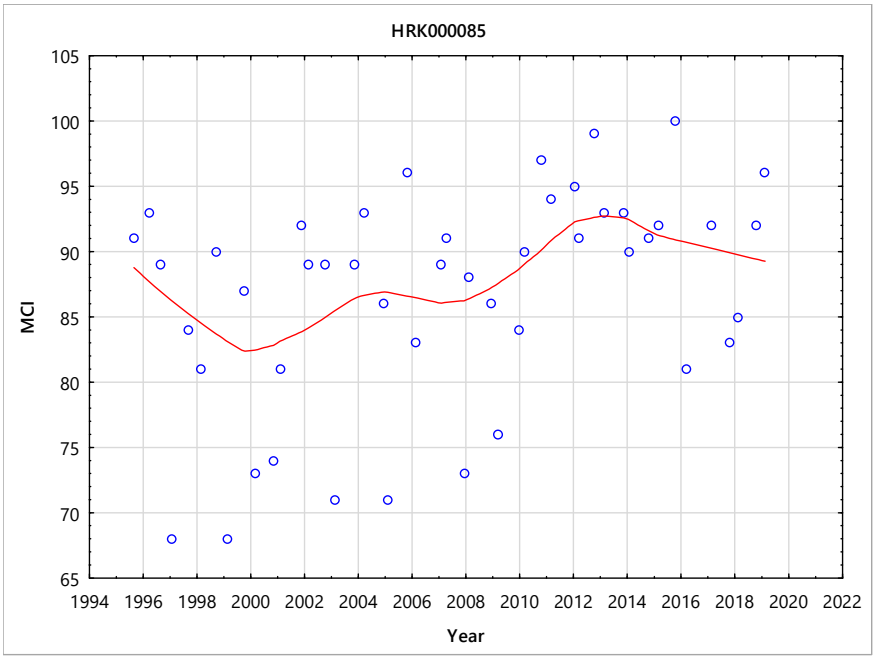


Figure 7 LOWESS trend plot of MCI data in the Herekawe Stream at the Centennial Drive site for the full dataset with a Mann-Kendall test for the full and ten-year dataset

There was a positive significant trend in MCI scores across the full dataset at this site, which is situated in the lower reaches of the stream, immediately downstream of a recently constructed walkway. Trends have varied at this site, with a general trend of improvement since 2000, and particularly after 2008 More recently there has been stability, but with some wide variations in individual MCI scores. The trendline variation (10 units) indicates some ecological variability. The trendline was indicative of 'fair' stream health.

A negative non-significant trend in MCI scores has been found over the ten-year period, in contrast with the significant positive result found in the full dataset. The ten-year dataset trend shows an increase from 2009 to 2012, but overall the trendline change was negligible. The trendline was indicative of 'fair' health.

3.2.2.2 Discussion

Spring and summer values are typically very similar at this site with seasonal median MCI values being identical over the 24-year period (Appendix II). The survey results were within expected parameters with the site having 'fair' health and not having any significant differences between the current score and median and predicted results.

3.2.3 Huatoki Stream

The Huatoki Stream is a small ringplain stream arising outside Egmont National Park that flows south to north with the middle and lower parts of the catchment in the New Plymouth city area. There are three SEM sites on the stream.

3.2.3.1 Hadley Drive site (HTK000350)

3.2.3.1.1 Taxa richness and MCI

Forty-three surveys have been undertaken, between December 1996 and February 2018, at this lower mid-reach, unshaded site, draining open developed farmland, on the outskirts of New Plymouth city. These results are summarised in Table 8, together with the results from the current period, and illustrated in Figure 8.

Table 8 Results of previous surveys performed in the Huatoki Stream at Hadley Drive together with 2018-2019 results

Site code	SEM data (1996 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
HTK000350	43	19-34	26	79-115	97	23	109	20	89

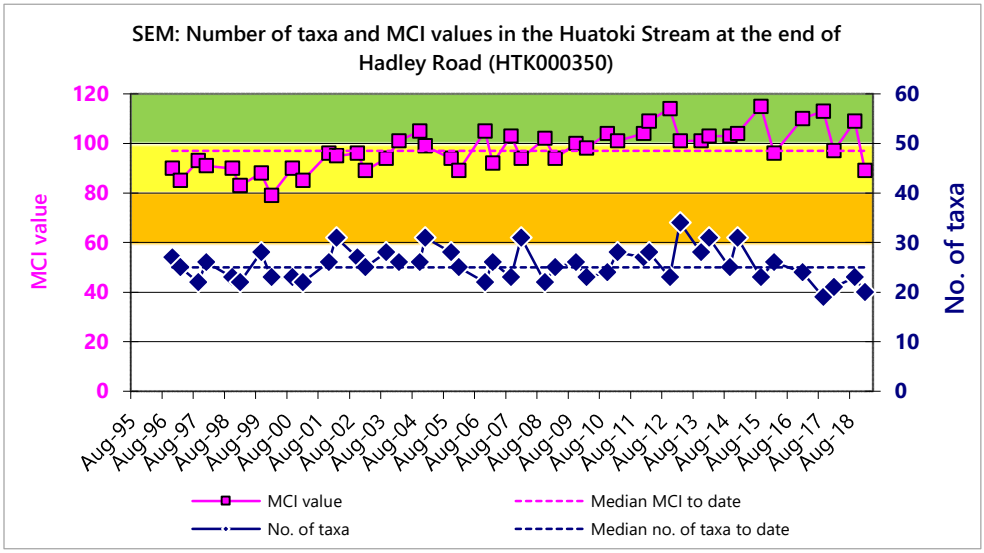


Figure 8 Numbers of taxa and MCI values in the Huatoki Stream at the end of Hadley Drive

A moderate range of richness (19 to 34 taxa) has been found with a relatively high median richness of 26 taxa, relatively typical of richness in the mid to lower reaches of ringplain streams rising outside of the National Park. During the 2018-2019 period spring (23 taxa) and summer (20 taxa) richness were slightly lower than the historical median richness.

MCI values have had a relatively wide range (36 units) at this site, typical of mid to lower reach sites on the ringplain. The spring 2018 (109 units) score was significantly higher (Stark, 1998) than the historical median by 12 units, while the summer 2019 (89 units) score was not significantly different to the historical median score. The spring and summer scores respectively categorised this site as having 'good' and 'fair' health generically (Table 3). The historical median score (97 units) placed this site in the 'fair' category for generic health.

3.2.3.1.2 Predicted stream 'health'

The Huatoki Stream rises below the National Park boundary and the site at Hadley Drive is in the lower mid-reaches at an altitude of 60 m asl. The REC predicted MCI value (Leathwick, et al. 2009) was 95 units. The summer score was significantly higher than the REC predicted value while there was no significant difference for the spring and historic median scores (Stark, 1998).

3.2.3.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) was produced (Figure 9). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 23 years of SEM results (1996-2019) and the most recent ten-years of results (2009-2019) from the site in the Huatoki Stream at Hadley Drive.

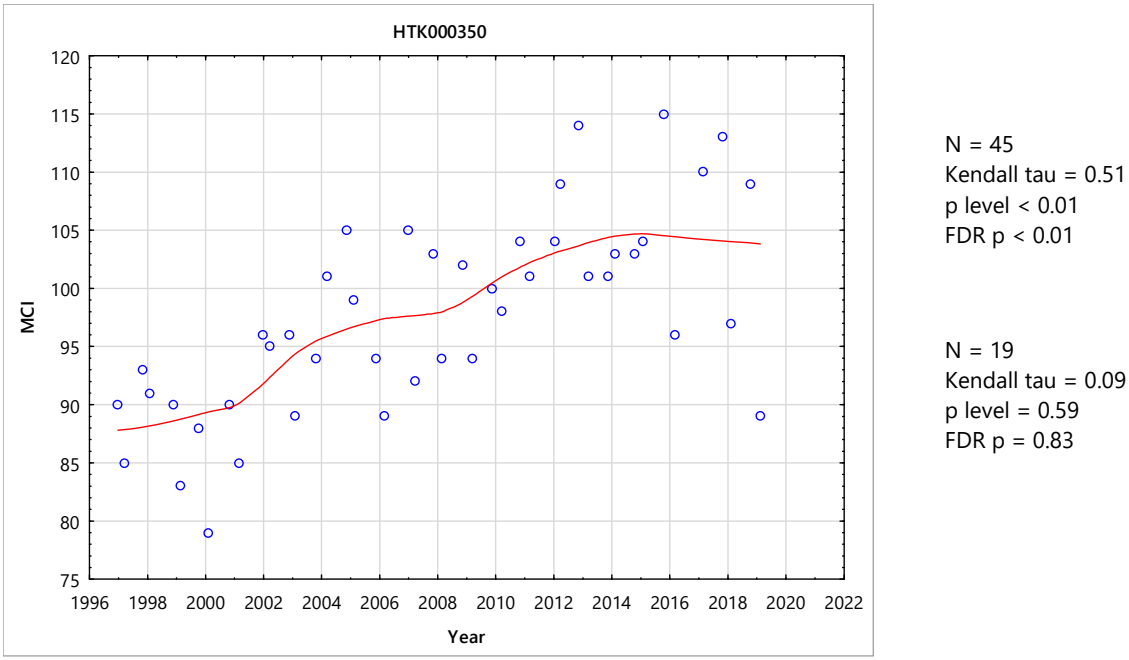


Figure 9 LOWESS trend plot of MCI data in the Huatoki Stream at the Hadley Drive site for the full dataset with a Mann-Kendall test for the full and ten-year dataset

A strong significant improvement ($p < 0.01$) in MCI scores, particularly since 2000 has been illustrated at this site on the outskirts of New Plymouth over the 23-year period. This may have been related to improvements in farming practices (including more recent riparian fencing) and/or wastes disposal in the rural catchment between the stream's seepage sources (below the National Park) and urban New Plymouth. The wide trendline range of MCI scores (16 units) indicates some changes of ecological importance. MCI scores have been indicative of 'fair' generic stream health almost throughout the period improving to 'good' health since 2010.

A non-significant trend in MCI scores has been found over the ten-year period in contrast with the significant positive result found in the full dataset. The trendline was mostly indicative of 'good' health.

3.2.3.2 Huatoki Domain site (HTK000425)

3.2.3.2.1 Taxa richness and MCI

Forty-three surveys have been undertaken at this lower middle reach site in the Huatoki Stream toward the downstream boundary of the Huatoki Domain between December 1996 and February 2018. These results are summarised in Table 9, together with the results from the current period, and illustrated in Figure 10.

Table 9 Results of previous surveys performed at Huatoki Stream in Huatoki Domain, together with the 2018-2019 results

Site code	SEM data (1996 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
HTK000425	43	17-32	25	91-117	104	23	106	20	103

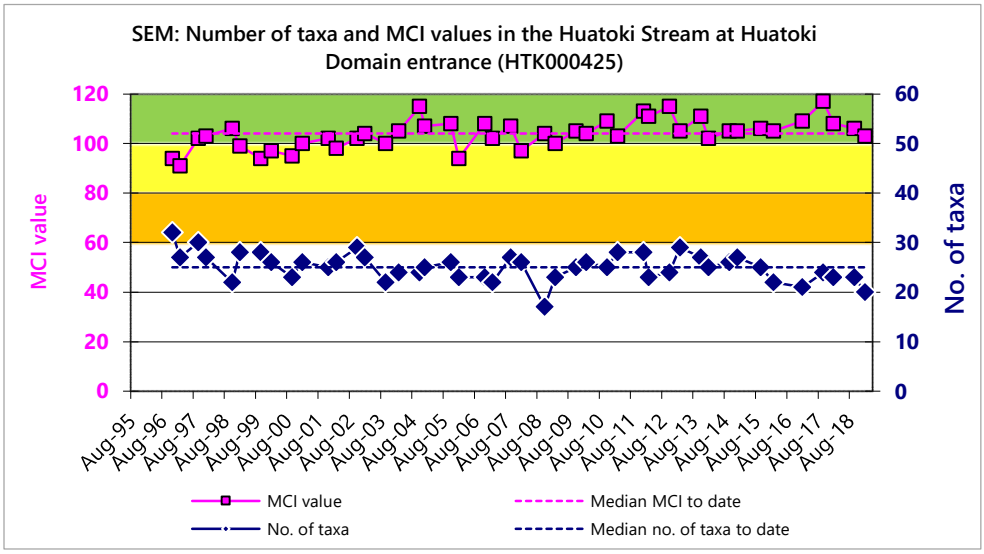


Figure 10 Numbers of taxa and MCI values in the Huatoki Stream at the Huatoki Domain

A moderate range of richness (17 to 32 taxa) has been found, with a median richness of 25 taxa (more representative of typical richness for the lower reaches of ringplain streams rising outside the National Park boundary). During the current period spring (23 taxa) and summer (20 taxa) richness were only slightly taxa lower than the historical median richness.

MCI values have had a moderately wide range (26 units) at this site. The median value (104 units) has been higher than typical of lower reach sites elsewhere on the ringplain however. The spring (106 units) score was a significant 13 units higher than the historical median (Stark 1998), while the summer (103 units) score was not significantly different to the historical median value. The spring and summer scores categorised this site as having 'good' health generically (Table 3). The historical median score (104 units) also placed this site in the 'good' category for generic health.

3.2.3.2.2 Predicted stream 'health'

The Huatoki Stream rises below the National Park boundary and the site at Hadley Domain is in the lower mid-reaches at an altitude of 30 m asl. The REC predicted MCI value (Leathwick, et al. 2009) was 92 units. The historical, spring and summer scores were all significantly higher than the REC value (Stark, 1998).

3.2.3.2.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 11). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 23 years of SEM results (1996-2019) and the most recent ten-years of results (2009-2019) from the site in the Huatoki Stream at Huatoki Domain.

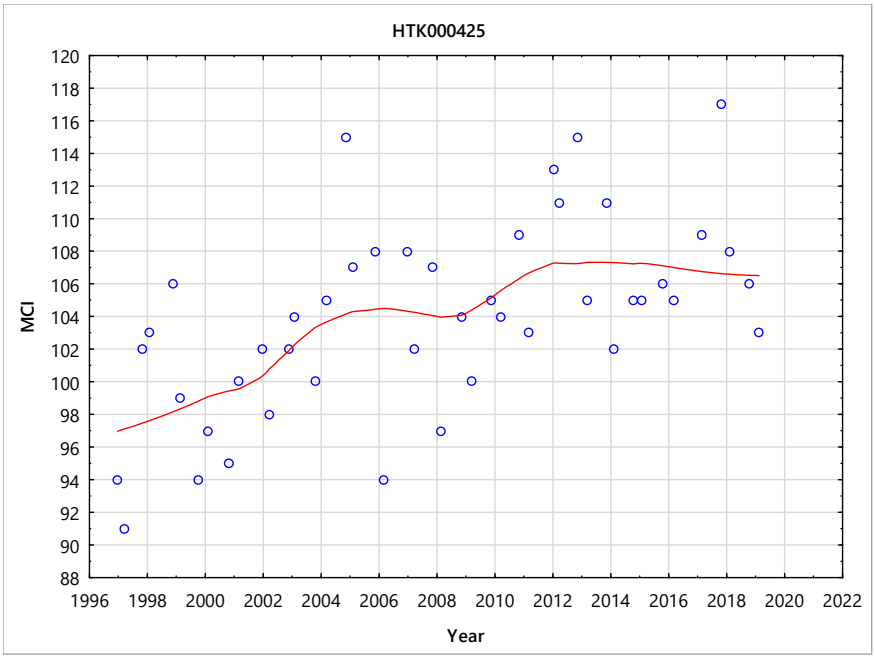


Figure 11 LOWESS trend plot of MCI data in the Huatoki Stream for the Huatoki Domain site for the full dataset with a Mann-Kendall test for the full and ten-year dataset

A similar temporal trend of a marked improvement in MCI scores, but not as strong as that found at the upstream site (at Hadley Drive), was identified at this site in the Domain although scores peaked with small decreases after 2006 and 2012. The overall trend has been very significant after FDR application ($p < 0.01$) and the trendline range of scores (12 units) indicates some ecological variation. The improving trend has probably been related to the upstream catchment activities noted above as no nearby habitat changes have been recorded within the Domain.

The trendline MCI scores indicated 'fair' generic stream health early in the monitoring period, improving to 'good' stream health since 2002.

A highly non-significant trend in MCI scores has been found over the ten-year period suggesting little recent change has occurred. The trendline was indicative of 'good' health.

3.2.3.3 Site near coast (HTK000745)

3.2.3.3.1 Taxa richness and MCI

Forty-three surveys have been undertaken at this lower reach site in the Huatoki Stream between December 1996 and February 2019. These results are summarised in Table 10, together with the results from the current period, and illustrated in Figure 12.

Table 10 Results of previous surveys performed in Huatoki Stream at the site near the coast, together with the 2018-2019 results

Site code	SEM data (1996 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
HTK000745	43	11-27	22	62-102	86	18	98	14	56

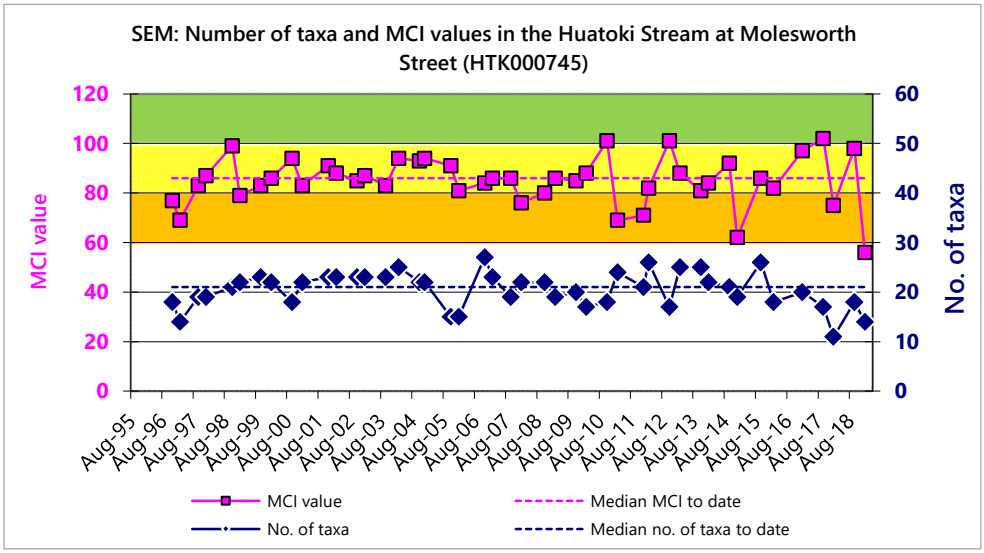


Figure 12 Numbers of taxa and MCI values in the Huatoki Stream at Molesworth Street (near coast)

A moderate range of richness (11 to 27 taxa) has been found, with a median richness of 22 taxa (more representative of typical richness in the lower reaches of ringplain streams rising outside the National Park boundary). During the 2018-2019 period spring (18 taxa) was four taxa less than historical median richness, while summer (14 taxa) richness was a substantial eight taxa lower than the historical median richness. The summer richness was also the second equal lowest richness recorded at this site to date.

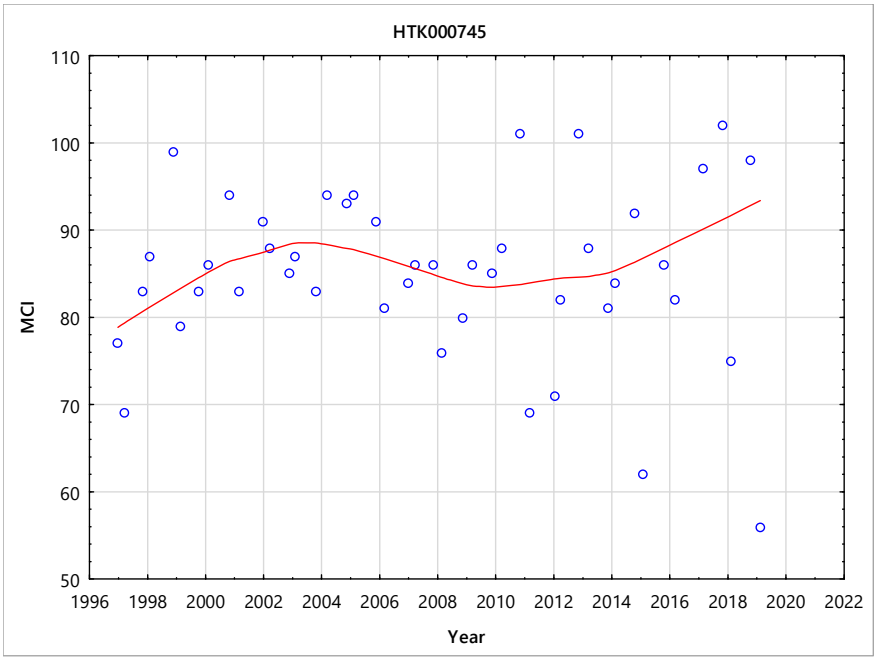
MCI values have had a relatively wide range (30 units) at this site. However, the median value (86 units) has been typical of lower reach sites elsewhere on the ringplain. The scores recorded in the current period showed substantial variation. The spring (98 units) score was significantly higher (Stark, 1998) than the median by 12 units. However, the summer (56 units) score was significantly (Stark, 1998) lower than the historical median by a very large 30 units and the lowest score recorded at the site to date. The MCI scores in spring and summer respectively categorised this site as having 'fair' and 'very poor' health generically (Table 3). The historical median score (86 units) placed this site in the 'fair' category for generic health.

3.2.3.3.2 Predicted stream 'health'

The Huatoki Stream rises below the National Park boundary and the site near the coast is in the lower reaches at an altitude of 5 m asl. The REC predicted MCI value (Leathwick, et al. 2009) was 93 units. The historical and spring scores were not significantly different to the REC value but the summer score was significantly lower (Stark, 1998).

3.2.3.3.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 13) using the full dataset. A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 23 years of SEM results (1996-2019) and the most recent ten-years of results (2009-2019) from the site in the Huatoki Stream near the coast.



N = 45
Kendall tau = 0.017
p level = 0.873
FDR p = 0.900

N = 19
Kendall tau = 0.01
p level = 0.95
FDR p = 0.95

Figure 13 LOWESS trend plot of MCI data for the site in the Huatoki Stream near the coast for the full dataset with a Mann-Kendall test for the full and ten-year dataset

A trend of steady improvement in smoothed MCI scores had occurred at this urbanised site until 2004 after which scores trended downward until plateauing more recently (with much more variability amongst individual scores) following the pulsed flows and subtle habitat changes caused by the beautification project which involved construction of a weir and a fishpass. Overall, there was a slight positive non-significant trend. The wide trendline range of scores (13 units) probably related in part to those activities noted for the two sites further upstream in the Huatoki catchment, the quality of stormwater dischargers entering the stream and the stream enhancement project specific to the reach immediately upstream of this site. The trendline scores were indicative of 'fair' generic stream health.

A non-significant positive trend in MCI scores has been found over the ten-year period congruent with the result found in the full dataset. The trendline was indicative of 'fair' health.

3.2.3.4 Discussion

Historically, there have been small summer decreases of MCI scores (Appendix II) in the Huatoki Stream but for the current monitoring period there were significant decreases in MCI scores from spring to summer at the top and bottom sites but not the middle, well shaded site. The seasonal change was probably the result of dry weather causing more stable flows and increased periphyton growth for the upper site. However, the new record low for the bottom site may well have been caused by poor preceding water quality rather than low flows as the site was not adversely affected by periphyton, though fine sediment was present which a fresh would help to remove.

As was normal, the two up sites at Hadley Drive and Huatoki Domain, had higher macroinvertebrate health than the lower site on Molesworth Street. There was little difference in the overall health between the two upstream communities in spring but the Huatoki Domain site had a significantly higher MCI score than the upper Hadley Drive site in summer, probably as a result of the Huatoki Domain site having better shading which helped to minimise periphyton growth. The significant decrease at the lower site can be attributed to increased urbanisation, habitat modification and deterioration in water quality.

3.2.4 Kapoaiaia Stream

The Kapoaiaia Stream is a small ringplain stream running in a westerly direction with a source situated inside Egmont National Park. This stream was selected for the purpose of monitoring a western Taranaki ringplain catchment with minimal existing riparian vegetation cover. Three sites in the Kapoaiaia Stream were included in the SEM programme commencing in the 2000-2001 year. These were located at Wiremu Road (in open farmland nearly 6 km below the National Park boundary), Wataroa Road bridge (nearly 8 km further downstream), and about 0.8 km from the coast (8 km further downstream, i.e. 25 km below the National Park boundary).

3.2.4.1 Wiremu Road site (KPA000250)

3.2.4.1.1 Taxa richness and MCI

Thirty-eight surveys have been undertaken in the Kapoaiaia Stream between March 1998 and February 2018 at this open, upper mid-reach site in farmland, 5.7 km downstream of the National Park. These results are summarised in Table 11 together with the results from the current period, and illustrated in Figure 14.

Table 11 Results of previous surveys performed in the Kapoaiaia Stream at Wiremu Road together with the 2018-2019 results

Site code	SEM data (1998 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KPA000250	38	19-31	25	83-131	117	25	127	23	107

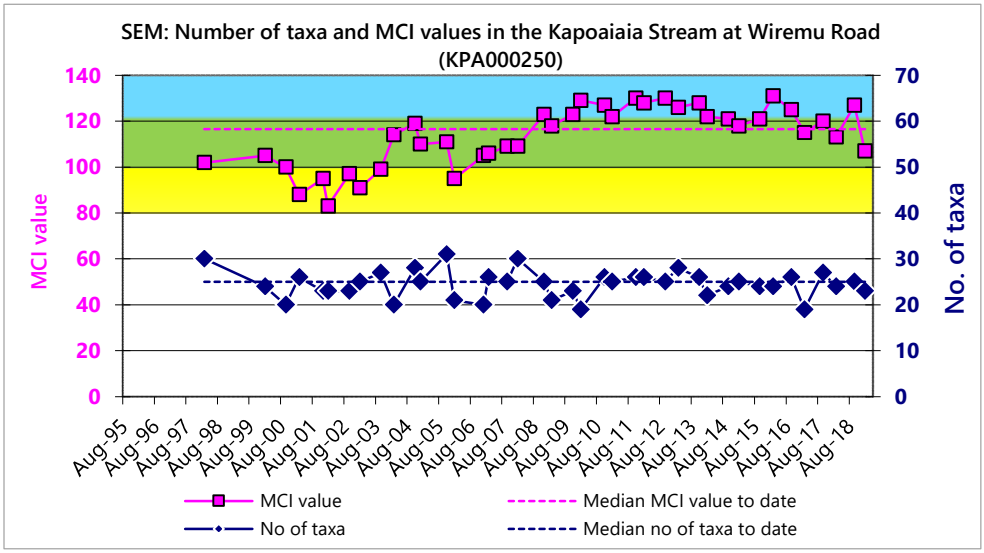


Figure 14 Numbers of taxa MCI values in the Kapoaiaia Stream at Wiremu Road

A moderate range of richness (19 to 31 taxa) has been found with a median richness of 25 taxa (more typical of richness in the mid-reaches of ringplain streams and rivers). During the current period, spring (25 taxa) and summer (23 taxa) richness were very similar to the historical median.

MCI values have had a wide range (48 units) at this site, wider than typical of a site in the upper mid-reaches of a ringplain stream although this site is in a reach of very open farmland, nearly 6km downstream from the National Park boundary. The spring (127 units) and summer (107 units) scores were not significantly different from the historical median. These scores categorised this site as having 'very good'

generic health (Table 3) in spring and 'good health' in summer. The historical median score (117 units) placed this site in the 'good' generic health category.

3.2.4.1.2 Predicted stream 'health'

The Kapoaiaia Stream site at Wiremu Road is 5.7 km downstream of the National Park boundary at an altitude of 240 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 112 for this site. The historical site median and summer survey were not significantly different from the distance predictive value and the spring score was significantly higher. The REC predicted MCI value (Leathwick, et al. 2009) was 111 units. The historical site median and summer survey were not significantly different from the REC predictive value and the spring score was significantly higher.

3.2.4.1.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 15) using the full dataset. A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 21 years of SEM results (1998-2019) and the most recent ten-years of results (2009-2019) from the site in the Kapoaiaia Stream at Wiremu Road.

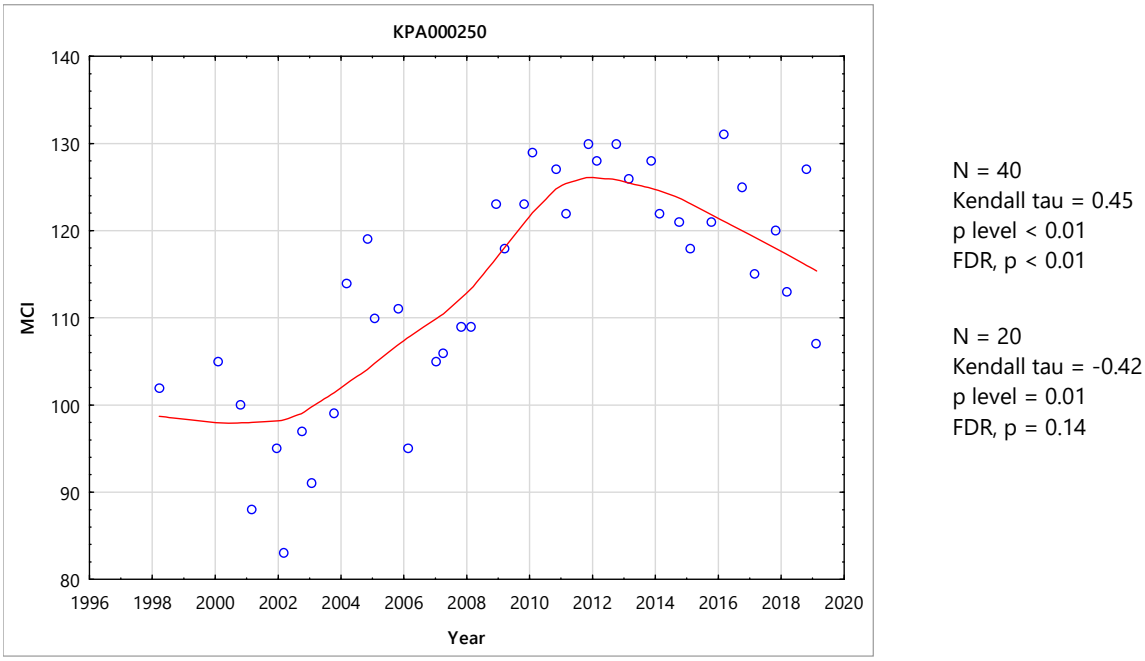


Figure 15 LOWESS trend plot of MCI data in the Kapoaiaia Stream at the Wiremu Road site

A very significant trend of improvement in MCI scores has been found over the 21-year duration of this monitoring period (FDR p < 0.01). There has been ecologically important variability in the extremely wide (28 units) range of trendline scores at this site also. This appears to have been related to farming practices, particularly variations in fertiliser usage, through the open reach between the National Park boundary and this upper site, which may have been exacerbated by the lack of riparian vegetation along this reach.

The trendline scores were indicative of generic stream health varying between 'fair' and 'very good' have been slightly lower than might be expected at times (particularly prior to 2004) at this site approximately 6 km below the National Park. A strong improvement has been obvious between 2007 and 2012 when it plateaued with some deterioration in 'health' over the 2013 to 2019 period.

A non-significant negative trend in MCI scores has been found over the ten-year period in contrast with the result found in the full dataset. The trendline was mostly indicative of 'very good' health for the most recent ten-year period but since 2017 has decreased to 'good' health.

3.2.4.2 Wataroa Road site (KPA000700)

3.2.4.2.1 Taxa richness and MCI

Thirty-eight surveys have been undertaken in the Kapoaiaia Stream at this mid-reach site at Wataroa Road between December 1996 and February 2018. These results are summarised in Table 12, together with the results from the current period, and illustrated in Figure 16.

Table 12 Results of previous surveys performed in the Kapoaiaia Stream at Wataroa Road, together with 2018-2019 results

Site code	SEM data (1996 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KPA000700	38	12-30	21	78-118	97	20	105	21	94

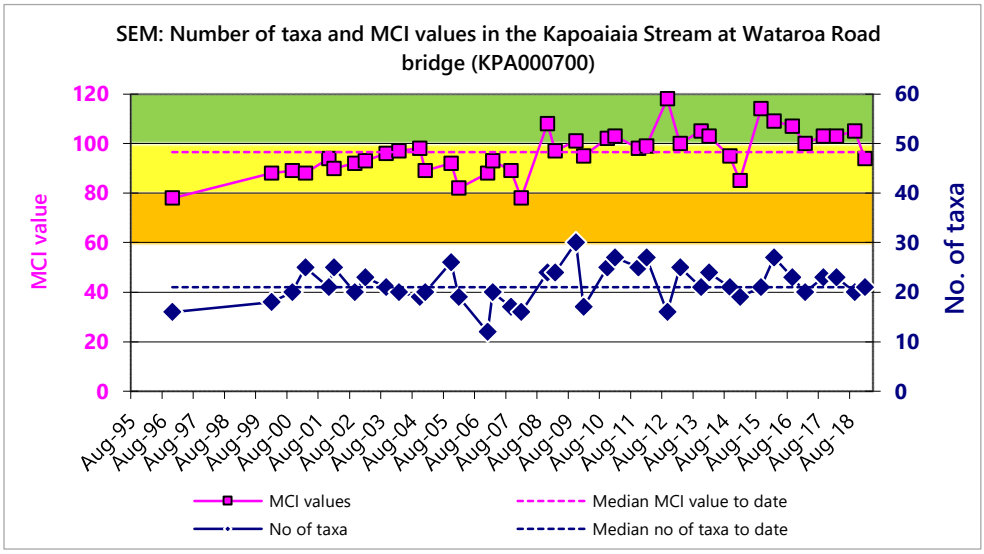


Figure 16 Numbers of taxa and MCI values in the Kapoaiaia Stream at Wataroa Road

A wide range of richness (12 to 30 taxa) has been found, with a median richness of 21 taxa, relatively typical of richness in the mid-reaches of ringplain streams and rivers. During the current period, spring (20 taxa) and summer (21 taxa) richness were similar to the historical median. MCI values have had a relatively wide range (40 units) at this site, more so than typical of many sites in the mid-reaches of ringplain rivers. The historical median value (97 units) is lower than values typical of mid-reach sites elsewhere on the ringplain. The spring (105 units) and summer (94 units) scores were similar to the historical median. These scores categorised this site as having 'good' (spring) and 'fair' (summer) health generically (Table 3). The historical median score (97 units) placed this site in the 'fair' category for generic health.

3.2.4.2.2 Predicted stream 'health'

The Kapoaiaia Stream site at Wataroa Road, is 13.5 km downstream of the National Park boundary at an altitude of 140 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 103 for this site. The historical site median, spring and summer scores were not significantly different to the distance predictive value. The REC

predicted MCI value (Leathwick, et al. 2009) was 105 units. The historical median, spring and summer scores were all not significantly different to the REC predictive value.

3.2.4.2.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 17). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 23 years of SEM results (1996-2019) and the most recent ten-years of results (2009-2019) from the site in the Kapoaiaia Stream at Wataroa Road.

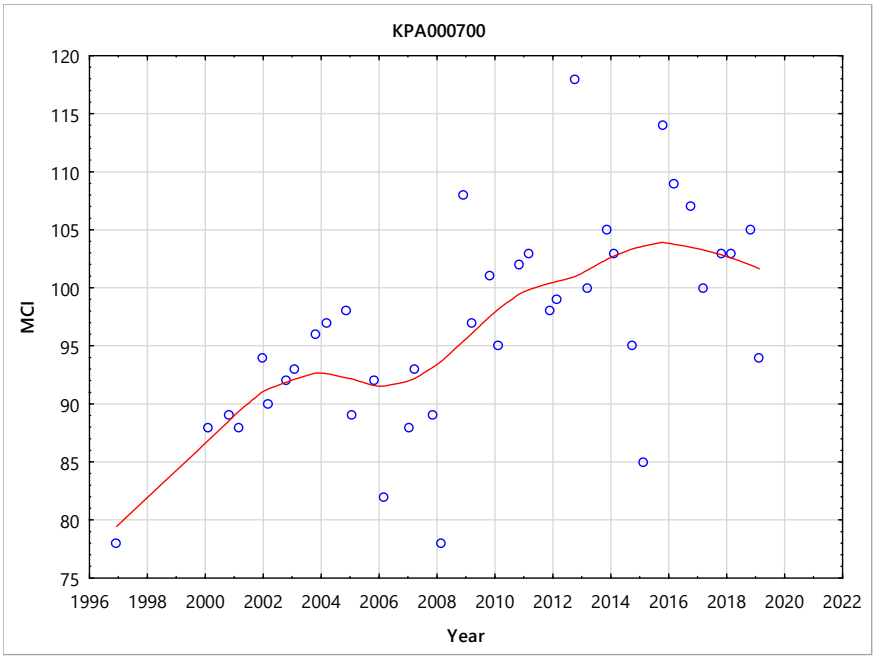


Figure 17 LOWESS trend plot of MCI data in the Kapoaiaia Stream at the Wataroa Road site

There was a significant positive trend over the 23-year period (FDR p < 0.01). Although the initial six years of the monitoring programme indicated a significant temporal improvement in MCI scores, these tended to decline between 2004 and 2007. However, more recent improvement have continued a positive trend. The range of trendline scores (28 units) have been ecologically important. This improvement has probably been influenced by the same drivers as the Wiremu Road site upstream. MCI scores across the trendline have consistently indicated 'fair' generic stream health at this mid-catchment site, improving to 'good' from 2012 onwards.

A non-significant positive trend in MCI scores has been found over the ten-year period. The trendline was mostly indicative of 'good' health for the most recent ten-year period.

3.2.4.3 Upstream of coast site (KPA000950)

3.2.4.3.1 Taxa richness and MCI

Thirty-eight surveys have been undertaken at this lower reach site near the coast in the Kapoaiaia Stream between December 1996 and February 2018. These results are summarised in Table 13, together with the results from the current period, and illustrated in Figure 18.

Table 13 Results of previous surveys performed in the Kapoaiaia Stream at the site upstream of the coast together with 2018-2019 results

Site code	SEM data (1996 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KPA000950	38	15-25	19	76-101	87	18	86	19	89

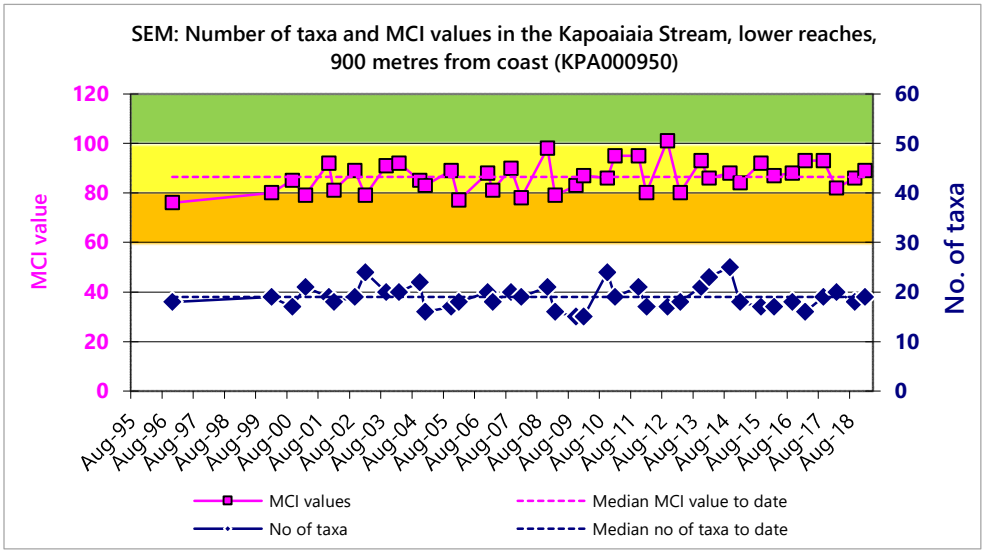


Figure 18 Numbers of taxa and MCI values in the Kapoaiaia Stream at the Cape Egmont (upstream of coast) site

A moderate range of richness (15 to 25 taxa) has been found with a median richness of 19 taxa relatively typical of richness in the lower reaches of ringplain streams and rivers. During the current period, spring (18 taxa) and summer (19 taxa) richness were similar to the historical median.

MCI scores have had a moderate range (25 units) at this site, slightly narrower than typical of sites in the lower reaches of ringplain streams. However, the median value (87 units) has been relatively typical of lower reach sites elsewhere on the ringplain. The spring (86 units) and summer (89 units) scores were not significantly different from the historical median. The MCI scores categorised this site as having 'fair' (spring and summer) health generically (Table 3). The historical median score (87 units) also placed this site in the 'fair' category for generic health.

3.2.4.3.2 Predicted stream 'health'

The Kapoaiaia Stream site near the coast is 25.2 km downstream of the National Park boundary at an altitude of 20 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 96 for this site. The historical site median, spring and summer scores were not significantly different to the distance predictive value.

The REC predicted MCI value (Leathwick, et al. 2009) was 99 units. The historical median and spring scores were significantly lower than the REC value while the summer score was not significantly different.

3.2.4.3.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) was produced (Figure 19). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 23 years of

SEM results (1996-2019) and the most recent ten-years of results (2009-2019) from the site in the Kapoaiaia Stream at near the coast.

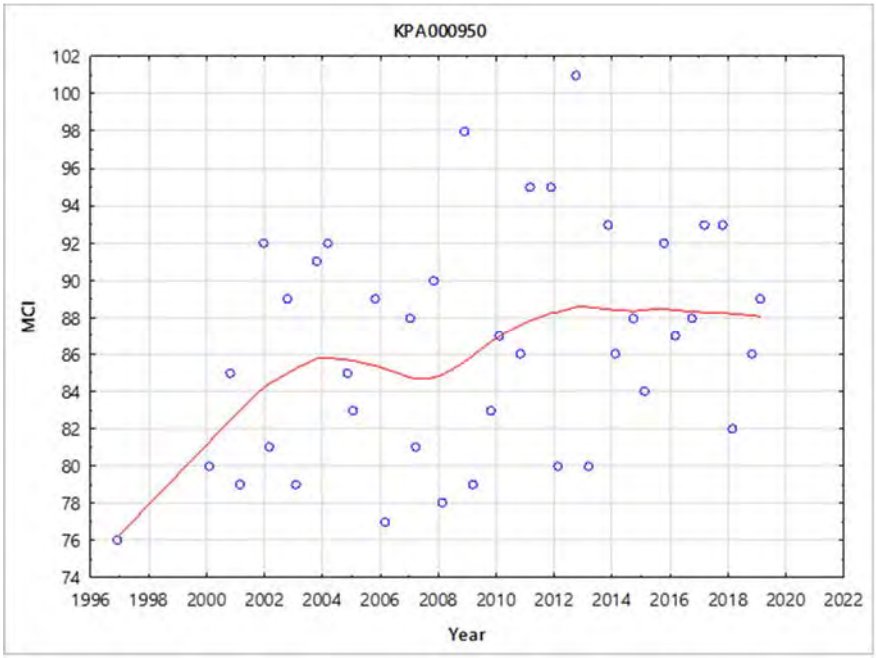


Figure 19 LOWESS trend plot of MCI data at the site upstream of the coast

The positive trend was close to being statistically significant after FDR application and continued improvement in the future will likely produce a statistically significant trend. There has been a similar, although more pronounced, trend at the mid-catchment site at Wataroa Road. However, there has been an ecologically important range (of 13 units) across the trendline, influenced by the low initial score, but not as wide as the range at the nearest upstream site. Subsequent to the December 1996 survey, no usage of the Pungarehu Dairy Factory (between the two sites) has occurred and since 2000 there has been a narrower, ecologically insignificant, range of MCI scores (eight units). In more recent years, there has been an increase in water abstraction in the lower reaches for irrigation purposes. The trendline range of MCI scores have consistently been indicative of 'fair' generic stream health although individual scores prior to 2010 have occasionally indicated 'poor' health, invariably under summer (warmer and lower) flow conditions.

A non-significant positive trend in MCI scores has been found over the ten-year period congruent with the full dataset though with a far weaker p value indicating a weaker trend and smaller dataset. The trendline was indicative of 'fair' health for the most recent ten-year period.

3.2.4.4 Discussion

MCI scores showed a significant decrease in a downstream direction for both spring and summer surveys. MCI scores at the upper site were 'very good' to 'good', 'good' to 'fair' at the middle site and 'fair' at the lower site indicating a deterioration in macroinvertebrate health. The deterioration in macroinvertebrate health was likely due to impacts associated with agriculture as the mid to lower reaches of the stream are in an agriculture dominated catchment. However, the two upper sites had significant positive trends indicating long term improvement and the lower site also appeared to be improving, but not to the same degree as the upper sites.

3.2.5 Katikara Stream

The Katikara Stream is a ringplain stream running in a westerly direction and arises within Egmont National Park. Two sites in the Katikara Stream, one located near the headwaters (just inside the National Park) and

the other near the coast, were first included in the SEM programme in the 2000-2001 year, for the purpose of long term monitoring of the progressive impacts of riparian vegetation planting initiatives within this north-western Taranaki catchment. In the 2008-2009 period severe headwater erosion events impacted upon the macroinvertebrate communities of the upper reaches of this stream (TRC, 2009).

3.2.5.1 Carrington Road site (KTK000150)

3.2.5.1.1 Taxa richness and MCI

Thirty-seven surveys have been undertaken at this upper reach site in the Katikara Stream inside the National park boundary at Carrington Road between September 1999 and February 2018. These results are summarised in Table 14 together with the results from the current period, and illustrated in Figure 20.

Table 14 Results of previous surveys performed in the Katikara Stream at Carrington Road, together with 2018-2019 results

Site code	SEM data (1999 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KTK000150	37	11-38	28	112-148	135	26	135	25	125

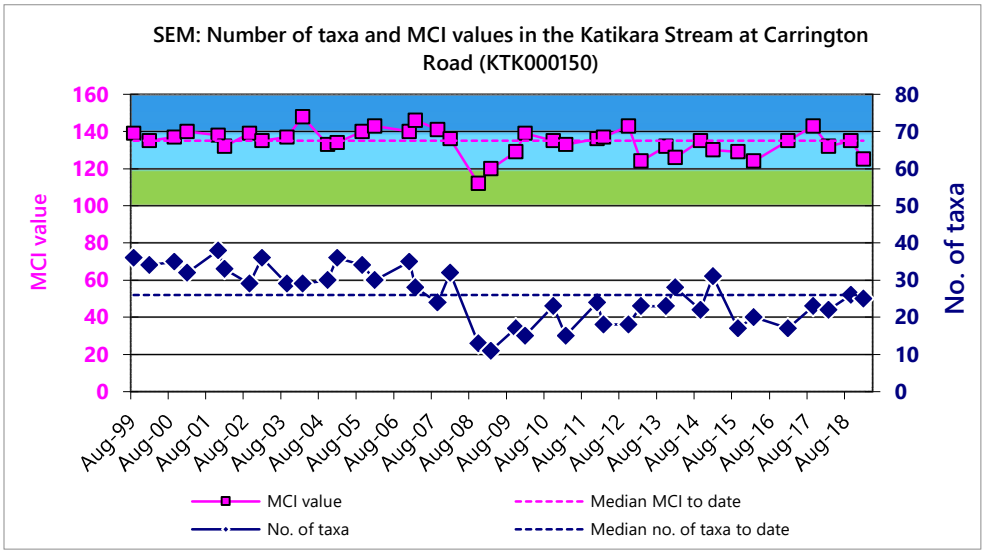


Figure 20 Numbers of taxa and MCI values in the Katikara Stream at Carrington Road

A very wide range of richness (11 to 38 taxa) has been found; wider than might be expected, due to the impacts of significant headwater erosion over the 2008-2009 period and subsequent recovery from these effects. The median richness of 28 taxa has been far more representative of typical richness in ringplain streams and rivers near the National Park boundary. During the current period spring (26 taxa) and summer (25 taxa) richness was recorded which was only slightly lower than the long-term median richness indicative of the site having largely recovered from the headwater erosion event.

MCI values at this site have had a wider range (36 units) than typical of a National Park boundary site, due in part to atypically lower values for a short period and on other isolated occasions since the 2008-2009 headwater erosion event. The median value (135 units) has been typical of upper reach sites (near or within the National Park) elsewhere on the ringplain. The spring (132 units) and summer (137 units) scores were not significantly different to the historical median (135 units). The spring and summer scores categorised this site as having 'very good' health generically (Table 3). The historical median score (135 units) also placed this site in the 'very good' category for the generic health.

3.2.5.1.2 Predicted stream 'health'

The Katikara Stream at Carrington Road is within the National Park boundary at an altitude of 420 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict MCI value of 132 for this site. The historical site median, spring and summers scores were not significantly different to the distance predictive value. The REC predicted MCI value (Leathwick, et al. 2009) was 131 units. Again, the historical, spring and summer scores were not significantly different to the REC value (Stark, 1998).

3.2.5.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 21). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 20 years of SEM results (1999-2019) and the most recent ten-years of results (2009-2019) from the site in the Katikara Stream at Carrington Road.

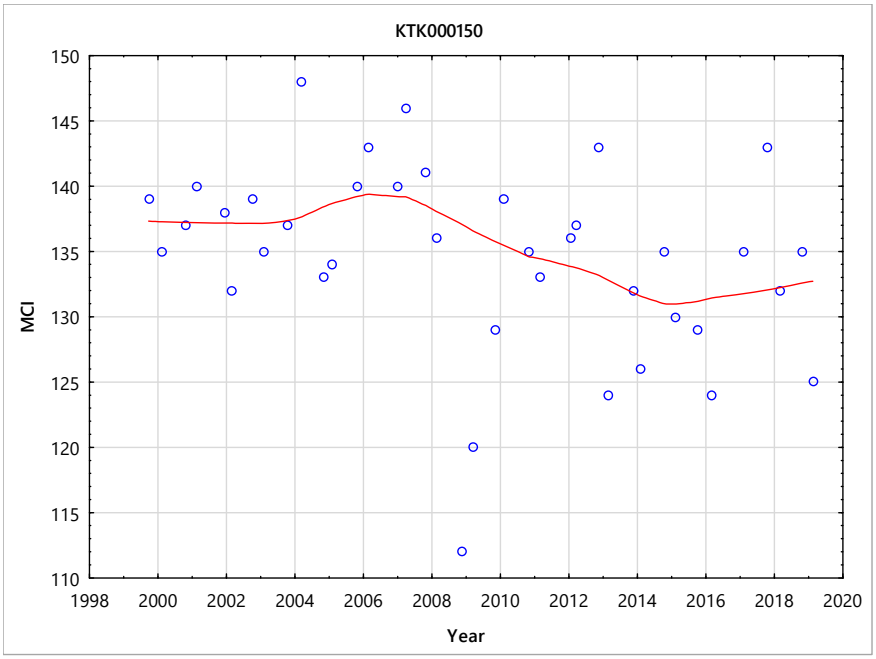


Figure 21 LOWESS trend plot of MCI data in the Katikara Stream at the Carrington Road site for the full dataset and a Mann-Kendall test for the full and ten-year dataset

A negative significant trend was found for the full dataset. Relatively stable MCI scores over the first four years of the period at this pristine site inside the National Park were followed by a very gradual rise. The subsequent downward trend has been due to significant headwater erosion effects during 2008, and subsequent limited recovery. The range of scores found across the trendline (8 units) over the period has been of marginal ecological importance with the range having widened appreciably since the erosion event. However, the trendline was indicative of 'very good' generic stream health throughout the period, bordering on 'excellent' in the 2006-2007 period.

There was a non-significant negative trend in MCI scores over the most recent ten-year period. The trendline was indicative of 'very good' health for the most recent ten-year period.

3.2.5.2 Coastal site (KTK000248)

3.2.5.2.1 Taxa richness and MCI

Thirty-five surveys have been undertaken in the Katikara Stream at this lower reach site near the coast between October 2000 and February 2018. The exact position of the site has been shifted slightly upstream from the summer 2016 survey onwards to avoid being flooded when the stream outlet blocks during low summer flows. The results of the thirty-seven surveys are summarised in Table 15, together with the results from the current period, and illustrated in Figure 22.

Table 15 Results of previous surveys performed in the Katikara Stream near the coast together with 2018-2019 results

Site code	SEM data (2000 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KTK000248	35	17-31	25	87-118	102	19	102	18	80

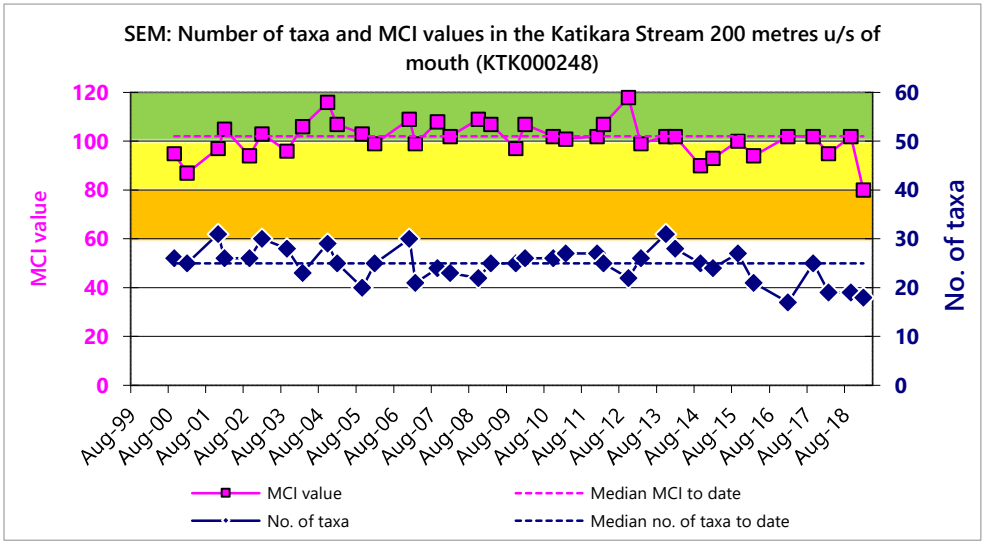


Figure 22 Numbers of taxa and MCI values in the Katikara Stream 200m u/s of the coast

A moderate range of richness (17 to 31 taxa) has been found with the headwater erosion events having a noticeable but less severe effect than that noted at the upstream site. The median richness of 25 taxa has been more representative of typical richness elsewhere in the lower reaches of ringplain streams and rivers. During the current period, spring taxa richness (18 units) and summer taxa richness (18 taxa) were seven taxa lower than the historical median indicating that headwater erosion was having a negative effect on taxa richness.

MCI values have had a wide range (38 units) at this site, typical of sites in the lower reaches of ringplain streams. The median value (102 units) has been higher than typical of lower reach sites elsewhere on the ringplain. The spring score (102 units) was not significantly different from the historical median but the summer score (80 units) was a significant 22 units lower and was the lowest score recorded to date at the site. The MCI scores in spring and summer respectively categorised this site as having 'good' and 'fair' health (Table 3). The historical median score (102 units) also placed this site in the 'good' category for generic health.

3.2.5.2.2 Predicted stream 'health'

The Katikara Stream at the site near the coast is 18.1 km downstream of the National Park boundary at an altitude of 5 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009); predict a MCI value of 99 for this site. The spring score and historical site median were not significantly different from the distance predictive value but the summer score was significantly lower than the predictive value. The REC predicted MCI value (Leathwick, et al. 2009) was 96 units. Again, the historical and spring scores were not significantly different to the REC value but the summer score was significantly lower (Stark, 1998).

3.2.5.2.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 23). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 19 years of SEM results (2000-2019) and the most recent ten-years of results (2009-2019) from the site in the Katikara Stream near the coast.

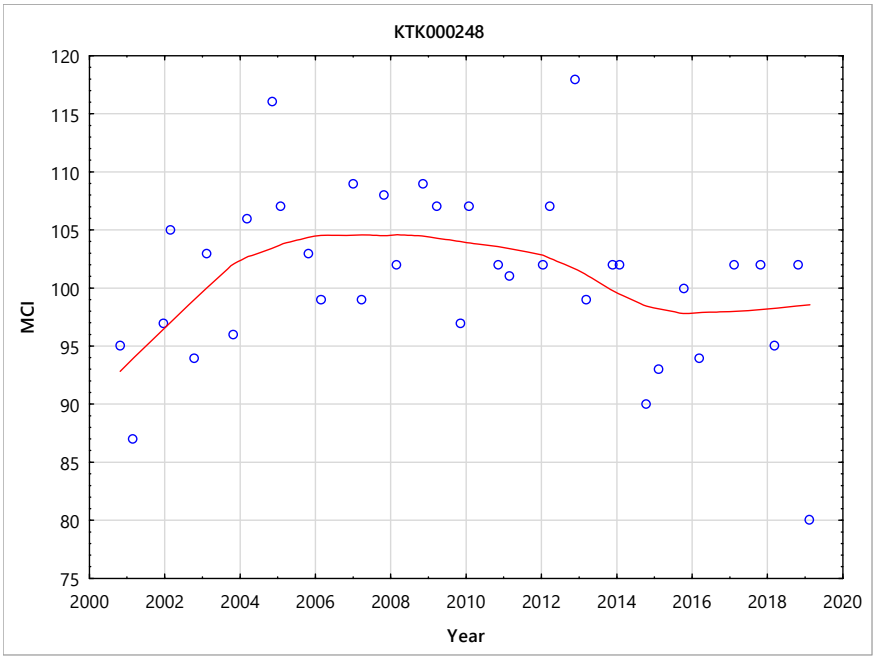


Figure 23 LOWESS trend plot of MCI data in the Katikara Stream at the coastal site for the full dataset and a Mann-Kendall test for the full and ten-year dataset

The trend over the 19-year period has not been significant (FDR p > 0.05). A relatively strong improvement in MCI scores has been recorded from 2000 to 2006 but then plateaued from 2006-2008 before decreasing from 2008 onwards coincident with the headwater erosion event also decreasing MCI scores and taxa richness at the upstream site. There had been a positive significant improvement at the site before the prolonged effects of the headwater erosion event had decreased MCI scores and the wide range of MCI scores (11 units) found throughout the trendline have been of ecological importance coincidentally with retirement and riparian planting of the margins of the lower reaches of this stream. The trendline range of scores indicative of 'fair' generic stream health have improved to 'good' health after 2003 where they remained until a return to 'fair' health most recently.

There was a non-significant negative trend in MCI scores over the most recent ten-year period. The trendline was indicative of 'good' health deteriorating to 'fair' health post 2013 for the most recent ten-year period.

3.2.5.3 Discussion

Historically, seasonal median scores have remained very similar at the National Park and coastal sites indicative of little change between spring and summer. However, the results from the current period showed a distinct decline between spring and summer, with the upper site having a non-significant difference but the lower site having a large, 22-unit decline. MCI scores fell significantly in a downstream direction over a stream distance of 18.1 km downstream from the National Park boundary. MCI scores for the upper site indicated 'very good' macroinvertebrate health while the lower site indicated 'good' to 'fair' health. The deterioration in macroinvertebrate health was likely due to impacts associated with agriculture as the mid to lower reaches of the stream are in an agriculture dominated catchment.

3.2.6 Kaupokonui River

The Kaupokonui River is a ringplain river with its source inside Egmont National Park that flows in a southerly direction. Five sites located along the length of the Kaupokonui River were included in the SEM programme, commencing in the 1999-2000 year for the purpose of long term monitoring of the impacts of riparian vegetation planting initiatives throughout this catchment. Two sites, at Opunake Road (KPK000250) and near the coast (KPK000990), were established specifically for this purpose, while the remaining three sites were components of existing consent monitoring programmes.

3.2.6.1 Opunake Road site (KPK000250)

3.2.6.1.1 Taxa richness and MCI

Thirty-nine surveys have been undertaken in the Kaupokonui River at this upper mid-reach site at Opunake Road (draining relatively open farmland approximately 3.3 km downstream of the National Park) between March 1998 and February 2018. These results are summarised in Table 16, together with the results from the current period, and illustrated in Figure 24.

Table 16 Results of previous surveys performed in the Kaupokonui River at Opunake Road, together with spring 2018 and summer 2019 results

Site code	SEM data (1998 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KPK000250	39	20-36	27	124-139	130	20	135	27	127

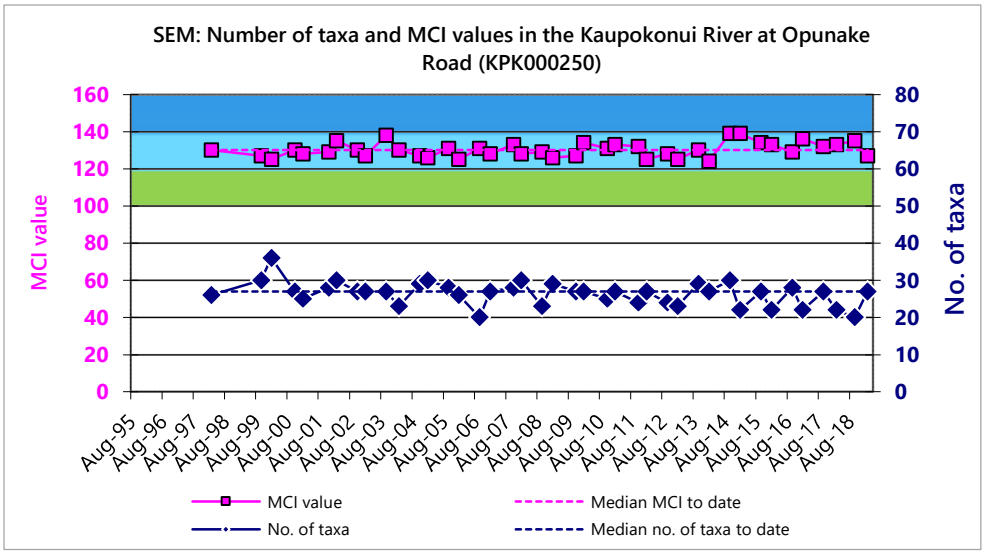


Figure 24 Numbers of taxa and MCI values in the Kaupokonui River at Opunake Road

A relatively wide range of richness (20 to 36 taxa) has been found; wider than might be expected, with a median richness of 27 taxa (more representative of typical richness in the upper mid-reaches of ringplain streams and rivers). During the current period spring (20 taxa) richness was lower than the historic median while the summer (27 taxa) richness was the same as the historical median.

MCI values have had a narrow range (15 units) at this site, more typical of sites in the upper reaches of ringplain rivers. The median value (130 units) has been higher than typical of mid-reach sites elsewhere on the ringplain. The spring (135 units) and summer (127 units) scores were non-significantly different to each other and to the historical median. These scores categorised this site as having 'very good', (spring and summer) health generically (Table 3). The historical median score (130 units) placed this site in the 'very good' category for generic health.

3.2.6.1.2 Predicted stream 'health'

The Kaupokonui River site at Opunake Road is 3.3 km downstream of the National Park boundary at an altitude of 380 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict a MCI value of 118 for this site. The spring and historical site median were significantly higher (Stark, 1998) than the distance predictive value while the summer score was not significantly higher. The REC predicted MCI value (Leathwick, et al. 2009) was 137 units. The historical, spring and summer scores were not significantly different to the REC value (Stark, 1998).

3.2.6.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) was produced (Figure 25). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 21 years of SEM results (1998-2019) and the most recent ten-years of results (2009-2019) from the site in the Kaupokonui River at Opunake Road.

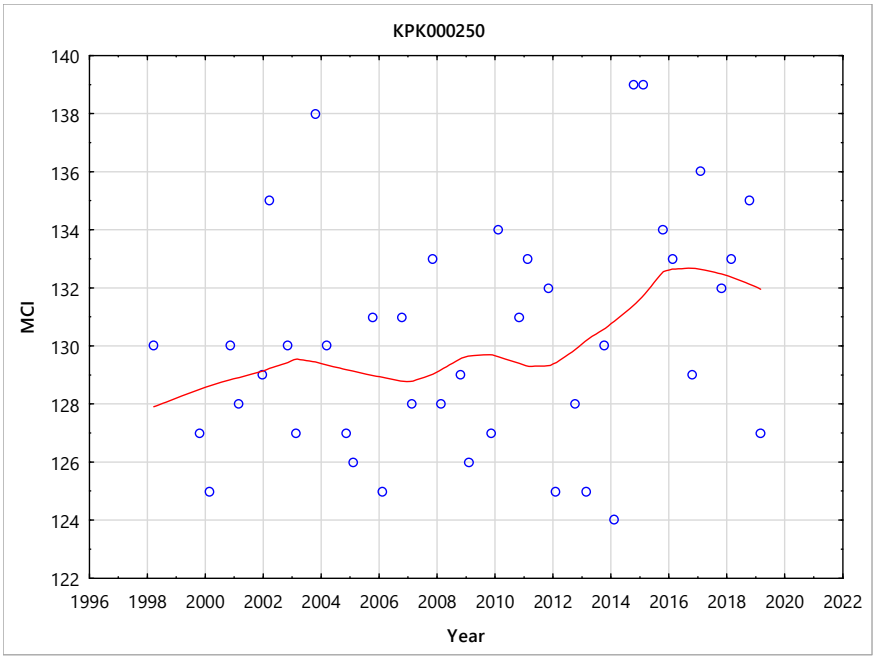


Figure 25 LOWESS trend plot of MCI data in the Kaupokonui River at the Opunake Road site for the full dataset and a Mann-Kendall test for the full and ten-year dataset

MCI scores have not been statistically significant at this site in the upper mid-reaches of the river over the 21-year monitoring period. The trendline was has been narrow and not ecologically important. The trendline was indicative of 'very good' generic river health.

There was a non-significant positive trend in MCI scores over the most recent ten-year period congruent with the full dataset. The trendline was indicative of 'very good' health for the most recent ten-year period.

3.2.6.2 Site upstream of the Kaponga oxidation ponds system (KPK000500)

3.2.6.2.1 Taxa richness and MCI

Forty-two surveys have been undertaken in the Kaupokonui River at this mid-reach site at the site upstream of the Kaponga oxidation ponds system between February 1996 and February 2018. These results are summarised in Table 17, together with the results from the current period, and illustrated in Figure 26.

Table 17 Results of previous surveys performed in the Kaupokonui River at the site upstream of the Kaponga oxidation ponds system together with 2018-2019 results

Site code	SEM data (1996 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KPK000500	42	20-33	26	98-133	117	21	138	23	104

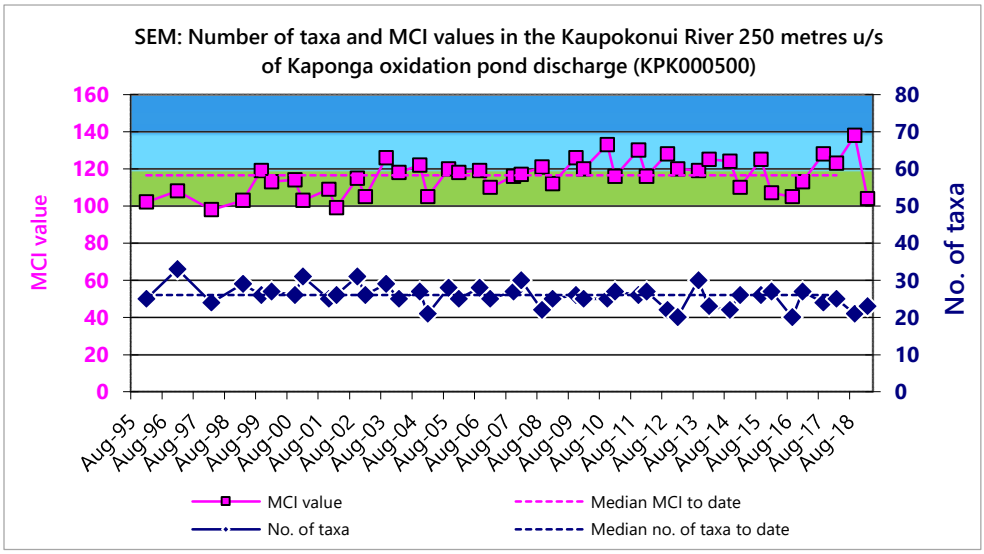


Figure 26 Numbers of taxa and MCI values in the Kaupokonui River upstream of Kaponga oxidation pond system

A moderate range of richness (20 to 33 taxa) has been found with a median richness of 26 taxa, typical of richness in the mid reaches of ringplain streams and rivers. During the current period, spring (21 taxa) and summer (23 taxa) richness were very similar to each other and slightly lower than the historical median.

MCI values have had a relatively wide range (35 units) at this site, slightly wider than typical of sites in the mid-reaches of ringplain rivers. The historic median value (117 units) has been very slightly higher than typical of mid-reach sites elsewhere on the ringplain. The spring score (138 units) was significantly higher than the median value and the highest score recorded to date at the site but the summer score (104 units) was significantly lower than both the median and summer score (Stark, 1998). The MCI scores categorised this site as having 'very good' spring health in spring and 'good' health in summer (Table 3). The historical median score (117 units) placed this site in the 'good' category for generic health.

3.2.6.2.2 Predicted stream 'health'

The Kaupokonui River site upstream of the Kaponga oxidation pond system is 9.2 km downstream of the National Park boundary at an altitude of 260 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict MCI values of 107 for this site. The historical site median (117) is nine units higher than the distance predictive value. The spring score was significantly higher than this value, while the summer score was significantly lower and the historic median was not significantly higher than the predictive value (Stark, 1998). The REC predicted MCI value (Leathwick, et al. 2009) was 127 units. The spring score was significantly higher than this value, while the summer score was significantly lower and the historic median was not significantly lower than the predictive value (Stark, 1998).

3.2.6.2.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 27). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1996-2019) and the most recent ten-years of results (2009-2019) from the site in the Kaupokonui River upstream of the Kaponga oxidation ponds system.

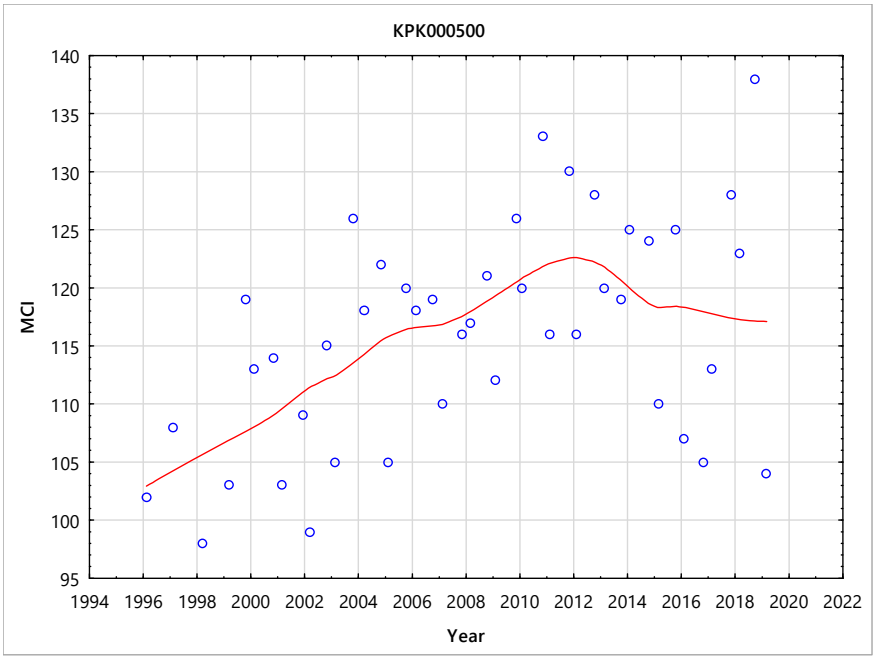


Figure 27 LOWESS trend plot of MCI data at the site in the Kaupokonui River upstream of the Kaponga oxidation ponds system for the full dataset with a Mann-Kendall test for the full and ten-year dataset

A highly significant positive trend in MCI scores has been found over the entire period. Improvements may have been related partly to improved dairyshed wastes disposal consents' compliance reported in this catchment. Trendline scores consistently indicated 'good' generic river health with a brief period of 'very good' health from 2010-2014.

There was a non-significant negative trend in MCI scores over the most recent ten-year period, in contrast to the full dataset, due to a decline in MCI scores for the most recent surveys. The trendline for the most recent ten-year period was mostly indicative of 'good' health with a brief period of 'very good' health from 2010-2014.

3.2.6.3 Site upstream of Kapuni railbridge (KPK000660)

3.2.6.3.1 Taxa richness and MCI

Forty-six surveys have been undertaken in the Kaupokonui River at this mid-reach site upstream of the Kapuni railbridge between December 1995 and March 2018. These results are summarised in Table 18, together with the results from the current period, and illustrated in Figure 28.

Table 18 Results of previous surveys performed in the Kaupokonui River upstream of Kapuni railbridge, together with 2018-2019 results

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KPK000660	46	15-32	24	71-128	103	19	118	26	110

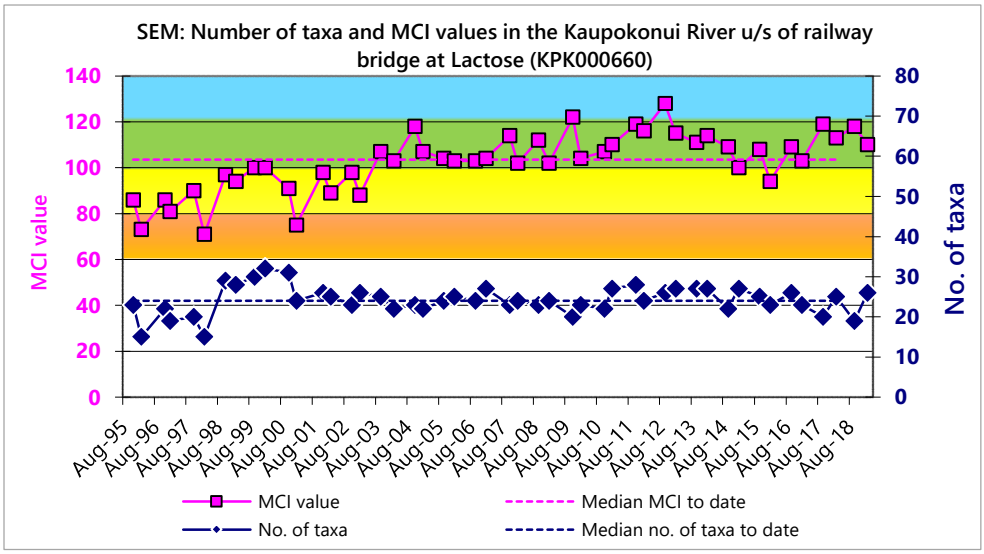


Figure 28 Numbers of taxa and MCI values in the Kaupokonui River upstream of Kapuni railbridge

A wide range of richness (15 to 32 taxa) has been found with a median richness of 24 taxa (more representative of typical richness in the mid reaches of ringplain streams and rivers). During the current period spring (19 taxa) and summer (26 taxa) richness were relatively similar to each other and the historical median.

MCI values have had a very wide range (57 units) at this site, much wider than typical of sites elsewhere in the mid reaches of ringplain rivers. However, the median value (103 units) has been relatively typical of mid reach sites elsewhere on the ringplain. The spring (118 units) and summer (110 units) scores were not significantly different from each other, and only the spring score was significantly different to the historical median (Stark, 1998).

These scores categorised this site as having 'good' (spring and summer) health generically (Table 3). The historical median score (103 units) placed this site in the 'good' category for generic health.

3.2.6.3.2 Predicted stream 'health'

The Kaupokonui River site upstream of the Kapuni railbridge is 15.5 km downstream of the National Park boundary at an altitude of 170 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict MCI value of 101 for this site. The spring score was significantly higher than the predictive value while the summer score and historic median were not significantly different. The REC predicted MCI value (Leathwick, et al. 2009) was 122 units. The spring score was not significantly different to this value but the summer score and historic median were significantly lower than the REC value (Stark, 1998).

3.2.6.3.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 29). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Kaupokonui River upstream of the Kapuni railbridge.

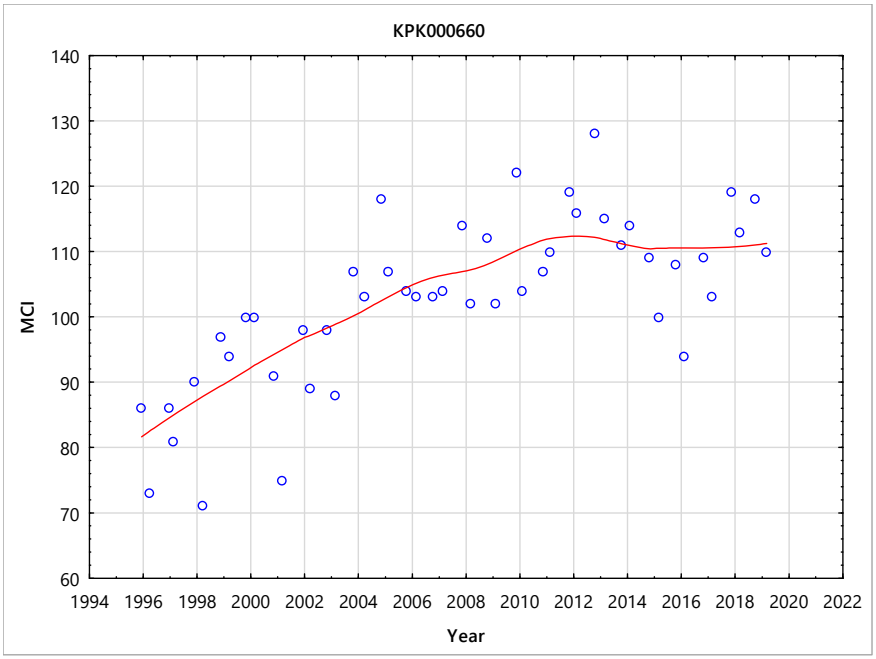


Figure 29 LOWESS trend plot of MCI data in the Kaupokonui River at the site upstream of Kapuni railbridge for the full dataset with a Mann-Kendall test for the full and ten-year dataset

A highly significant improvement in MCI scores has been found over the entire period at this mid-catchment site (FDR p < 0.01). This trendline has a wide range (31 units) which has been ecologically important. Fonterra factory wastewater irrigation activities nearby in this catchment have been better managed during this period and surveillance monitoring has reported improved dairy shed waste treatment ponds systems compliance upstream of this site. The trend in generic river health has moved from 'fair' to 'good' where it has remained since 2003.

There was a non-significant negative trend in MCI scores over the most recent ten-year period in contrast to the full dataset due to a decline in MCI scores for the most recent surveys. The trendline for the most recent ten-year period was mostly indicative of 'good' health. Since 2012, the MCI scores have largely plateaued and were in the 'good' category.

3.2.6.4 Upper Glenn Road site (KPK000880)

3.2.6.4.1 Taxa richness and MCI

Forty-six surveys have been undertaken in the Kaupokonui River at this lower reach site at Upper Glenn Road between 1995 and March 2018. These results are summarised in Table 19, together with the results from the current period, and illustrated in Figure 30.

Table 19 Results of previous surveys performed in the Kaupokonui River at Upper Glenn Road, together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KPK000880	46	14-31	19	66-110	91	17	92	16	81

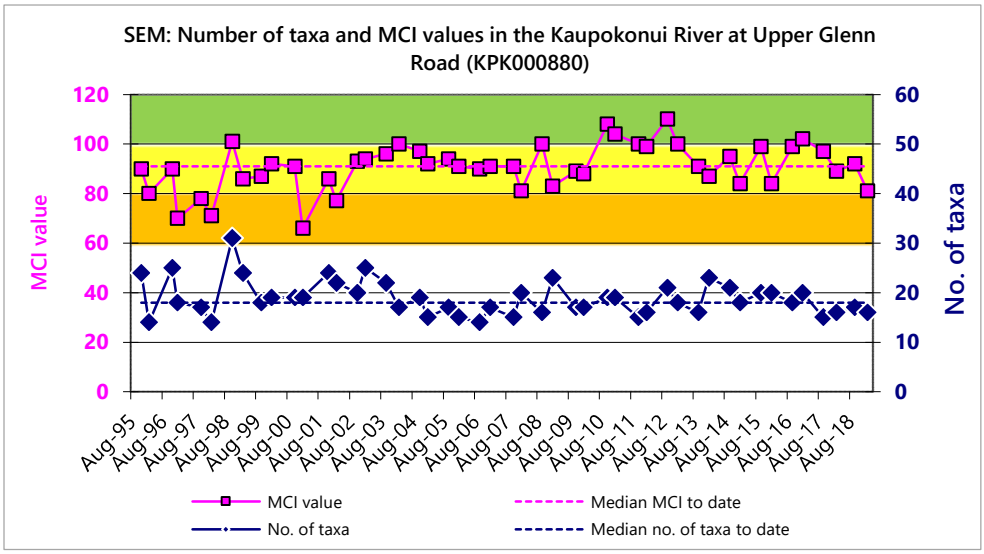


Figure 30 Numbers of taxa and MCI values in Kaupokonui River at Upper Glenn Road

A wide range of richness (14 to 31 taxa) has been found with a median richness of 19 taxa (typical of richness in the lower reaches of ringplain streams and rivers). During the current period spring (17 taxa) and summer (16 taxa) richness were similar to each other and to the historical median taxa number.

MCI values have had a very wide range (44 units) at this site, more typical of sites in the lower reaches of ringplain streams and rivers. The median value (91 units) has been slightly lower than typical of scores at lower reach sites elsewhere on the ringplain. The spring (92 units) and summer (81 units) scores were not significantly different from the historical median score. These scores categorised this site has having 'fair' health in both spring and summer (Table 3). The historical median score (91 units) also placed this site in the 'fair' category for generic health.

3.2.6.4.2 Predicted stream 'health'

The Kaupokonui River site at Upper Glenn Road is 25.7 km downstream of the National Park boundary at an altitude of 60 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict MCI value of 95 for this site. The spring, summer and historic median were not significantly different to the predictive distance value. The REC predicted MCI value (Leathwick, et al. 2009) was 106 units. The spring, summer and historic medians scores were all significantly lower than the REC value (Stark, 1998).

3.2.6.4.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 31). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 24 years of SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Kaupokonui River at Upper Glenn Road.

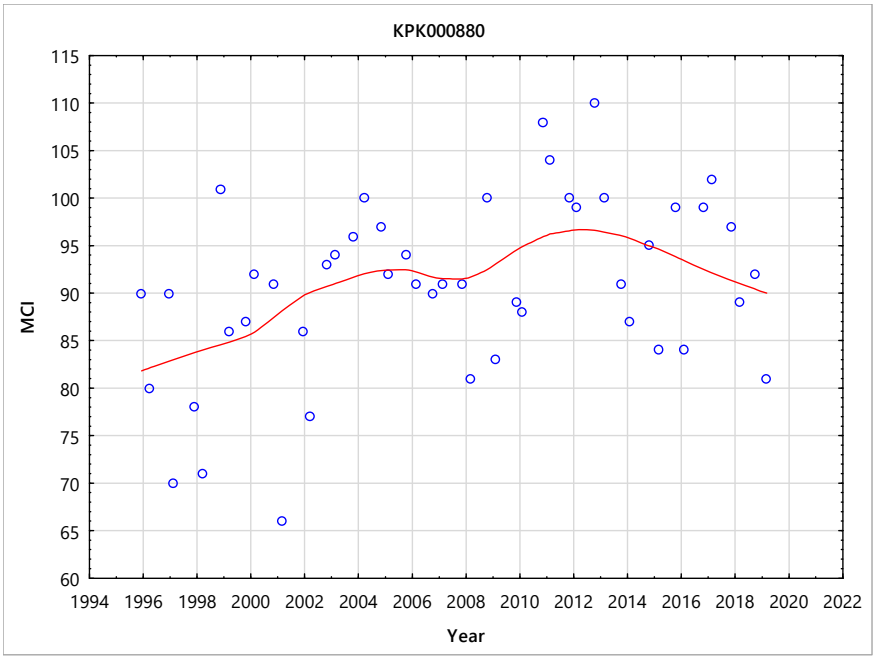


Figure 31 LOWESS trend plot of MCI data in the Kaupokonui River at the Upper Glenn Road site for the full dataset with a Mann-Kendall test for the full and ten-year dataset

A non-significant improvement in MCI scores was found at this site (FDR p = 0.05) after applying FDR. There has mostly been an increasing trend up until 2012, with a decreasing trend found since. The trendline range of MCI scores (15 units) has been ecologically important but nowhere near as wide as that upstream. The overall positive trend was due to improved wastes management further upstream in the catchment but more particularly in relation to a reduction in heat input (via cooling water) to the river at the Fonterra, Kapuni factory. The trendline MCI scores have consistently indicated 'fair' generic river health throughout the period.

There was a non-significant negative trend in MCI scores over the most recent ten-year period in contrast to the full dataset, due to a decline in MCI scores since 2012. The trendline for the most recent ten-year period was indicative of 'fair' health.

3.2.6.5 Kaupokonui Beach site (KPK000990)

3.2.6.5.1 Taxa richness and MCI

Thirty-eight surveys have been undertaken in the Kaupokonui River at this lower reach site at Kaupokonui Beach between 1999 and February 2018. These results are summarised in Table 20, together with the results from the current period, and illustrated in Figure 32.

Table 20 Results of previous surveys performed in the Kaupokonui River at the Kaupokonui Beach site, together with 2018-2019 results

Site code	SEM data (1999 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KPK000990	38	11-26	19	69-103	91	20	93	15	80

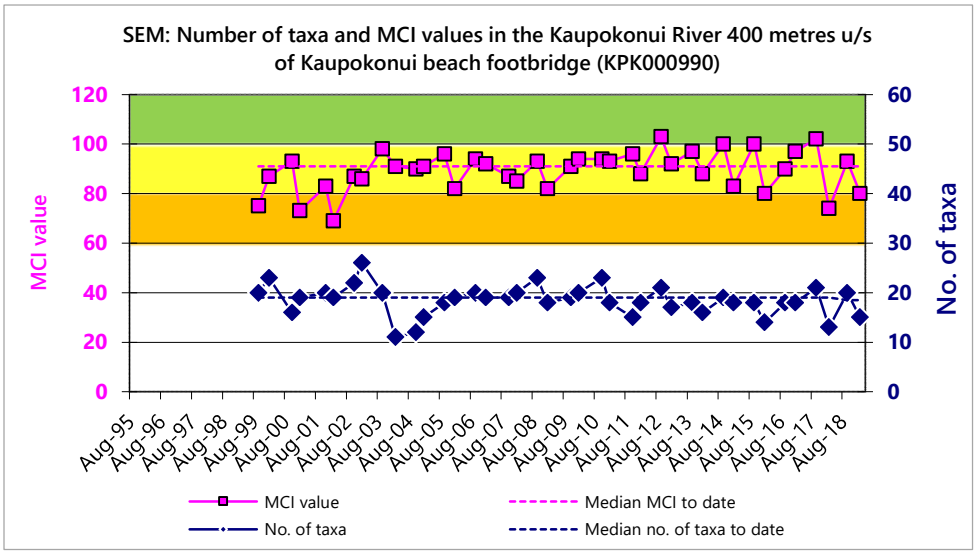


Figure 32 Numbers of taxa and MCI values in the Kaupokonui River at the Kaupokonui Beach site

A wide range of richness (11 to 26 taxa) has been found, with a median richness of 19 taxa. During the current period spring (20 taxa) and summer (15 taxa) richness were different from each other by five taxa but differed only slightly from the historical median richness.

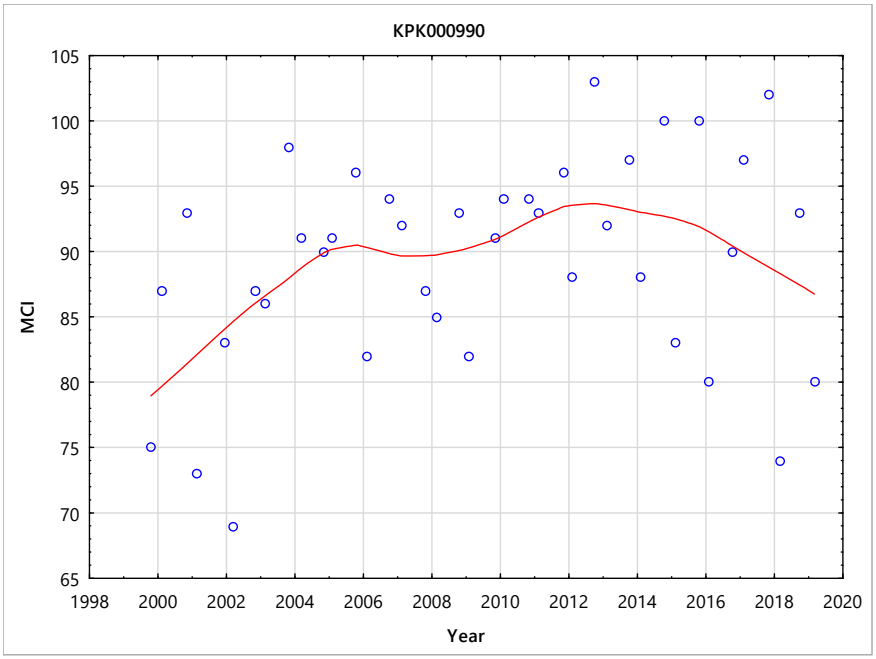
MCI values have had a moderate range (34 units) at this site, typical of sites in the lower reaches of ringplain streams and rivers. The median value (91 units) has been typical of scores at lower reach sites elsewhere on the ringplain. The spring (93 units) and summer (80 units) scores varied widely and were significantly different from each other with the summer score also significantly lower than the historical median. The MCI scores categorised this site as having 'fair' health for both spring and summer (Table 3). The historical median score (91 units) placed this site in the 'fair' category for generic health.

3.2.6.5.2 Predicted stream 'health'

The Kaupokonui River at the Kaupokonui Beach site is 31.1 km downstream of the National Park boundary at an altitude of 5 m asl. Relationships for ringplain streams and rivers developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict a MCI value of 93 for this site. The spring and historic median scores were not significantly different to the distance value, while the summer score was significantly lower than the distance value. The REC predicted MCI value (Leathwick, et al. 2009) was 96 units. Again, the spring and historic median scores were not significantly different to the REC predicted MCI value), while the summer score was significantly lower than the REC value (Stark, 1998).

3.2.6.5.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 33). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 20 years of SEM results (1999-2019) and the most recent ten-years of results (2009-2019) from the site in the Kaupokonui River at Kaupokonui Beach.



N = 40
Kendall tau = 0.21
p level = 0.05
FDR p = 0.09

N = 20
Kendall tau = -0.13
p level = 0.43
FDR p = 0.69

Figure 33 LOWESS trend plot of MCI data in the Kaupokonui River at the Kaupokonui Beach site for the full dataset with Mann-Kendall test for the full and ten-year dataset

There was a positive improvement over the 19 year time period (p = 0.05) which was very close to being statistically significant (e.g. p < 0.05) after FDR application. The trendline has largely increased since 1999 to 2012 apart from a small dip from 2005-2008, but since 2012 has started to decline. The trendline had an ecologically important range of scores (14 units), although much narrower than ranges at the two nearest upstream sites, possibly reflecting certain upstream improvements in waste disposal management (documented earlier) which have had reduced impacts with greater distance downstream. The trendline range has been indicative of 'fair' generic river health throughout the period.

There was a non-significant minor negative trend in MCI scores over the most recent ten-year period. Since 2012, the trend has started to decline. The trendline for the most recent ten-year period was indicative of 'fair' health.

3.2.6.6 Discussion

MCI scores deteriorated in a downstream direction for the current monitoring period with the upper site recording 'very good' health while the bottom site recording 'fair' health. MCI scores typically fall in a downstream direction between the upper site and the furthest downstream site by 44 units over a river distance of 27.8 km. MCI scores were typical for all the sites when seasonal variation was taken into account except the Kaponga oxidation ponds system site in spring, which had a significantly higher result, even with seasonal variation taken into account. The general deterioration in macroinvertebrate health was likely due to cumulative inputs from point and diffuse sources in a catchment dominated by agriculture but which also has some industrial and urban influence.

Time trend analysis showed the majority of sites had significant positive trends over the full dataset indicating that macroinvertebrate communities have been getting healthier over time. However, there were no significant trends over the most recent ten-year period. All sites, except the most upstream site, showed a decreasing trendline from 2012 onwards indicating that improvements in macroinvertebrate communities have plateaued.

3.2.7 Kurapete Stream

The Kurapete Stream is a ringplain seepage-sourced stream running in an easterly direction that flows into the Manganui River, which is itself a tributary of the Waitara River. Two sites, one located immediately upstream of the Inglewood Wastewater Treatment Plant (WWTP) and the other nearly six km downstream, were included in the SEM programme for the purposes of long term monitoring of the impacts of the removal of the treated wastewater discharge from the stream and also, riparian vegetation planting initiatives in the catchment.

3.2.7.1 Site upstream of Inglewood WWTP (KRP000300)

3.2.7.1.1 Taxa richness and MCI

Forty-five surveys have been undertaken, between 1995 and March 2018, at this mid-reach, shaded site, draining developed farmland, downstream of Inglewood, but immediately upstream of the WWTP. These results are summarised in Table 21, together with the results from the current period, and illustrated in Figure 34.

Table 21 Results of previous surveys performed in the Kurapete Stream upstream of Inglewood WWTP, together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KRP000300	45	12-32	22	80-107	95	23	98	12	98

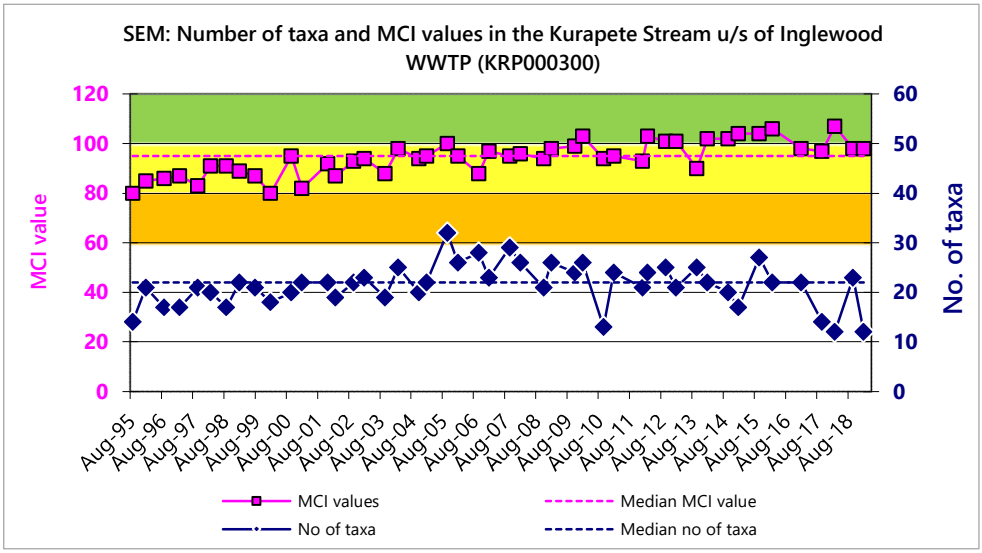


Figure 34 Numbers of taxa and MCI values in the Kurapete Stream upstream of the Inglewood WWTP

A relatively wide range of richness (13 to 32 taxa) has been found with a moderate median richness of 22 taxa, relatively typical of richness in the mid reaches of ringplain streams rising outside the National Park boundary. During the current period spring richness (23 taxa) was very similar to the historic median but the summer richness (12 taxa) was substantially lower than both the historic median and spring richness and was the lowest richness recorded to date for the site.

MCI values have had a moderate range (27 units) at this site, typical of mid-reach sites in seepage streams on the ringplain. The spring and summer scores (98 units) were not significantly different to the historical

median (Stark, 1998). The scores categorised this ringplain stream site as having 'fair' health (Table 3). The historical median score (95 units) placed this site in the 'fair' category for generic health.

3.2.7.1.2 Predicted stream 'health'

The Kurapete Stream rises below the National Park boundary and the site upstream of the Inglewood WWTP is in the mid-reaches at an altitude of 180 m asl. The REC predicted MCI value (Leathwick, et al. 2009) was 92 units. The spring, summer and historical median scores were not significantly different to the REC value (Stark, 1998).

3.2.7.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 35). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 24 years of SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Kurapete Stream upstream of the Inglewood WWTP.

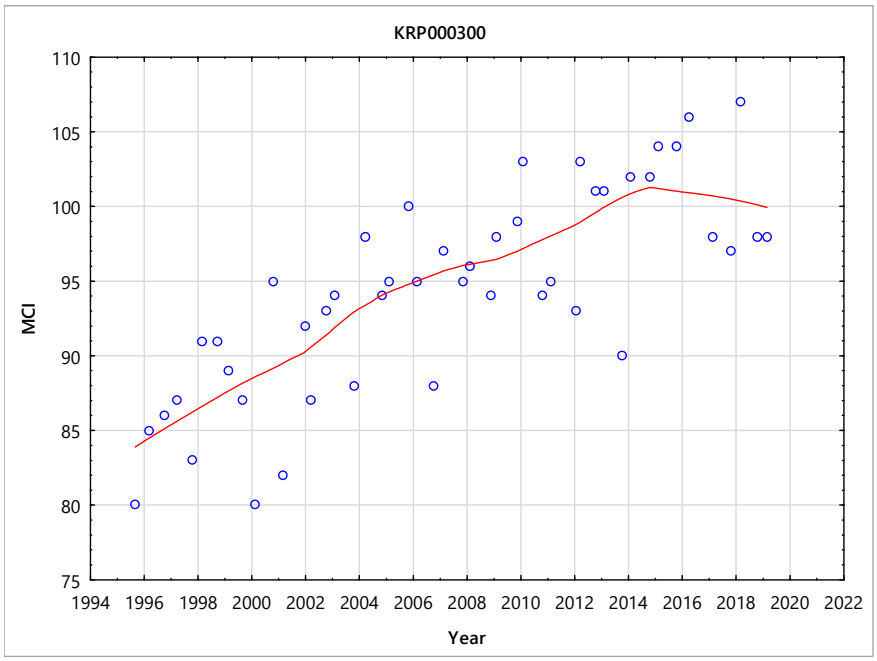


Figure 35 LOWESS trend plot of MCI data in the Kurapete Stream at the site upstream of the Inglewood WWTP for the full dataset with Mann-Kenndall tests for the full and ten-year dataset

The very strong positive temporal trend in MCI scores has been highly significant at this site (FDR $p < 0.01$) immediately upstream of the Inglewood WWTP discharge but below the tributary inflow draining the old Inglewood landfill. This improvement has followed the diversion of the iron-oxide laden drainage out of the stream and into the WWTP system, which markedly reduced sediment deposition on the streambed. The strong earlier trend tended to ease between 2004 and 2009 with a subsequent increase in improvement more recently. The overall range of MCI scores across the trendline (18 units) has been ecologically important. The trendline range of MCI scores have been indicative of 'fair' generic stream health throughout the period until recently where it is now of 'good' health.

There was a non-significant positive trend in MCI scores over the most recent ten-year period. The trendline for the most recent ten-year period was indicative of 'fair' health changing to 'good' health since 2013.

3.2.7.2 Site approximately 6km downstream of the Inglewood WWTP outfall (KRP000660)

3.2.7.2.1 Taxa richness and MCI

Forty-five surveys have been undertaken at this lower reach site in the Kurapete Stream 6 km downstream of the Inglewood WWTP outfall (KRP000660) between 1995 and March 2018. These results are summarised in Table 22, together with the results from the current period, and illustrated in Figure 36.

Table 22 Results of previous surveys performed in the Kurapete Stream at the site 6 km downstream of the Inglewood WWTP outfall together with the 2018-1019 results

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
KRP000660	45	18-30	25	74-112	94	24	98	23	93

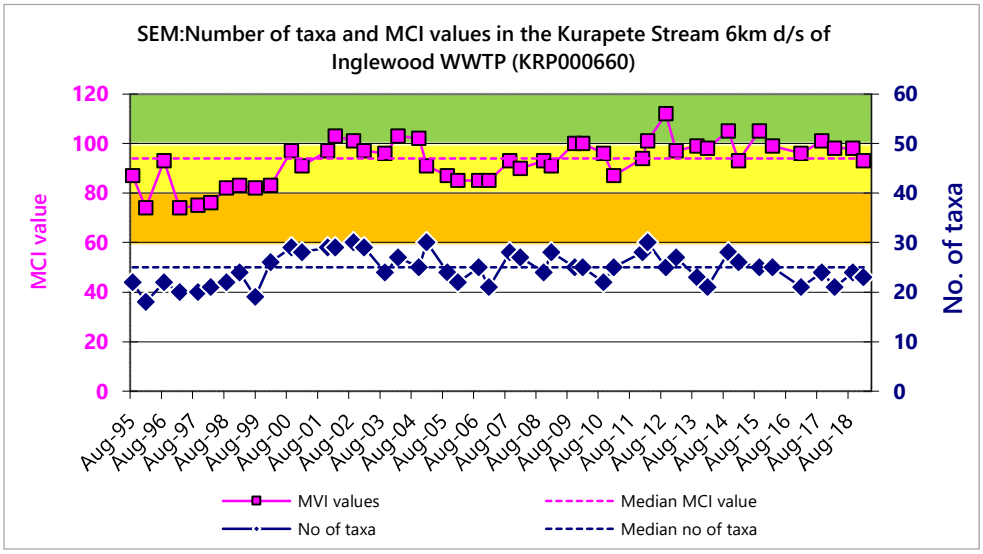


Figure 36 Numbers of taxa and MCI values in the Kurapete Stream, 6 km downstream of the Inglewood WWTP outfall

A moderate range of richness (18 to 30 taxa) has been found, with a median richness of 25 taxa (slightly higher than typical of richness for the lower mid-reaches of ringplain streams rising outside the National Park boundary. During the current period spring (24 taxa) and summer (23 taxa) richness were slightly lower than the historical median.

MCI values have had a wide range (42 units) at this site. The median value (94 units) has been typical of lower mid-reach sites in similar seepage-fed streams elsewhere on the ringplain. The spring (98 units) and summer (93 units) score was not significantly different to the historical median (Stark, 1998). These scores categorised this site as having 'fair' health for spring and summer (Table 3). The historical median score (94 units) placed this site in the 'fair' category for generic health.

3.2.7.2.2 Predicted stream 'health'

The Kurapete Stream rises below the National Park boundary and the site 6 km downstream of the Inglewood WWTP outfall is in the lower mid-reaches at an altitude of 120 m asl. The REC predicted MCI value (Leathwick, et al. 2009) was 102 units. The spring, summer and historical median scores were not significantly different from this value (Stark, 1998).

3.2.7.2.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 37). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 24 years of SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Kurapete Stream at the site six km downstream of the Inglewood WWTP outfall.

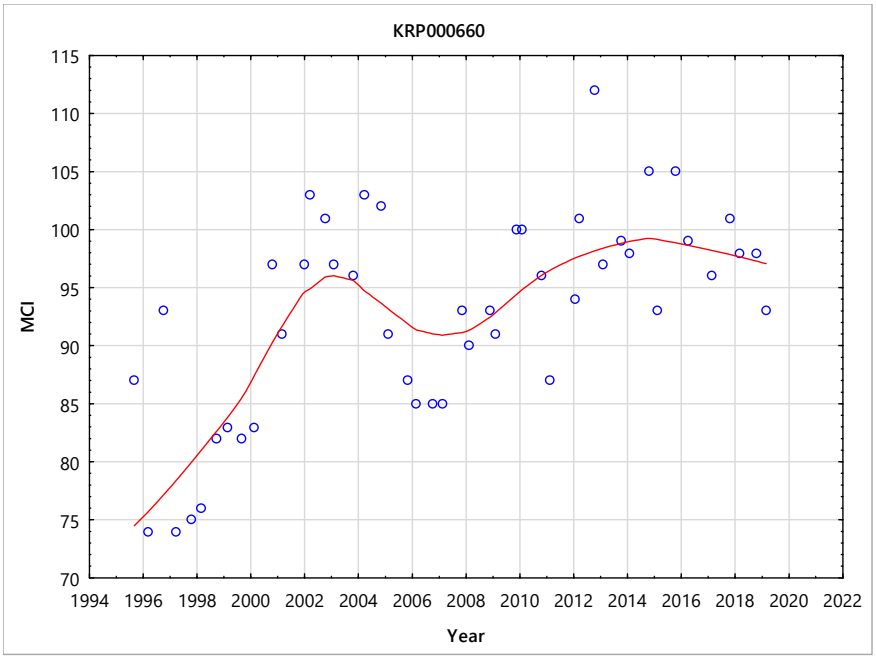


Figure 37 LOWESS trend plot of MCI data in the Kurapete Stream for the site 6 km downstream of the Inglewood WWTP outfall for the full dataset with Mann-Kendall test for the full and ten-year dataset

There has been a highly significant positive trend of MCI score improvement (FDR p < 0.01). There was a noticeably increase in the steepness of the trend after 2000 (following diversion of all Inglewood WWTP wastes out of the stream (to the New Plymouth WWTP) which was emphasised by an ecologically important increase in score of 24 units. A decreasing trend in scores has been followed by a steady recovery since 2007 coincident with relatively few consented municipal wastes short-duration discharge overflows to the stream during recent years. Overall, the trendline scores indicated improving stream health from 'poor' to 'fair' indicative of the positive effects of diversion of the Inglewood WWTP discharge out of the stream.

There was a non-significant minor negative trend in MCI scores over the most recent ten-year period even though there was a relatively large increase in the trendline from 2009 to 2014. The trendline for the most recent ten-year period was indicative of 'fair' health.

3.2.7.3 Discussion

MCI scores indicated that both sites had 'fair' macroinvertebrate health with little difference between the two sites. MCI scores were typical for the two sites with little difference from historical medians. Taxa richness was low for the upper site during spring but not for the lower site. Three of the last four surveys have had relatively low taxa richness at the upper site. No obvious reason for the lower than normal taxa richness was evident at the time of sampling or for the previous monitoring year.

The time trend analysis showed the sites had significant positive trends over the full datasets indicating that macroinvertebrate communities have been getting healthier over time but that improvements have largely plateaued with little change over the most recent 10-year period.

3.2.8 Maketawa Stream

The Maketawa Stream is a ringplain stream with a source inside Egmont National Park that flows in an easterly direction into the Manganui River. Two sites, originally surveyed as components of the Maketawa catchment baseline investigation (Stark, 2003), were included in the 2002-03 SEM programme in recognition of the fisheries significance of this sub-catchment of the Manganui River catchment.

3.2.8.1 Derby Road site (MKW000200)

3.2.8.1.1 Taxa richness and MCI

Thirty-six surveys have been undertaken at this upper reach site in the Maketawa Stream between March 1998 and March 2018. These results are summarised in Table 23 together with the results from the current period, and illustrated in Figure 38.

Table 23 Results of previous surveys performed in the Maketawa Stream at Derby Road together with 2018-2019 results

Site code	SEM data (1998 to Mar 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
MKW000200	36	8-33	23	100-142	129	25	133	30	126

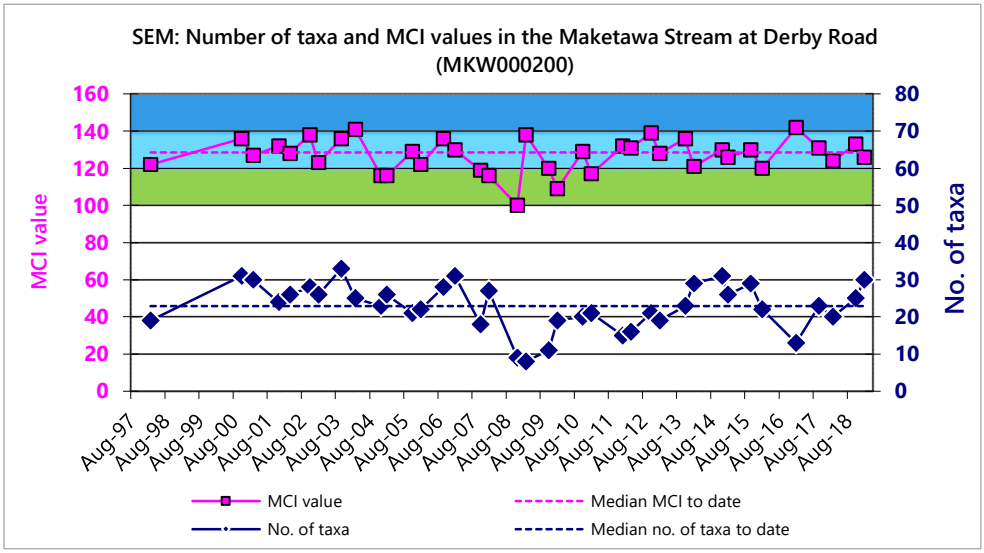


Figure 38 Number of taxa and MCI values in the Maketawa Stream at Derby Road

A very wide range of richness (8 to 33 taxa) has been found as a result of marked reductions in richness due to the impacts of previous headwater erosion events, with a median richness of 23 taxa (slightly lower than typical richness found in the upper reaches of ringplain streams and rivers). During the current period, spring (25 taxa) and summer (30 taxa) richness were slightly higher than the previously recorded median.

MCI values have had a very wide range (42 units) at this site, atypical of a site in the upper reaches of a ringplain stream mainly due to headwater erosion effects referenced above. The median value (129 units) however, has been more typical of upper reach sites elsewhere on the ringplain. The spring (133 units) and summer (126 units) scores were not significantly different (Stark, 1998) to the historical median. The scores categorised this site as having 'very good' generic health (Table 3) in spring and summer. The historical median score (129 units) placed this site in the 'very good' category for generic health.

3.2.8.1.2 Predicted stream 'health'

The Maketawa Stream site at Derby Road is 2.3 km downstream of the National Park boundary at an altitude of 380 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 121 for this site. The spring score was significantly higher than the distance predictive value while the summer score and historic median were not significantly different to the distance predictive value. The REC predicted MCI value (Leathwick, et al. 2009) was 130 units. The historical site median, spring and summer scores were not significantly different to this value.

3.2.8.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 39). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all SEM results (1998-2019) and the most recent ten-years of results (2009-2019) from the site in the Maketawa Stream at Derby Road.

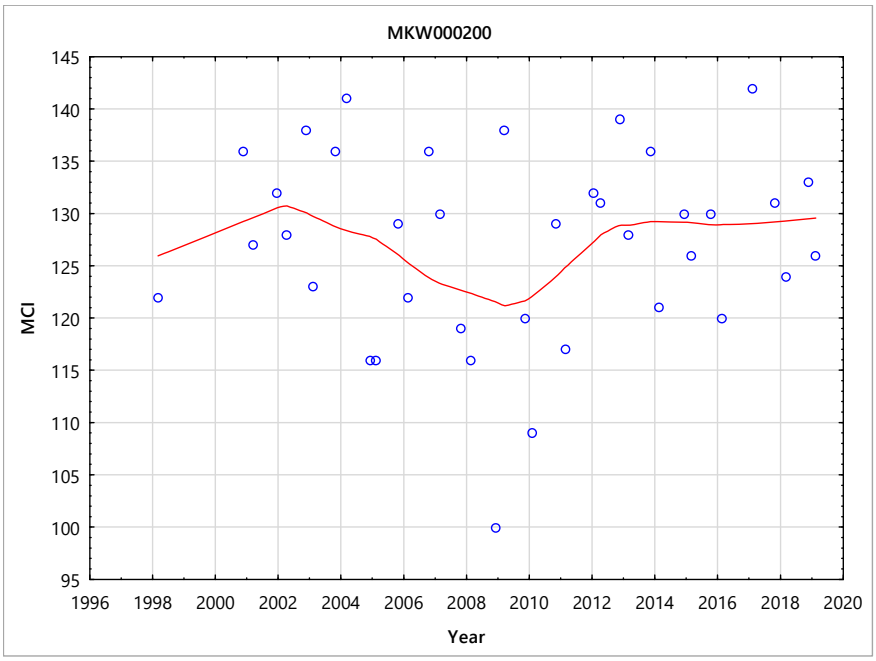


Figure 39 LOWESS trend plot of MCI data at the Derby Road site, Maketawa Stream for the full dataset with Mann-Kendall test for the full and ten-year dataset

No significant trend in MCI scores has been found over the entire monitoring period at this relatively pristine site. Scores decreased following the headwater erosion events, prior to recovery over the more recent five-year period. The variability in the trendline (range 9 units) represented minor ecological importance during the period accentuated by the impact of headwater erosion events during 2008. Overall, the trendline remained indicative of 'very good' generic stream health for the majority of the period, dropping toward 'good' health briefly between 2008 and 2010.

There was a non-significant positive trend in MCI scores over the most recent ten-year period, congruent with the full dataset, even though there was a relatively large increase in the trendline from 2010 to 2013. The trendline for the most recent ten-year period was indicative of 'very good' health.

3.2.8.2 Tarata Road site (MKW000300)

3.2.8.2.1 Taxa richness and MCI

Thirty-five surveys have been undertaken at this mid-reach site at Tarata Road in the Maketawa Stream between March 2000 and March 2018. These results are summarised in Table 24, together with the results from the current period, and illustrated in Figure 40.

Table 24 Results of previous surveys performed in the Maketawa Stream at Tarata Road together with 2018-2019 results

Site code	SEM data (2000 to Mar 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 18		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
MKW000300	35	12-31	22	90-127	108	18	109	23	105

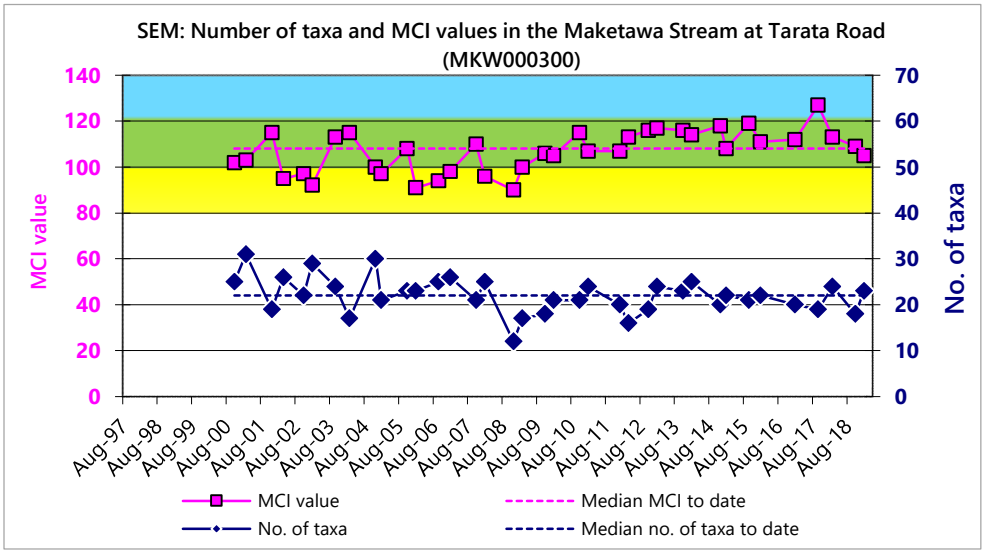


Figure 40 Number of taxa and MCI values in the Maketawa Stream at Tarata Road

A wide range of richness (12 to 31 taxa) has been found; wider than might be expected, with a median richness of 22 taxa which is more representative of typical richness in the mid-reaches of ringplain streams and rivers. During the current period, spring (18 taxa) and summer (23 taxa) richness was similar to the median taxa number. MCI scores have had a relatively wide range (37 units) at this site, more typical of sites in the mid to lower reaches of ringplain streams. The median value (108 units) has been relatively typical of mid-reach sites elsewhere on the ringplain. The spring (109 units) and summer (105 units) score was within the range typical for the site and not significantly different to the historical median (Stark, 1998). The scores categorized this site as having 'good' spring and summer health (Table 3). The historical median score (108 units) also placed this site in the 'good' category for generic health.

3.2.8.2.2 Predicted stream 'health'

The Maketawa Stream site at Tarata Road is 15.5 km downstream of the National Park boundary at an altitude of 150 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 101 for this site. The historical site median, spring and summer scores were not significantly different to the distance predictive value. The REC predicted MCI value (Leathwick, et al. 2009) was 111 units. Again, the historical site median, spring and summer scores were not significantly different to the REC predictive value.

3.2.8.2.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 41). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all the SEM results (2000-2019) and the most recent ten-years of results (2009-2019) from the site in the Maketawa Stream at Tarata Road.

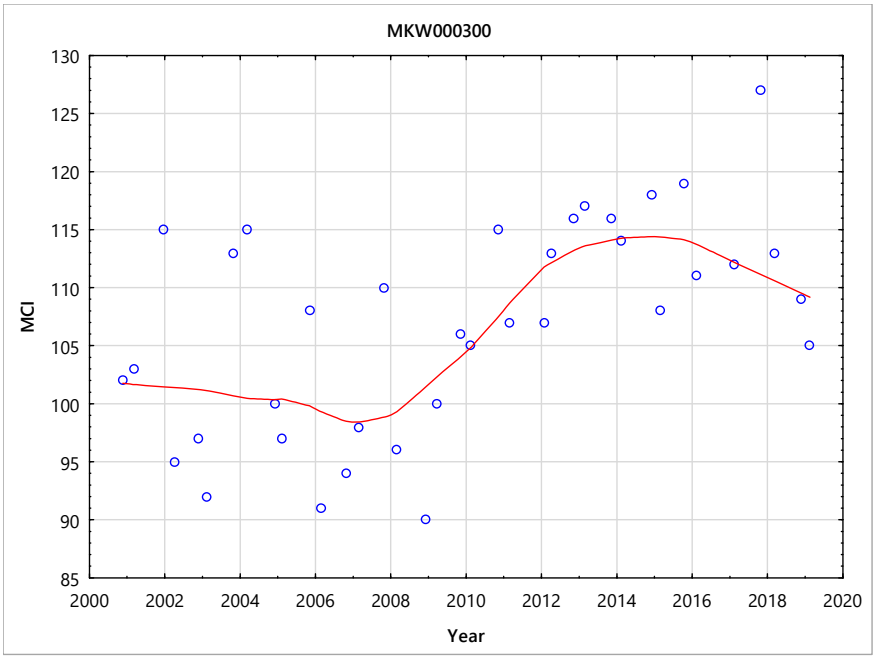


Figure 41 LOWESS trend plot of MCI data at the Tarata Road site for the full dataset with Mann-Kendall test for the full and ten-year dataset

The positive trend in MCI scores found over the entire monitoring period has been highly statistically significant (FDR p < 0.01). Ecological variability, which have ranged over 16 units, has been important ecologically with scores indicative of 'good' generic stream health (Table 3) trending downward to 'fair' stream health, between 2006 and 2008 before returning to 'good' health where it currently remains.

There was a positive, but non-significant trend in MCI scores over the most recent ten-year period, even though there was a relatively large increase in the trendline from 2009 to 2014. The trendline for the most recent ten-year period was indicative of 'good' health.

3.2.8.3 Discussion

Both sites had typical, moderate, taxa richness. MCI scores at the upper Maketawa Stream site indicated that the macroinvertebrate community was in 'very good' health. The lower Maketawa Stream site MCI scores indicated 'good' macroinvertebrate health. There was a significant decrease in MCI scores in a downstream direction for both spring and summer which was typical for the site. The general deterioration in macroinvertebrate health was likely due to cumulative inputs from point and diffuse sources in a catchment dominated by agriculture but which also has some industrial and urban influence.

The time trend analysis showed the upper site had no significant trends which would be expected from a site with few impacts that has not changed significantly over time. The lower site had a significant positive trend over the full dataset indicating that macroinvertebrate communities have been getting healthier over time. Long-term improvements in macroinvertebrate health at the site were likely in relation to higher levels of fencing and riparian planting in the catchment in combination with a reduction in point source inputs from farm oxidation ponds with effluent now being discharged to land. However, there were no significant trends over the most recent ten-year period suggesting little recent improvement.

3.2.9 Mangaehu River

The Mangaehu River is a large eastern hill country river and is a major tributary of the Patea River. There is one SEM site located on the Mangaehu River not far from its confluence with the Patea River.

3.2.9.1 Raupuha Road site (MGH000950)

3.2.9.1.1 Taxa richness and MCI

Forty-six surveys have been undertaken at this lower reach site in the Mangaehu River between October 1995 and February 2018. These results are summarised in Table 25, together with the results from the current period, and illustrated in Figure 42.

Table 25 Results of previous surveys performed in the Mangaehu River at Raupuha Road, together with 2018-2019 results

Site code	SEM data (1995 to Feb 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
MGH000950	46	12-26	20	77-104	92	17	99	20	96

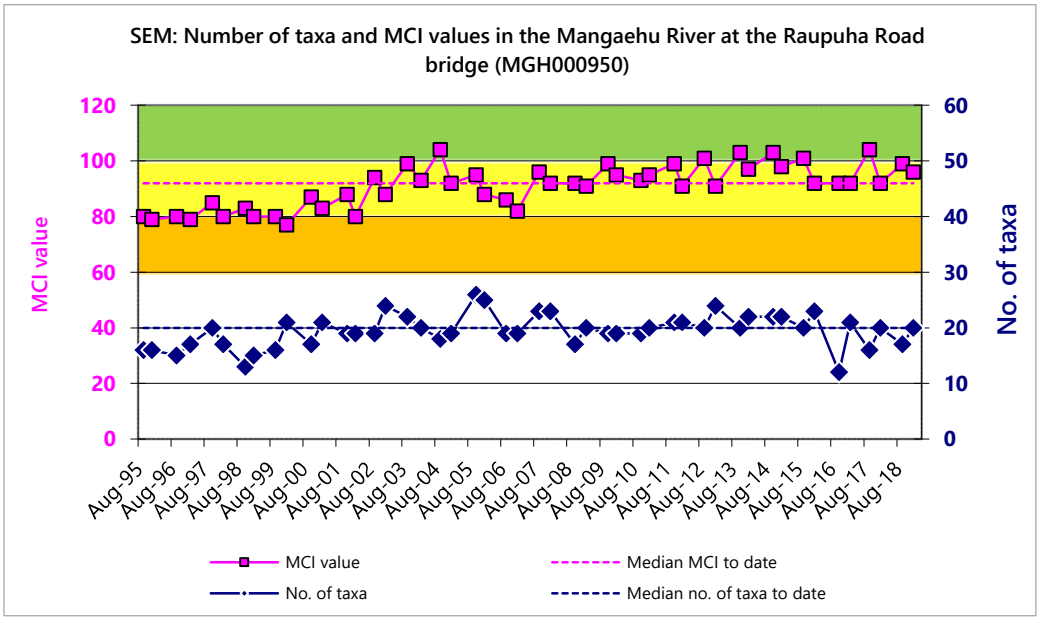


Figure 42 Numbers of taxa and MCI values in the Mangaehu River at Raupuha Road

A relatively wide range of richness (12 to 26 taxa) has been found with a moderate median richness similar to richness in the lower reaches of hill country rivers, although generally at lower altitudes. During the current period, spring (17 taxa) summer (20 taxa) taxa richness were similar to the historical median.

MCI values have had a relatively wide range (27 units) at this site typical of a site in the lower reaches of streams and rivers. The median value (92 units) has been typical of lower reach sites. The spring (99 units) and summer (96 units) scores were not significantly different to the historical median. These scores categorised this site as having 'fair' health in both spring and summer (Table 3). The historical median score (92 units) placed this site in the 'fair' category for the generic method of assessment.

3.2.9.1.2 Predicted stream 'health'

The Mangaehu River site at Raupuha Road, at an altitude of 120 m asl, is in the lower reaches of a river draining an eastern hill country catchment. The REC predicted MCI value (Leathwick, et al. 2009) was 117 units. The historical median, spring and summer scores were all significantly lower than this value.

3.2.9.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 43). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Mangaehu River at Raupuha Road.

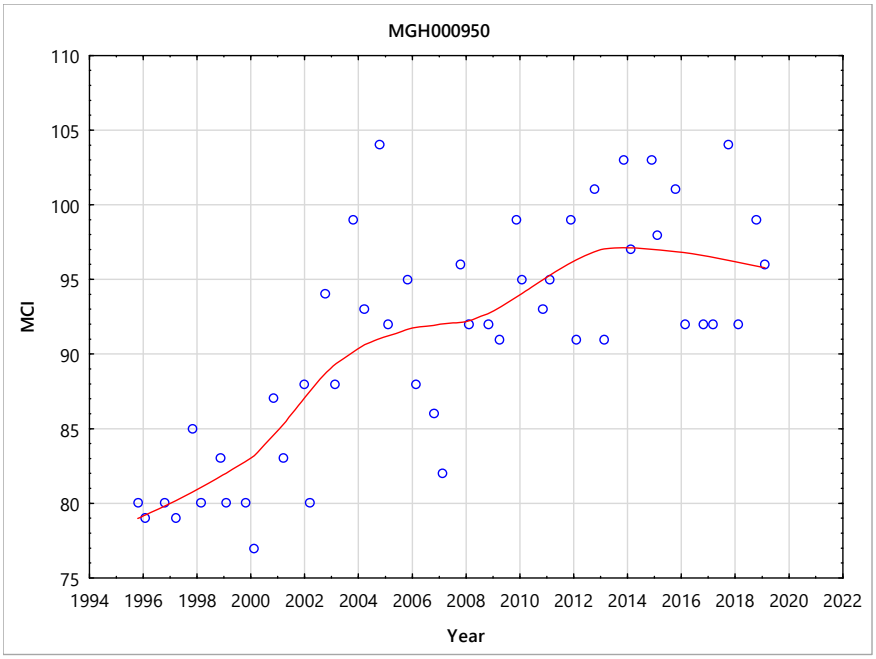


Figure 43 LOWESS trend plot of MCI data for the Raupuha Road site, Mangaehu River for the full dataset with Mann-Kendall test for the full and ten-year dataset

A significant positive temporal trend in MCI scores ($p < 0.01$ after FDR) was found at this lower reach, hill country river site. The wide range of trendline scores (19 units) has also been ecologically important, particularly over the period since 2000. The trendline was originally bordering on 'poor/fair' generic river health but has now trended upward to 'fair' health.

There was a non-significant positive trend in MCI scores over the most recent ten-year period with a decline in the trendline from 2014 onwards. The trendline for the most recent ten-year period was indicative of 'fair' health.

3.2.9.2 Discussion

The Mangaehu River had a typical taxa richness. MCI scores at the site indicated that the macroinvertebrate community was in 'fair' health. The time trend analysis showed a significant positive trend over the full dataset indicating that macroinvertebrate communities have been getting healthier over time. There was no significant trend for the ten-year dataset. Long term improvements in macroinvertebrate health at the site were likely in relation to an apparent reduction in river bed sedimentation possibly related to fewer severe flood events particularly since 2000 with scores tending to plateau between in 2004 and 2008 before improving steadily again since then. Work has also been undertaken encouraging farmers to stabilise erosion prone hill slopes by planting appropriate vegetation such as poplar. Recent scores show a decrease

in the trend coincident with widespread periphyton mats on the streambed in conjunction at times with widespread filamentous periphyton, which provide favourable habitat and food for more tolerant taxa resulting in lower macroinvertebrate health scores.

3.2.10 Manganui River

The Manganui River is a ringplain river whose source is inside Egmont National Park and is a significant tributary of the Waitara River. There are two SEM sites located on the river, one at its mid reaches and another at its lower reaches.

3.2.10.1 State Highway 3 site (MGN000195)

3.2.10.1.1 Taxa richness and MCI

Forty-six surveys have been undertaken at this mid reach site in the Manganui River between September 1995 and March 2018. These results are summarised in Table 26 together with the results from the current period, and illustrated in Figure 65.

Table 26 Results of previous surveys performed in the Manganui River u/s of railway bridge (SH 3), together with 2018-2019 results

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
MGN000195	46	9-26	21	106-143	126	18	133	25	123

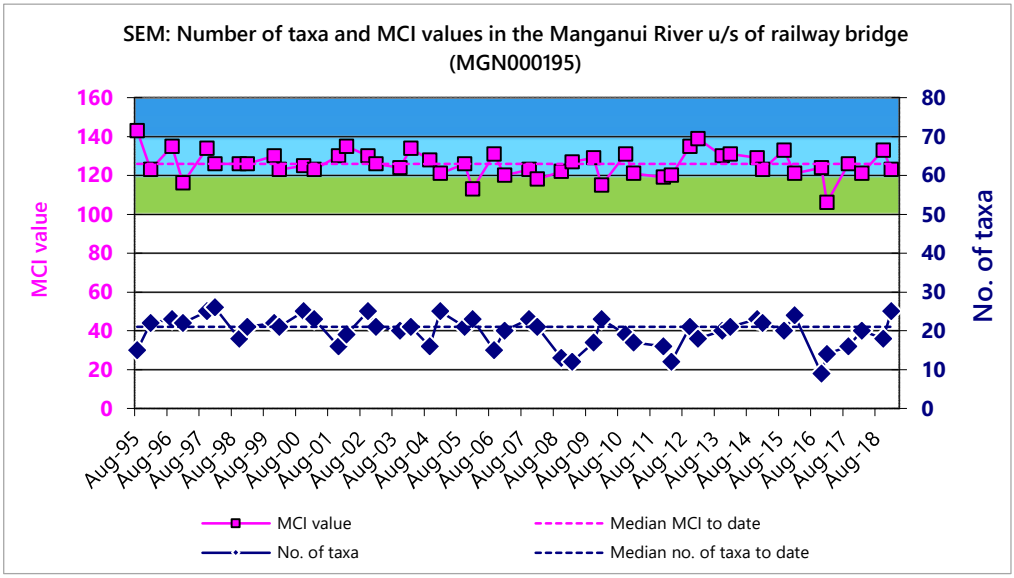


Figure 44 Numbers of taxa and MCI values in the Manganui River above the railway bridge (SH3)

A wide range of richness (9 to 26 taxa) has been found, with a median richness of 21 taxa which was slightly lower than typical richness in the mid-reaches of ringplain streams and rivers. During the current period spring (18 taxa) and summer (25 taxa) richness were both similar to the historical median though summer richness was noticeably higher than spring richness.

MCI values have had a relatively wide range (37 units) at this site, slightly wider than typical for a site in the mid reaches of a ringplain stream. The median value (126 units) was higher than has been typical of similar

mid-reach sites elsewhere on the ringplain. The spring (133 units) and summer (123 units) scores were not significantly different to the historical median. These scores categorised this site as having 'very good' health (Table 3) in spring and summer. The historical median score (126 units) placed this site in the 'very good' generic health.

3.2.10.1.2 Predicted stream 'health'

The Manganui River site at SH3 is 8.7 km downstream of the National Park boundary at an altitude of 330 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 107 for this site. The historical site median, spring and summer scores were significantly above the distance predictive value. The REC predicted MCI value (Leathwick, et al. 2009) was 124 units. The historical site median, spring and summer scores were not significantly different to this value.

3.2.10.1.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 45). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all of the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Manganui River at SH3.

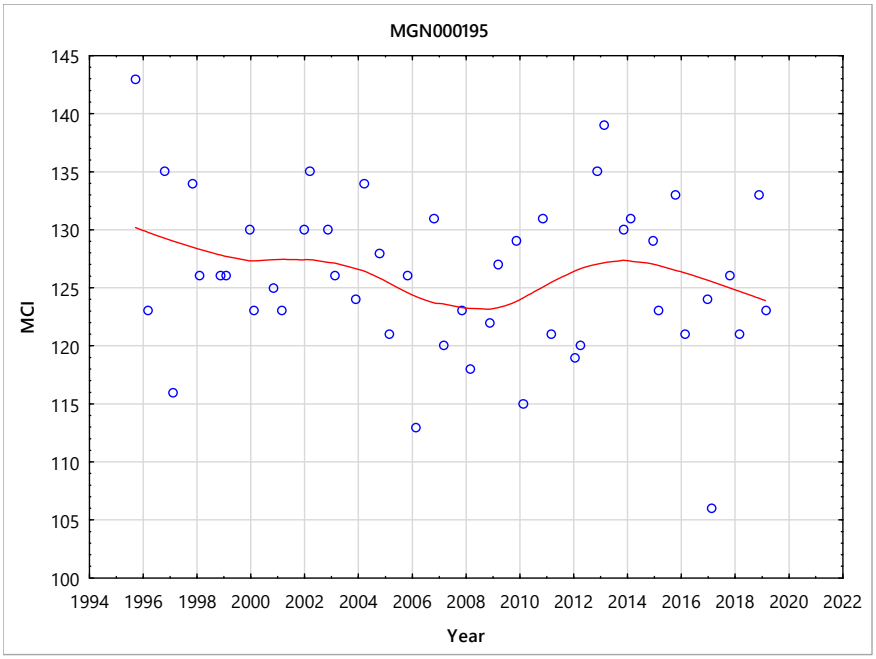


Figure 45 LOWESS trend plot of MCI data at the SH3 site, Manganui River

A very slight overall decrease in MCI scores was identified (more accentuated over the first 12 years) which was not statistically significant for the 24-year period. The scores (range of nine units) represented no ecological importance in terms of variability. These trendline consistently indicated 'very good' generic river health over the entire period.

There was a minor non-significant negative trend in MCI scores over the most recent ten-year period, congruent with the full dataset. The trendline for the most recent ten-year period was indicative of 'very good' health.

3.2.10.2 Bristol Road site (MGN000427)

3.2.10.2.1 Taxa richness and MCI

Forty-six surveys have been undertaken at this lower reach site at Bristol Road in the Manganui River between October 1995 and March 2018. These results are summarised in Table 27 together with the results from the current period, and illustrated in Figure 46.

Table 27 Results of previous surveys performed in the Manganui River at Bristol Road together with 2018-2019 results

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Mar 2019	
		Range	Taxa no	Taxa no	Median	Taxa no	MCI	Taxa no	MCI
MGN000427	46	14-26	20	77-117	98	20	89	20	93

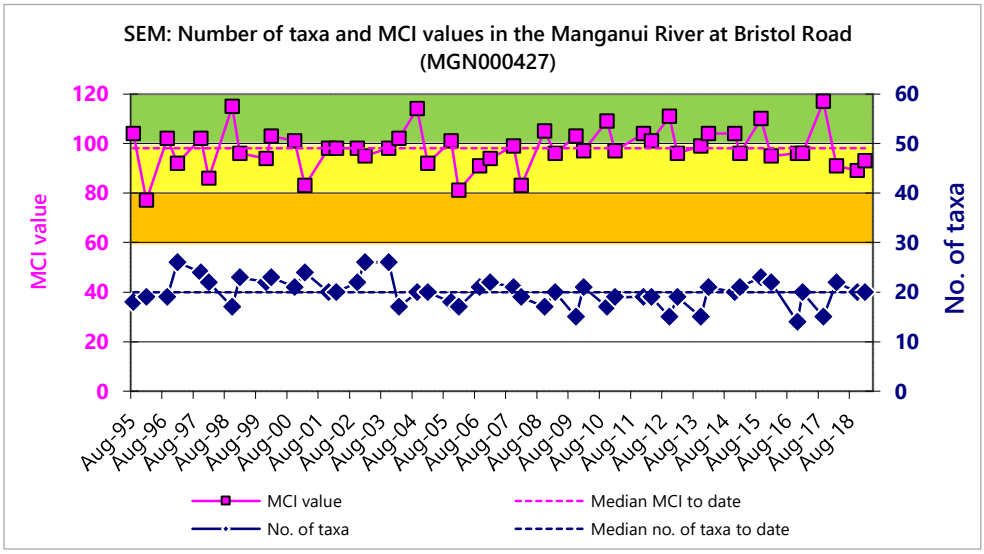


Figure 46 Numbers of taxa and MCI values in the Manganui River at Bristol Road

A moderate range of richness (14 to 26 taxa) has been found with a median richness of 20 taxa which is representative of typical richness in ringplain streams and rivers in the lower reaches. During the current period, the spring (20 taxa) and summer (20 taxa) richness the same as the historical median.

MCI scores have had a very wide range (40 units) at this site, typical of sites in the lower reaches of streams elsewhere on the ringplain although this site was located at an atypically higher altitude of 140 m asl for a lower reach site more than 37 km downstream from the National Park boundary. The median value (98 units) has been higher than typical of lower reach ringplain sites. The spring (89 units) and summer (93 units) scores were both lower than the historical median. These scores categorised this site as having 'fair' spring and summer health (Table 3). The historical median score (98 units) placed this site in the 'fair' category for generic health.

3.2.10.2.2 Predicted stream 'health'

The Manganui River site at Bristol Road is 37.9 km downstream of the National Park boundary at an altitude of 140 m asl. Relationships for ringplain streams developed between MCI and distance from the National park boundary (Stark and Fowles, 2009) predict a MCI value of 91 for this site. The historical site median, spring and summer scores were not significantly different to the predictive value (Stark, 1998). The REC

predicted MCI value (Leathwick, et al. 2009) was 103 units. The historical site median and summer score was not significantly different to the REC predictive value, while the spring score was significantly lower.

3.2.10.2.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 47). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all of the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Manganui River at Bristol Road.

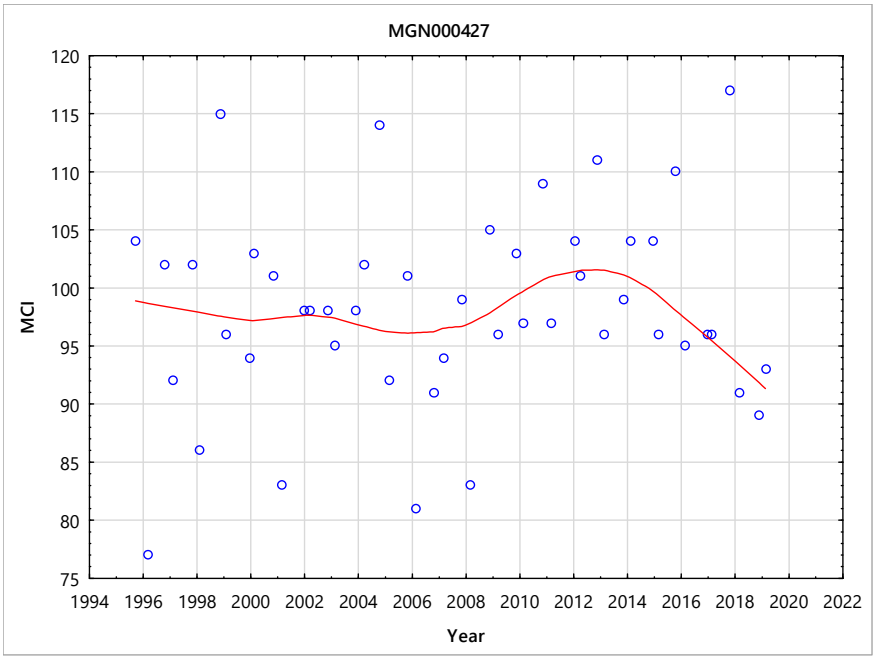


Figure 47 LOWESS trend plot of MCI data at the Bristol Road site, Manganui River

The slight overall positive trend in MCI scores was not statistically significant and though there has been some variability in the trendline of 10 units been of minor ecological importance. The trendline was indicative of 'fair' generic river health at this site throughout the majority of 23-year period.

There was a negative trend in MCI scores over the most recent ten-year period, in contrast with the full dataset, with a decline in the trendline from 2013 onwards. This trend was not statistically significant after FDR application (FDR p = 0.22), although continued deterioration in the future will likely cause a statistically significant result. The trendline for the most recent ten-year period was indicative of 'fair' health with a brief period of 'good' health between 2010 and 2015.

3.2.10.3 Discussion

The Manganui River had typical taxa richness. MCI scores were also typical at the upper site and slightly lower than the historic median at the lower site. MCI scores indicated that the upper site was in 'very good' health while the lower site was in 'fair' health. MCI score typically fell in a downstream direction in both spring and summer, over a stream distance of 29.2 km downstream from the National Park boundary. Based on the long-term median, SEM MCI scores fell in a downstream direction by 28 units. The deterioration in macroinvertebrate health was likely due to cumulative inputs from point and diffuse sources in a catchment that was dominated by agriculture.

The time trend analysis showed no significant trends for either site for both the full and ten-year dataset indicting no significant changes in macroinvertebrate health over time at the two monitored sites though the lower site had a non-significant negative trend which may become significant if the trend continues its current trajectory.

3.2.11 Mangaoraka Stream

The Mangaoraka Stream is a ringplain stream whose source is outside Egmont National Park. The stream flows in a northerly direction and is a tributary of the Waiongana Stream where it joins close to the coast. A single site is surveyed.

3.2.11.1 Corbett Road site (MRK000420)

3.2.11.1.1 Taxa richness and MCI

Forty-five surveys have been undertaken at this lower reach site in the Mangaoraka Stream between October 1995 and February 2018. These results are summarised in Table 28, together with the results from the current period, and illustrated in Figure 48.

Table 28 Results of previous surveys performed in Mangaoraka Stream at Corbett Road, together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Taxa no	Taxa no	Median	Taxa no	MCI	Taxa no	MCI
MRK000420	45	11-30	25	75-105	90	18	94	28	81

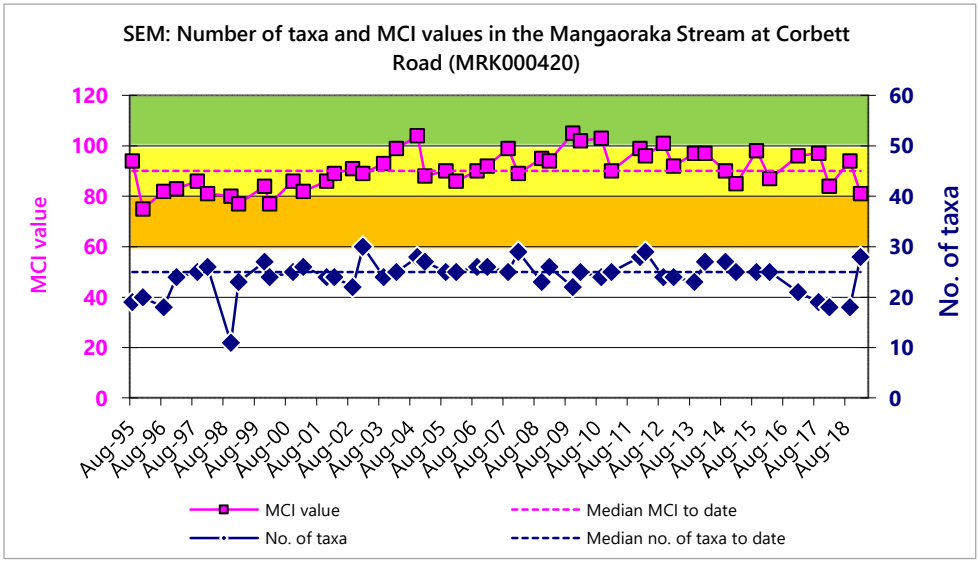


Figure 48 Numbers of taxa and MCI values in the Mangaoraka Stream at Corbett Road

A wide range of richness (11 to 30 taxa) has been found, with a median richness of 25 taxa (more representative of typical richness in the lower reaches of ringplain streams rising outside the National Park boundary). During the current period there was substantial variability displayed with spring (18 taxa) richness significantly lower than summer (28 taxa) richness and the historical median richness, by ten and seven taxa respectively.

MCI values have also had a relatively wide range (30 units) at this site to date. The median value (90 units) has been typical of lower reach sites elsewhere on the ringplain. The spring (94 units) and summer (81 units) scores were not significantly different to the historical median but the summer score was significantly lower than the spring score. The MCI scores categorised this site as having 'fair' health generically (Table 3). The historical median score (90 units) placed this site in the 'fair' generic health.

3.2.11.1.2 Predicted stream 'health'

The Mangaoraka Stream rises below the National Park boundary and the site at Corbett Road is in the lower reaches at an altitude of 60 m asl. The REC predicted MCI value (Leathwick, et al. 2009) was 92 units. The historical site median and spring scores were also not significantly different to this value but the summer score was significantly lower.

3.2.11.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 49). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all of the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Mangaoraka Stream at Corbett Road.

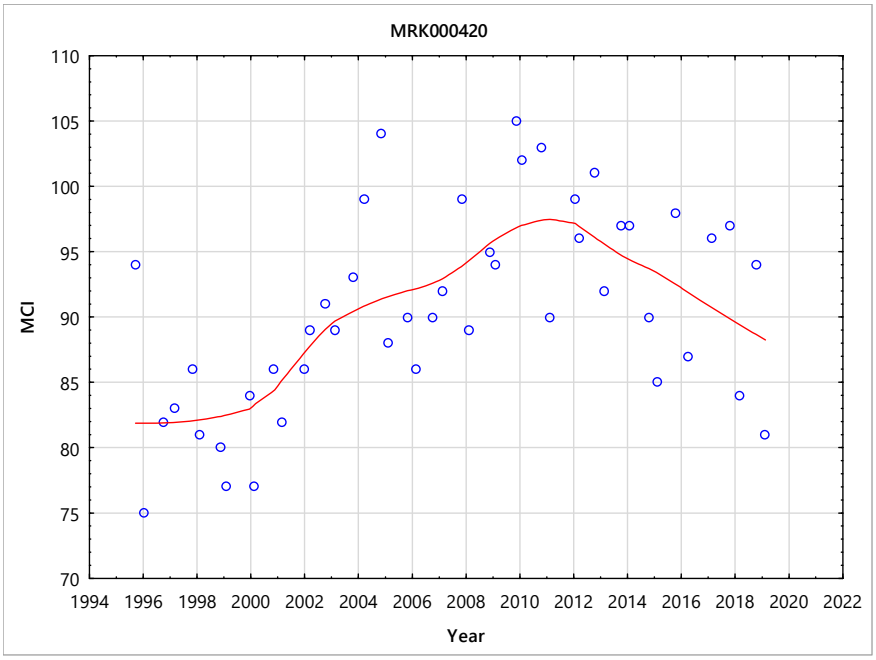


Figure 49 LOWESS trend plot of MCI data at the Corbett Road site, Mangaoraka Stream for the full dataset with Mann-Kendall test for the full and ten-year dataset

The MCI scores have shown a highly significant improvement ($p < 0.01$ after FDR). Scores improved from 1995 to 2011 but have since decreased from 2011 to 2019. The trendline has varied over an ecologically important range of 16 units during the period. SEM physicochemical monitoring at this site had illustrated significant improvements in aspects of organic loadings at this site in the lower reaches of the stream prior to mid-2008. This was coincident with more rigorous surveillance monitoring of nearby quarrying and waste disposal activities and good dairy shed wastewater disposal compliance performance during that period. The trendline was indicative of 'fair' generic stream health.

There was a non-significant negative trend in MCI scores over the most recent ten-year period after FDR ($p = 0.05$), in contrast with the significant positive trend of the full dataset, with a decline in the trendline from 2012 onwards.

3.2.11.2 Discussion

The site had a lower than usual taxa richness during spring, similar to what was found for the preceding monitoring year, but the summer result was slightly higher than the historical median indicating richness had returned to more typical levels. MCI scores were typical and indicated 'fair' health. MCI values

significantly decreased between spring and summer at this lower reach site by 13 units (Appendix II) indicating significant seasonal variation.

The time trend analysis showed a significant positive trend for the full dataset indicting a significant improvement in macroinvertebrate health over the full duration of monitoring. However, there was a non-significant (but extremely close to being significant) negative trend for the ten-year dataset which will probably become significant for the next monitoring year if the current trend continues. Recently, deteriorating water quality (i.e. increased dissolved reactive phosphorus, total phosphorus, faecal coliforms, enterococci and decreased visual clarity as a measure by black disc) has been recorded at the site (TRC, 2018). The decline in water quality was due to a large increase in land use activity, namely new poultry farms and a deterioration in stock control, resulting in an overall increase in pollution loads on the catchment. The declining water quality was probably the main driver negatively impacting the macroinvertebrate community present at the site.

3.2.12 Mangati Stream

The Mangati Stream is a small coastal stream, and flows in a northerly direction through a mix of agriculture, industrial and urban areas. Two sites, located above and below an industrial area, are sampled for SEM purposes.

3.2.12.1 Site downstream of railbridge (MGT000488)

3.2.12.1.1 Taxa richness and MCI

Between September 1995 and February 2018, forty-five surveys have been undertaken at this site, which lies in the mid reaches of the stream and drains an industrial catchment. Historical results are summarised in Table 29, together with the results from the current period, and illustrated in Figure 50.

Table 29 Results of previous surveys performed in the Mangati Stream at the site downstream of the railbridge, together with 2018-2019 results

Site code	SEM data (1995 to Feb 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
MGT000488	45	9-29	16	56-91	78	20	79	16	74

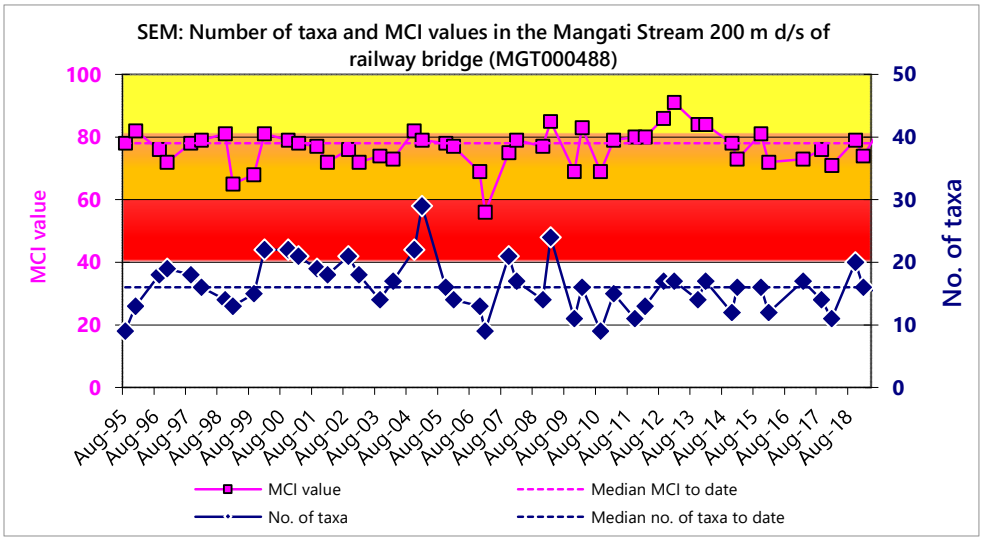


Figure 50 Numbers of taxa and MCI values in the Mangati Stream downstream of the railbridge

A very wide range of richness (9 to 29 taxa) has been found; with a median richness of 16 taxa which was a typical richness in Taranaki lowland coastal streams. During the current period, the spring survey (20 taxa) had a slightly higher taxa richness than the historic median while the summer survey (16 taxa) had a richness exactly the same as the historic median.

MCI values have had a wide range (35 units) at this site, relatively typical of a site in a small coastal stream. The median historical value (78 units) has also been typical of such streams and the spring (79 units) and summer (74 units) score was not significantly different to the historical median (Stark, 1998). These scores categorised this site as having 'poor' health in spring and summer (Table 3). The historical median score (78 units) also placed this site in the 'poor' health category for the generic method of assessment.

3.2.12.1.2 Predicted stream 'health'

The Mangati Stream site downstream of the railbridge is in the middle reaches of a small lowland, coastal stream at an altitude of 30 m asl. The REC predicted MCI value (Leathwick, et al. 2009) was 80 units. The historical site median, spring and summer scores were not significantly different to this value.

3.2.12.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 51). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all of the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Mangati Stream at the site downstream of the railbridge.

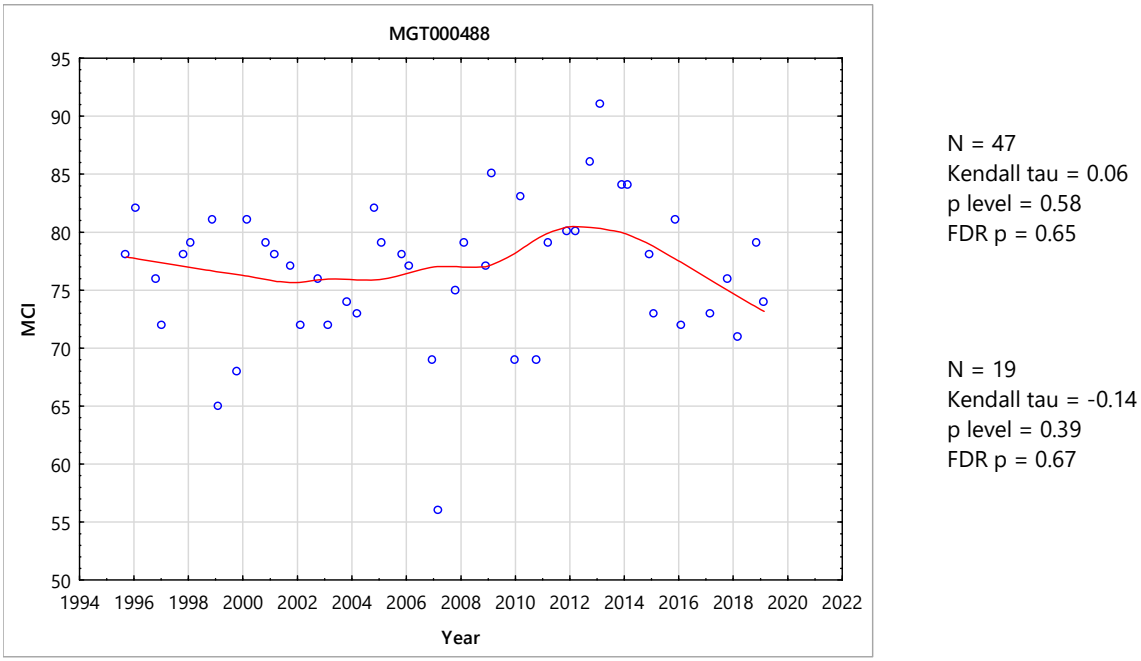


Figure 51 LOWESS trend plot of MCI data at the Mangati Stream site downstream of the railbridge for the full dataset with Mann-Kendall test for the full and ten-year dataset

There was a non-significant positive overall trend identified in the MCI scores over the full time range. The trendline had a range of eight units indicative of marginal ecological importance over the period. Overall, the trendline was indicative of 'poor' generic stream health throughout most of the period.

There was a non-significant negative trend in MCI scores over the most recent ten-year period after FDR, in contrast with the full dataset, with a decline in the trendline from 2012 onwards, probably as a result of increased earthworks upstream of the site. The trendline for the most recent ten-year period was indicative of 'poor' health.

3.2.12.2 Te Rima Place, Bell Block site (MGT000520)

3.2.12.2.1 Taxa richness and MCI

Forty-five surveys have been undertaken at this lower reach site at SH45 in the Mangati Stream between October 1995 and February 2018. These results are summarised in Table 30, together with the results from the current period, and illustrated in Figure 52.

Table 30 Results of previous surveys performed in the Mangati Stream at Te Rima Place, Bell Block together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
MGT000520	45	3-22	10	44-79	67	13	74	12	73

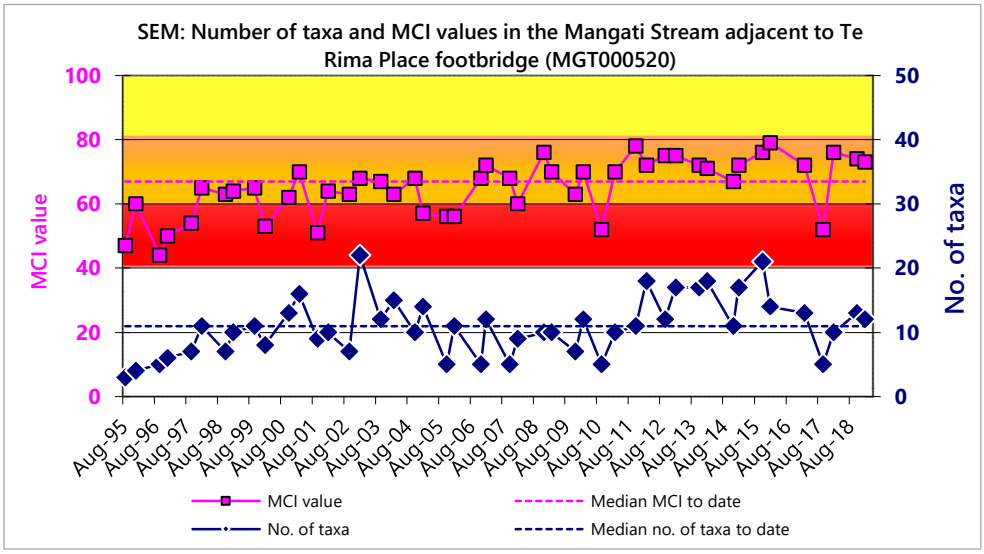


Figure 52 Numbers of taxa and MCI values in the Mangati Stream at Te Rima Place footbridge

A wide range of richness (3 to 22 taxa) has been found; wider than might be expected with a median richness of 10 taxa, lower than typical richness in the lower reaches of small lowland, coastal streams in Taranaki. During the current period, spring (13 taxa) and summer (12 taxa) richness was similar to the historical median richness.

MCI scores have had a relatively wide range (35 units) at this site, typical of sites in the lower reaches of small lowland, coastal streams. The spring (74 units) and summer (73 units) scores were non-significantly higher than the historic median. The scores categorised this site as having 'poor' health in both spring and summer (Table 3). The historical median score (67 units) also placed this site in the 'poor' category for the generic method of assessment.

3.2.12.2.2 Predicted stream 'health'

The Mangati Stream at Te Rima Place, Bell Block is in the lower, more gravel-bottomed reaches of a small lowland, coastal stream at an altitude of 20 m asl. The REC predicted MCI value (Leathwick, et al. 2009) was 88 units. The historical site median, spring and summer scores were significantly lower than this value.

3.2.12.2.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 53). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on 24 years of SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Mangati Stream at Te Rima Place.

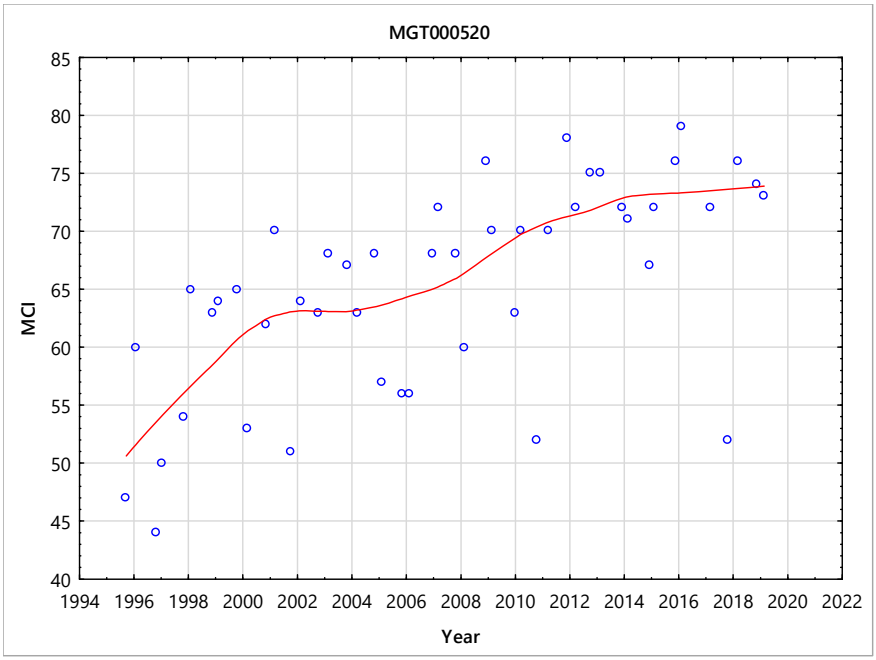


Figure 53 LOWESS trend plot of MCI data at the Mangati stream site at Te Rima Place, Bell Block for the full dataset with Mann-Kendall test for the full and ten-year dataset

A positive significant trend in MCI scores has indicated continued improvement coincident with better control and treatment of industrial point source discharges in the catchment and wetland installation (stormwater interception) in the mid catchment with this improvement continuing in recent years. The trendline had a range of scores (23 units) that has been ecologically important with MCI scores indicative of a shift from 'very poor' over the first four years to 'poor' generic stream health during the remaining period.

There was a non-significant positive trend in MCI scores over the most recent ten-year period with the trendline slope starting to flatten out after 2014. The trendline for the most recent ten-year period was indicative of 'poor' health.

3.2.12.3 Discussion

Taxa richness at both sites were similar to historic medians indicating no recent effects of illegal discharges, that unfortunately sometimes occur in the stream. MCI scores were congruent with taxa richness, with both sites having typical scores compared with historic medians.

The time trend analysis showed no significant trends for the upper site but there was a significant, positive trend at the lower site for the full dataset. This indicates that macroinvertebrate health has been improving at the lower site and suggests that improvements in water quality have largely occurred between the two sites. The lack of a significant trend for the ten-year dataset indicates that improvements have been recently levelling off.

3.2.1 Mangawhero Stream

The Mangawhero Stream is a small stream that arises as a seepage stream draining the Ngaere swamp with a lower sub-catchment (Mangawharawhara Stream) rising on the ringplain but outside of Egmont National Park. Two sites are located on the stream, one above the discharge point of the Eltham WWTP and another close to the where it joins the Waingongoro River.

3.2.1.1 Site upstream of the Eltham Municipal WWTP discharge (MWH000380)

3.2.1.1.1 Taxa richness and MCI

Forty-six surveys have been undertaken in this mid-reach site in the Mangawhero Stream within about 3 km of the Ngaere swamp between October 1995 and March 2018. These results are summarised in Table 31, together with the results from the current period, and illustrated in Figure 54.

Table 31 Results of previous surveys performed in Mangawhero Stream upstream of Eltham WWTP, together with 2018-2019 results

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
MWH000380	46	10-24	15	58-85	74	13	88	15	83

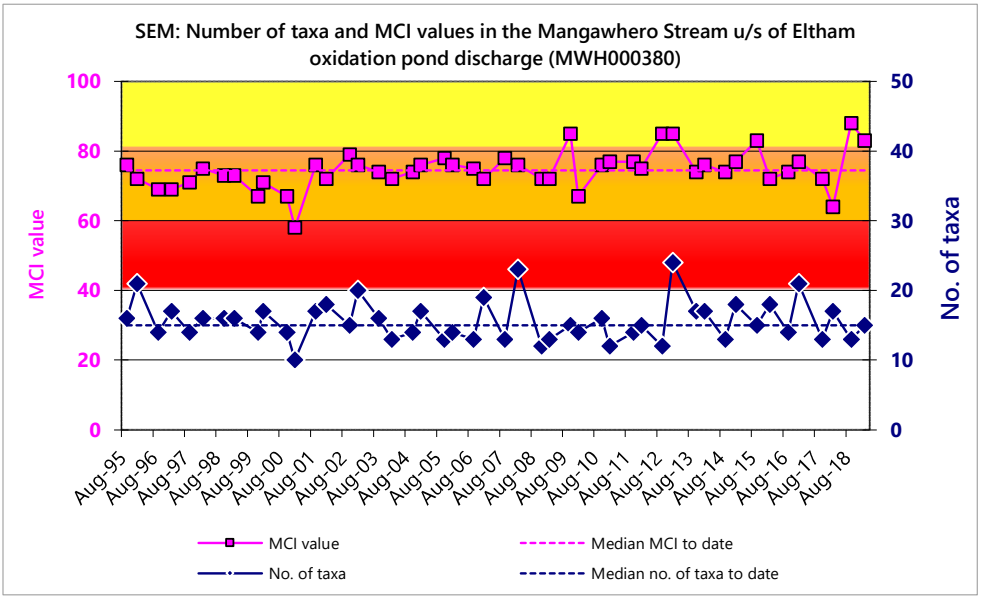


Figure 54 Numbers of taxa and MCI values in the Mangawhero Stream upstream of Eltham WWTP

A moderately wide range of richness (10 to 24 taxa) has been found, with a median richness of 15 taxa (more representative of typical richness in small swamp drainage streams where a median richness of 18 taxa has been found at similar altitudes. During the current period spring (13 taxa) and summer (15 taxa) richness were relatively similar to each other and to the historical median.

MCI values have had a moderate range (27 units) at this site. The median value (74 units) has been typical of similar non-ringplain sites elsewhere in the region. The spring (88 units) score was significantly higher than the historical median, while the summer (83 units) score was not significantly higher than the historical median (Stark, 1998). These scores categorised this site as having 'fair' (spring and summer) health generically (Table 2). The historical median score (74 units) placed this site in the 'poor' category for generic health.

3.2.1.1.2 Predicted stream 'health'

The Mangawhero Stream rises as seepage from the Ngaere swamp and is not a ringplain stream at the site upstream of the Eltham WWTP. This site is at an altitude of 200 m asl and toward its upper reaches. The REC predicted MCI value (Leathwick, et al. 2009) was 92 units. The historical median was significantly lower than the REC predictive value while the spring and summer scores were not significantly different.

3.2.1.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 55). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all of the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Mangawhero Stream upstream of the Eltham WWTP discharge.

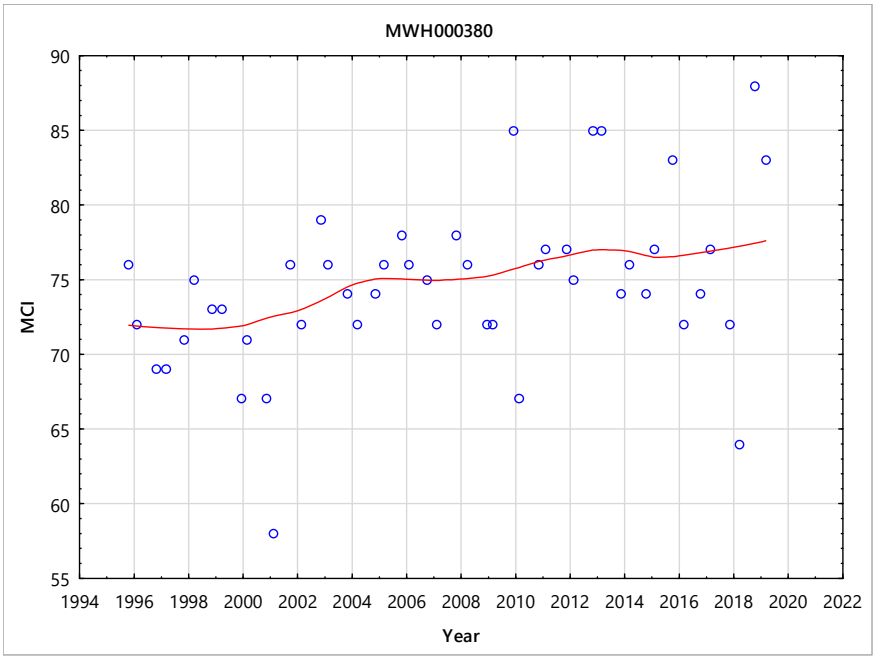


Figure 55 LOWESS trend plot of MCI data at site upstream of the Eltham WWTP discharge, Mangawhero Stream for the full dataset with Mann-Kendall test for the full and ten- year dataset

A highly significant ($p < 0.01$, after FDR) trend in MCI scores has been found over the full monitoring period at this site. However, the narrow range of trendline scores (six units) has been of only minor ecological importance. The trendline has consistently have been indicative of 'poor' generic stream health (Table 2) throughout the period.

In contrast to the full dataset the there was a negative, but non-significant, trend in MCI scores over the most recent ten-year. The trendline for the most recent ten-year period was indicative of 'poor' health.

3.2.1.2 Site downstream of the Mangawharawhara Stream confluence (MWH000490)

3.2.1.2.1 Taxa richness and MCI

Forty-six surveys have been undertaken at this lower mid-reach site in the Mangawhero Stream between October 1995 and March 2018. These results are summarised in Table 32, together with the results from the current period, and illustrated in Figure 56.

Table 32 Results of previous surveys performed in the Mangawhero Stream downstream of the Mangawharawhara Stream confluence, together with 2018-2019 results

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
MWH000490	46	13-30	20	63-102	80	16	96	20	88

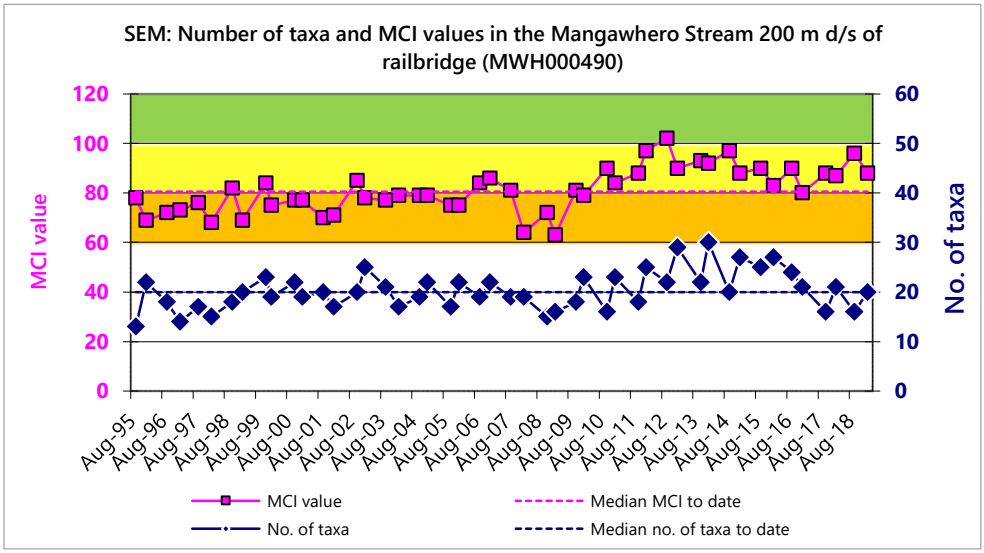


Figure 56 Numbers of taxa and MCI values in the Mangawhero Stream downstream of the railbridge and Mangawharawhara Stream confluence

A relatively wide range of richness (13 to 30 taxa) has been found with a moderate median richness of 20 taxa (more representative of typical richness in the lower-mid reaches of streams and rivers). During the current period spring (16 taxa) and summer (20 taxa) richness were similar to the historical median richness.

MCI values have had a wide range (39 units) at this site, more typical of a site in the middle to lower reaches of ringplain streams. However, the median value (80 units) has been lower than typical of lower mid-reach sites elsewhere. The spring (96 units) score was significantly higher than the historic median while the summer (88 units) score was not significantly different to the historical median (Stark, 1998). The MCI scores categorised the site as having 'fair' health generically (Table 2) in both spring and summer. The historical median score (80 units) placed this site in the 'fair' category for generic health.

3.2.1.2.2 Predicted stream 'health'

The Mangawhero Stream site below the Mangawharawhara Stream confluence, at an altitude of 190 m asl, is in the lower reaches of a stream draining a catchment comprised of the Ngaere Swamp drainage system and a mid-reach ringplain sub-catchment with its headwaters outside the National Park. The REC predicted MCI value (Leathwick, et al. 2009) was 93 units. The historic median was significantly lower than this value while the spring and summer scores were not significantly different to the REC predictive value.

3.2.1.2.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 57). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Mangawhero Stream downstream of the Mangawharawhara Stream confluence.

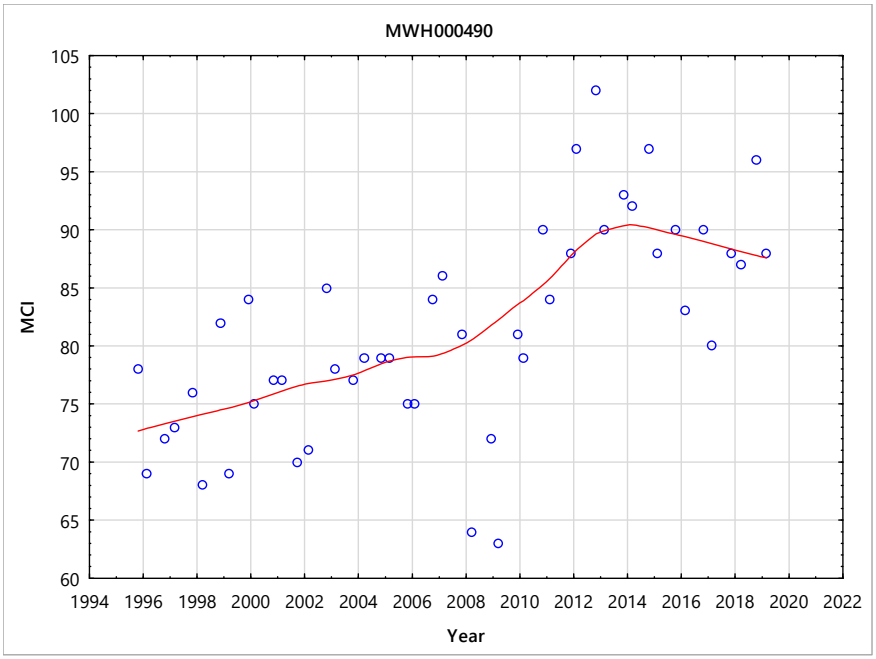


Figure 57 LOWESS trend plot of MCI data at the Mangawhero Stream site downstream of the Mangawharawhara Stream confluence for the full dataset with Mann-Kendall test for the full and ten-year dataset

A significant ($p < 0.01$, after FDR) improvement in MCI scores has been illustrated at this more ringplain-like site in the lower reaches of the stream near its confluence with Waingongoro River. The wide range in trendline scores (17 units) was of major ecologically importance. Scores rose steadily from 1995 to 2010 and then rapidly improved following the diversion of the Eltham WWTP wastes discharge out of the stream in July 2010. However, more recently from 2014 onwards a decline in the trendline was evident.

There was a non-significant trend in MCI scores over the most recent ten-year period. The trendline for the most recent ten-year period was indicative of 'fair' health.

3.2.1.3 Discussion

The Mangawhero Stream generally had moderate taxa richness with the upper site typically having slightly lower richness than the lower site due to poorer habitat quality and the current survey results were largely congruent with previous surveys. MCI scores indicated 'fair' health at the upper site and lower site. The scores continue to reflect the lowland, swampy, nature of the headwaters of the Mangawhero Stream. MCI scores typically improved in a downstream direction in both spring and summer over a stream distance of 16.5 km between the upper and lower sites of this stream. This was principally a result of improvement in physical habitat between the two sites.

The time trend analysis showed a significant positive trend for both sites for the full dataset. This indicates that macroinvertebrate health has been improving over the long term. The upper site has probably improved due to riparian plantings that now provide significant shade at the site. Improvement at the lower site was consistent with the diversion of the major point source Eltham municipal wastewater discharge out of the Mangawhero Stream which was completed in June 2010. The ten-year trends for both sites were close to being flat with very small Kendall tau and p-values recorded indicating no recent changes in macroinvertebrate community health in the Mangawhero Stream.

3.2.2 Mangorei Stream

The Mangorei Stream is a ringplain stream and tributary of the Waiwhakaiho River. A site was established in the lower reaches of the Mangorei Stream, near the confluence with the Waiwhakaiho River, for the SEM programme in 2002-2003, in recognition of the importance of this catchment as the only major inflow to the lower reaches of the river below a significant hydroelectric power scheme and New Plymouth District Council water supply abstractions.

3.2.2.1 SH3 site (MGE000970)

3.2.2.1.1 Taxa richness and MCI

Thirty-one surveys have been undertaken at this lower reach site in the Mangorei Stream between November 2002 and March 2018. These results are summarised in Table 62, together with the results from the current period, and illustrated in Figure 58.

Table 33 Results of previous surveys performed in the Mangorei Stream at SH 3 together with the 2018-2019 results

Site code	SEM data (2002 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
MGE000970	31	22-33	27	86-113	102	22	107	22	84

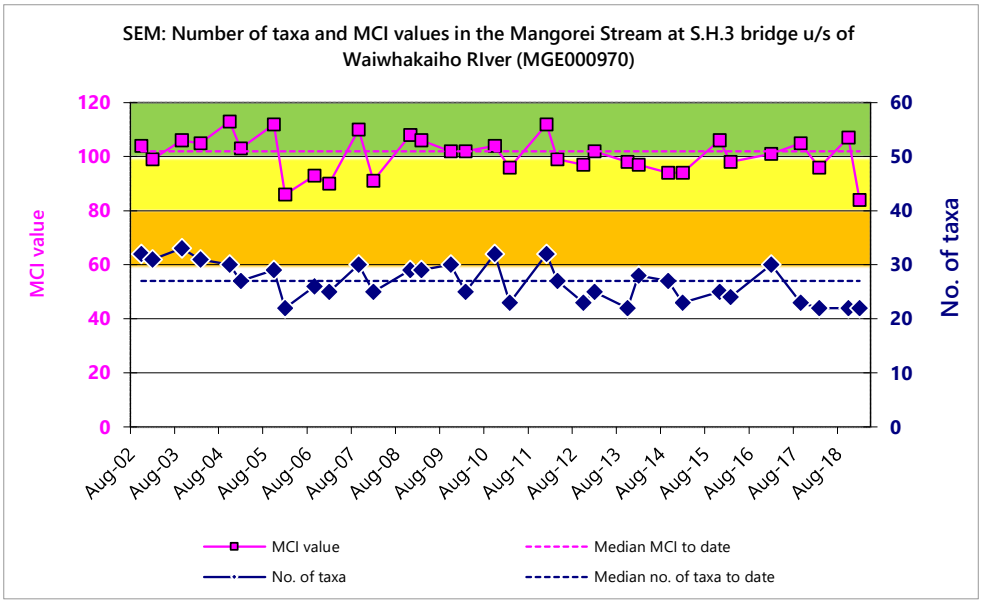


Figure 58 Numbers of taxa and MCI values in the Mangorei Stream at SH3

A moderate range of richness (22 to 33 taxa) has been found with a relatively high median richness of 27 taxa which was more representative of typical richness in upper and middle reaches of ringplain streams and rivers. During the current period, spring (22 taxa) and summer (22 taxa) richness was lower than the historical median richness and were the equal lowest recorded taxa richness to date.

MCI values have had a relatively wide range (27 units) at this site, typical of a site in the lower reaches of a ringplain stream. However, the median value (102 units) has been more typical of mid-reach sites elsewhere on the ringplain. The spring (107 units) score was similar to the historic median but the summer score (84 units) was significantly lower than both the spring score and historic median and was the lowest score recorded to date for this site. The scores categorised this site as having 'good' (spring) and 'fair' (summer)

health generically (Table 3). The historical median score (102 units) placed this site in the 'good' health category.

3.2.2.1.2 Predicted stream 'health

The Mangorei Stream site at SH3 is 15.6 km downstream of the National Park boundary at an altitude of 90 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict MCI values of 101 for this site. The historical site median and spring score were not significantly different to the distance predictive value but the summer score was significantly lower.

The REC predicted MCI value (Leathwick, et al. 2009) was 101 units. The historical site median and spring score were not significantly different to the REC predictive value but the summer score was significantly lower.

3.2.2.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 59). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all the SEM results (2002-2019) and the most recent ten-years of results (2009-2019) from the site in the Mangorei Stream at SH3.

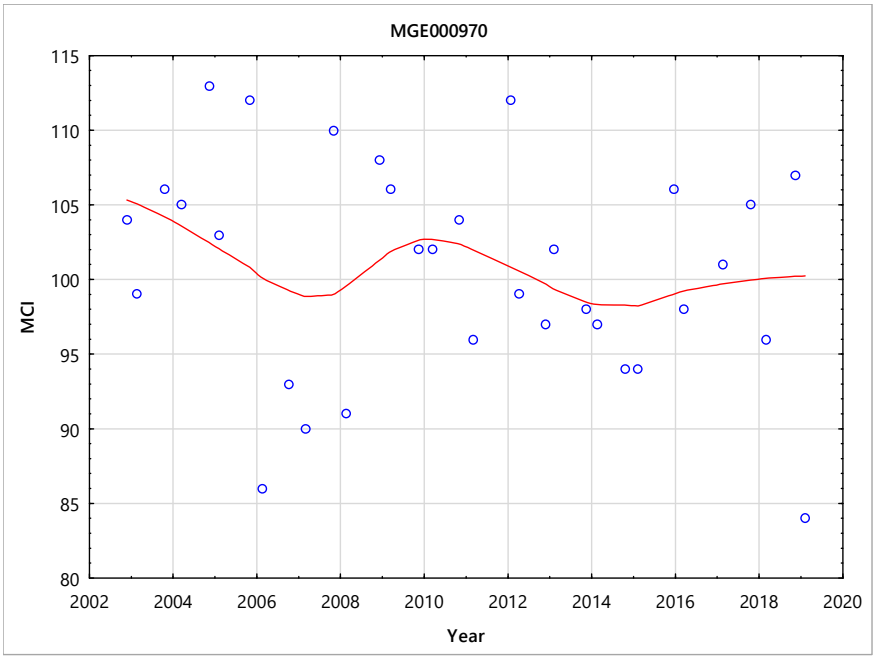


Figure 59 LOWESS trend plot of MCI data at the SH3 site, Mangorei Stream for the full dataset with Mann-Kendall test for the full and ten-year dataset

The slightly negative decline over the 16-year period has not been statistically significant at this site. The trendline range of scores (7 units) has been indicative of marginal ecological importance. During the monitoring period, the trendline has alternated between 'fair' and 'good' generic stream health.

There was also a non-significant negative trend in MCI scores over the most recent ten-year period, congruent with the full dataset. The trendline for the most recent ten-year period has alternated between 'fair' and 'good' generic stream health.

3.2.2.2 Discussion

The Mangorei Stream had moderate taxa richness but both spring and summer results were the equal lowest recorded at the site. MCI scores were widely divergent between spring and summer with the summer result significantly lower than what was typically found for the site and was a new record low for the site. These results suggest a likely deterioration in either habitat and/or water quality at the site.

The time trend analysis showed a negative, but non-significant trend for both the full and ten-year datasets. This indicates that there has been little change in macroinvertebrate health.

3.2.3 Patea River

The Patea River is a large, ringplain river that originates within Egmont National Park and flows in a south-easterly direction. Three SEM sites are located in the upper and middle reaches of the river.

3.2.3.1 Barclay Road site (PAT000200)

3.2.3.1.1 Taxa richness and MCI

Forty-six surveys have been undertaken at this upper reach, shaded site adjacent to the National Park boundary in the Patea River between October 1995 and April 2018. These results are summarised in Table 34, together with the results from the current period, and illustrated in Figure 60.

Table 34 Results of previous surveys performed in the Patea River at Barclay Road, together with 2018-2019 results

Site code	SEM data (1995 to April 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		March 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
PAT000200	46	23-35	30	127-150	138	25	135	23	148

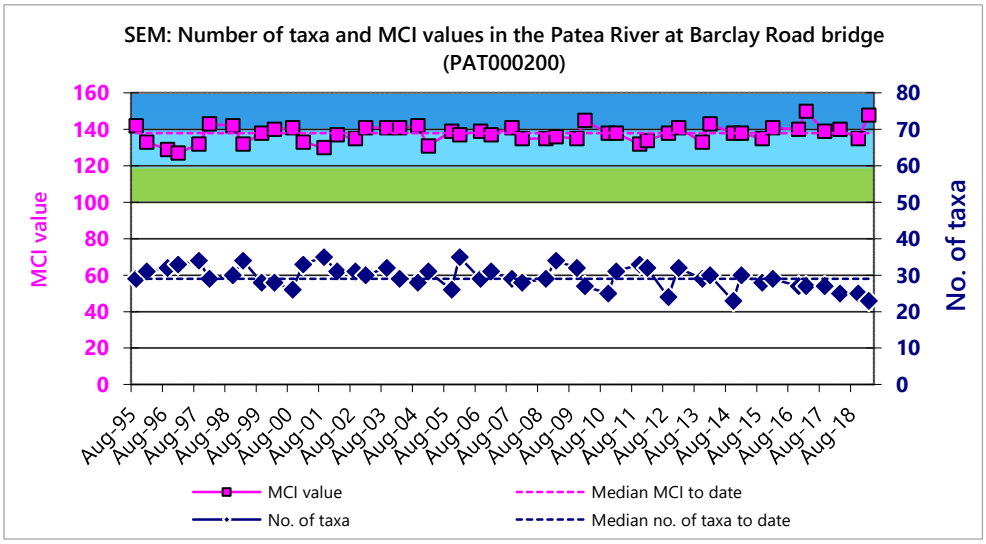


Figure 60 Numbers of taxa and MCI values in the Patea River at Barclay Road

A moderate range of richness (23 to 35 taxa) has been found with a relatively high median richness of 30 taxa, typical of richness in ringplain streams and rivers near the National Park boundary. During the current period spring (25 taxa) and summer (23 taxa) richness were lower than the historical median.

MCI values have had a moderate range (23 units) at this site, typical of a National Park boundary site. The high median value (138 units) has been typical of upper reach sites elsewhere on the ringplain. The spring

(135 units) and summer (148 units) scores were not significantly different to the historic median and categorised this site as having 'very good' (spring) and 'excellent' (summer) health generically. (Table 3). The historical median score (138 units) placed this site in the 'very good' category for generic health.

3.2.3.1.2 Predicted stream 'health'

The Patea River site at Barclay Road is 1.9 km downstream of the National Park boundary at an altitude of 500 m asl. Some bush cover extends from the National Park adjacent to most of the reach upstream of this site which is situated in farmland. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value 125 distance for this site. The historical site median (138 units) and summer score were significantly higher than the distance predictive value while the spring score was not significantly different.

The REC predicted MCI value (Leathwick, et al. 2009) was 129 units. The historical median and spring score were not significantly different to this value while the summer score was significantly higher.

3.2.3.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 90). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Patea River at Barclay Road.

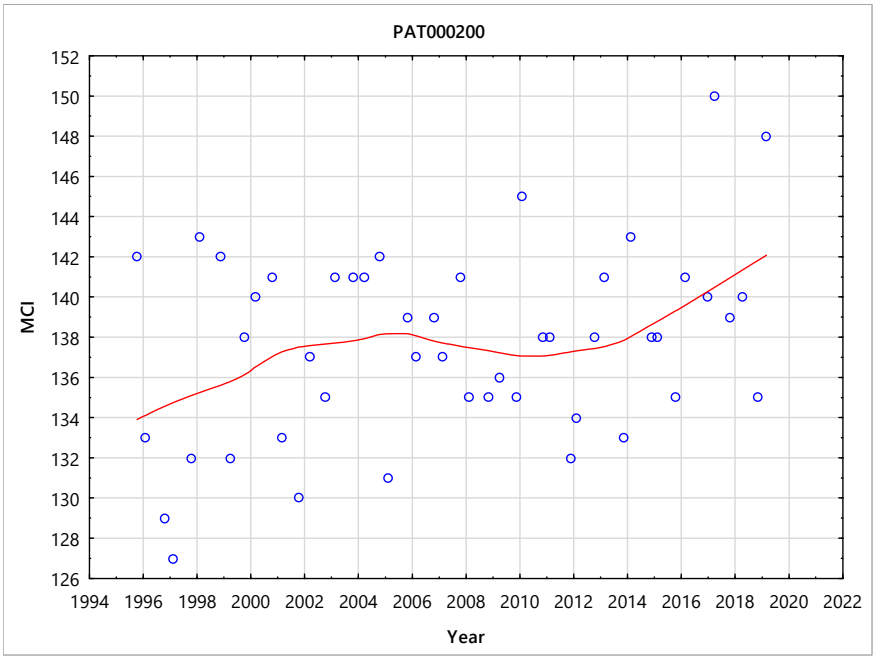


Figure 61 LOWESS trend plot of MCI data at the Barclay Road site, Patea River for the full dataset with Mann-Kendall test for the full and ten-year dataset

No statistically significant temporal trend in MCI scores has been found at this upper catchment site over the full monitoring period during which there has been an overall trend of slight improvement. The trendline range (8 units) did show minor ecological importance. The trendline has indicated 'very good' generic river health until 2017 when it improved to 'excellent' (Table 3) at this relatively pristine site just outside the National Park boundary. Interestingly, physiochemical data has been collected at this site, which shows significantly improving total nitrogen, and nitrate, suggesting water quality in the past has been impacted by farming.

The ten-year trend also showed a non-significant improving trend consistent with the trend for the full period.

3.2.3.2 Swansea Road site (PAT000315)

3.2.3.2.1 Taxa richness and MCI

Forty-six surveys have been undertaken in the Patea River at this mid-reach site at Swansea Road, Stratford between October 1995 and April 2018. These results are summarised in Table 35, together with the results from the current period, and illustrated in Figure 62.

Table 35 Results of previous surveys performed in the Patea River at Swansea Road, together with 2018-2019 results

Site code	SEM data (1995 to April 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		March 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
PAT000315	46	20-32	26	99-130	111	25	110	26	113

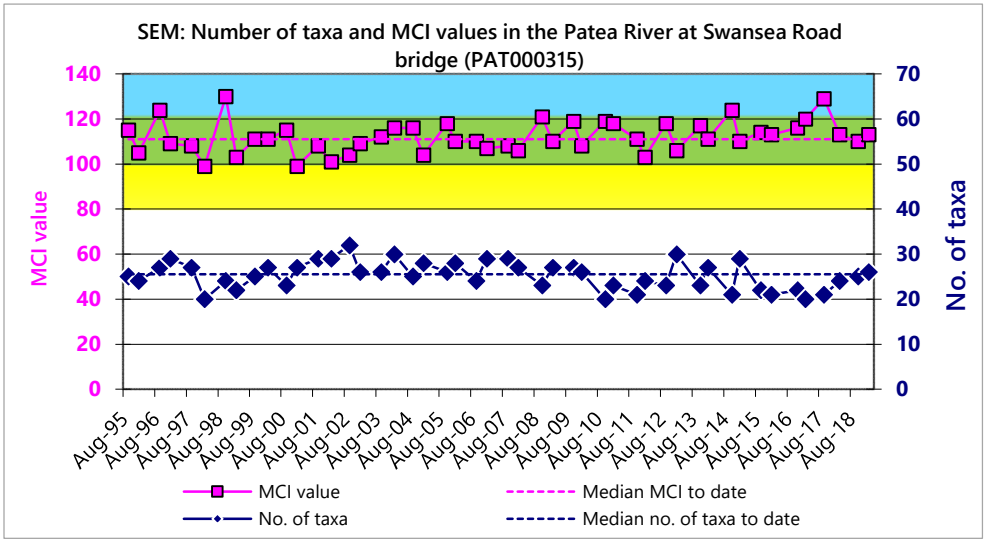


Figure 62 Numbers of taxa and MCI values in the Patea River at Swansea Road

A moderate range of richness (20 to 32 taxa) has been found, with a median richness of 26 taxa, typical of richness in the mid reaches of ringplain streams and rivers. During the current period, spring (25 taxa) and summer (26 taxa) richness were very similar to the median taxa number.

MCI values have had a relatively wide range (31 units) at this site, more so than typical of many sites in the mid reaches of ringplain rivers. The median value (111 units) has been relatively typical of scores in mid-reach sites elsewhere on the ringplain. The spring (110 units) and summer (113 units) scores were very similar to each other and to the historical median. These scores categorised this site as having 'good' (spring and summer) health generically (Table 3). The historical median score (111 units) placed this site in the 'good' category for generic health.

3.2.3.2.2 Predicted stream 'health'

The Patea River site at Swansea Road, Stratford is 12.4 km downstream of the National Park boundary at an altitude of 300 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict MCI values of 103 units for this site. The historical

site median, spring summer scores were not significantly different to the distance predictive value (Stark, 1998).

The REC predicted MCI value (Leathwick, et al. 2009) was 112 units. The historical site median, spring and summer scores were not significantly different to the REC predictive value (Stark, 1998).

3.2.3.2.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 63). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all of the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Patea River at Swansea Road.

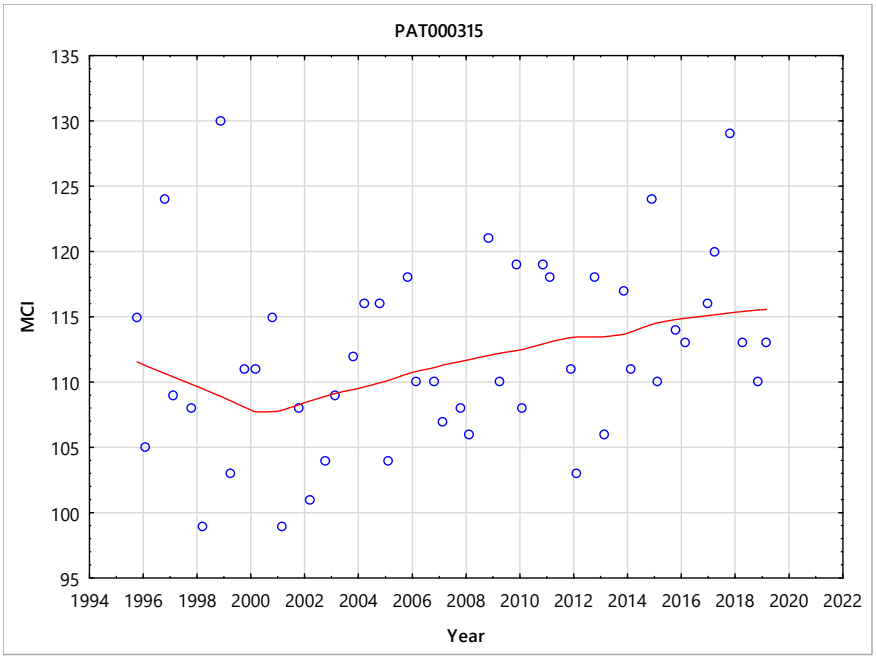


Figure 63 LOWESS trend plot of MCI data at the Swansea Road site, Patea River for the full dataset with Mann-Kendall test for the full and ten-year dataset

The small positive temporal trend in MCI scores was not statistically significant over the full monitoring period after FDR was applied to the p value (FDR p =0.05). The trendline range of scores (8 units) was of minor ecological importance. The trendline range of scores consistently indicated 'good' generic river health (Table 3) throughout the monitoring period.

The ten-year period had no statistical significant trend indicating that there was very little change in the last ten years at the site.

3.2.3.3 Skinner Road site (PAT000360)

3.2.3.3.1 Taxa richness and MCI

Forty-six surveys have been undertaken in the Patea River at this mid-reach site at Skinner Road (some 6 km downstream of the Swansea Road, Stratford site), between October 1995 and April 2018. These results are summarised in Table 36, together with the results from the current period, and illustrated in Figure 64.

Table 36 Results of previous surveys performed in the Patea River at Skinner Road, together with 2018-2019 results

Site code	SEM data (1995 to April 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		March 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
PAT000360	46	15-33	23	86-112	98	19	98	21	90

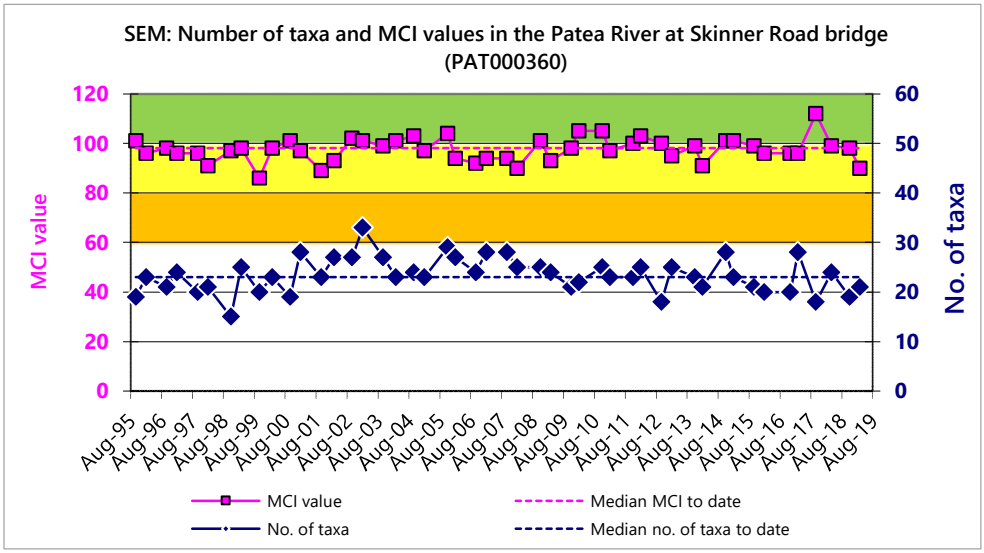


Figure 64 Numbers of taxa and MCI values in the Patea River at Skinner Road

A wide range of richness (15 to 33 taxa) has been found with a median richness of 23 taxa (more representative of typical richness in the mid-reaches of ringplain streams and rivers). During the current period spring (19 taxa) and summer (21 taxa) richness were slightly lower than the historical median.

MCI values have had a moderately large range (26 units) at this site, typical of sites in the mid-reaches of ringplain streams and rivers. The median value (98 units) has been relatively typical of the scores at mid-reach sites elsewhere on the ringplain. The spring (98 units) was the same as the historical median and while the summer score (90 units) was not significantly lower than the historic median and spring score. They categorised this site as having 'fair' health (spring and summer) generically (Table 3). The historical median score (98 units) placed this site in the 'fair' category for generic health.

3.2.3.3.2 Predicted stream 'health'

The Patea River site at Skinner Road is 19.2 km downstream of the National Park boundary at an altitude of 240 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict MCI values of 99 for this site. The historical site median, spring and summer scores were not significantly different to this value (Stark, 1998). The REC predicted MCI value (Leathwick, et al. 2009) was 109 units. The historical, spring and summer scores were all significantly lower than the REC predictive value.

3.2.3.3.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 65). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Patea River at Skinner Road.

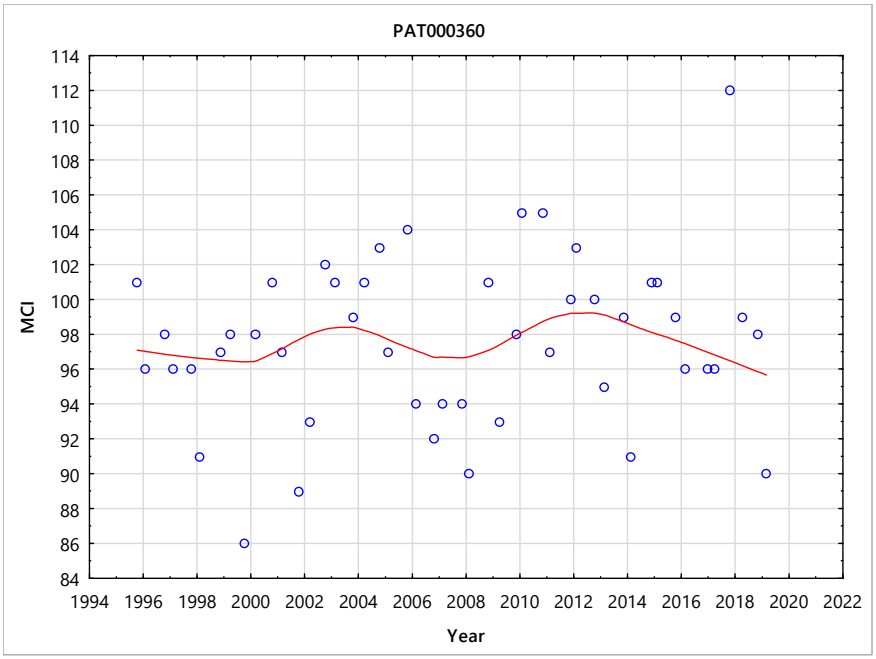


Figure 65 LOWESS trend plot of MCI data at the Skinner Road site, Patea River for the full dataset with Mann-Kendall test for the full and ten-year dataset

The small positive temporal trend in MCI scores over the entire monitoring period has not been statistically significant. An apparent decline in scores between 2004 and 2008 has been followed by some improvement followed by a more recent decline in scores again. The very small range exhibited by the trendline (3 units) has been of no ecological importance over the period. The trendline consistently indicated 'fair' generic river health (Table 3).

In contrast to the full dataset, the ten-year trend shows a declining trend. However, this was neither ecologically important or statistically significant.

3.2.3.4 Discussion

The Patea River at the SEM sites was found to have moderate to moderately high taxa richness which was consistent with the results from past surveys.

The upper site had 'very good' and 'excellent' macroinvertebrate community health in spring and summer respectively. The middle site had generally 'good' health while the lower site was in the poorest condition with only 'fair' health.

Overall, MCI scores fell in a downstream direction between the upper site and the furthest downstream site by 37 units in spring and 58 units in summer, over a river distance of 17.3 km indicating a significant deterioration in macroinvertebrate community health between the upper and lower site. This was consistent with previous surveys with a median decrease of 40 units recorded over all surveys.

The time trend analysis showed no significant changes at any of the sites, though the middle site was close to showing a statistically significant improvement. Overall, the time trend analysis indicated that macroinvertebrate community health had not been significantly improving or deteriorating at sites in the upper/middle Patea River since monitoring began. Lack of improvement for the upper site was probably due to it already being in great condition; while the lower site has consistency had discharges from the Stratford WWTP during the monitoring period which has likely mitigated other effects in the catchment.

3.2.4 Punehu Stream

The Punehu Stream is a ringplain stream whose source is located within Egmont National Park and flows in a southerly direction with its mouth located east of the town of Opunake. There are two SEM sites, one located in its upper middle reaches and the other located in its lower reaches.

3.2.4.1 Wiremu Road site (PNH000200)

3.2.4.1.1 Taxa richness and MCI

Forty-six surveys have been undertaken in the Punehu Stream between October 1995 and February 2018 at this open, upper mid-reach site in farmland, 4 km downstream of the National Park These results are summarised in Table 37 together with the results from the current period, and illustrated in Figure 66.

Table 37 Results of previous surveys performed in the Punehu Stream at Wiremu Road together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		March 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
PNH000200	46	18-32	27	104-137	124	20	135	21	122

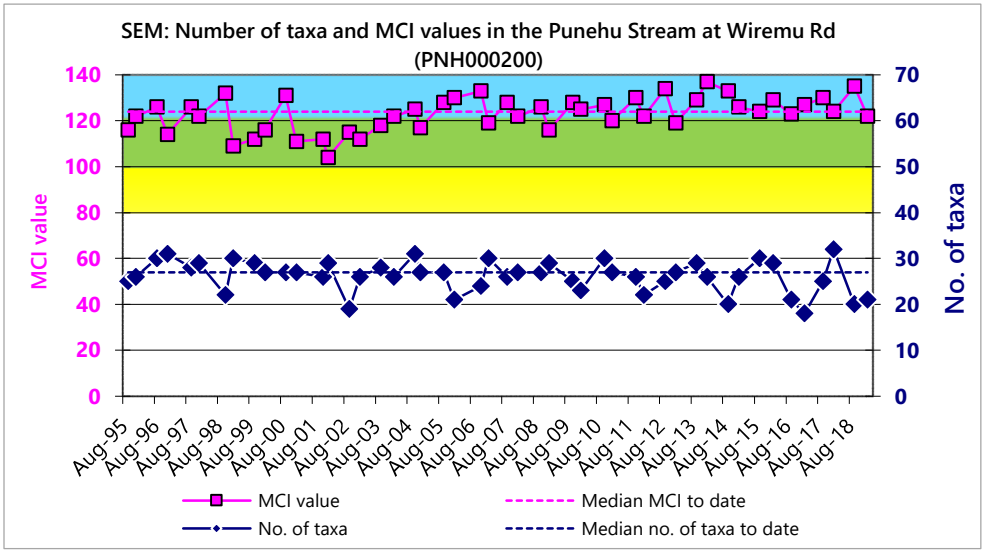


Figure 66 Numbers of taxa and MCI values in the Punehu Stream at Wiremu Road

A moderate range of richness (18 to 32 taxa) has been found at this site with a median richness of 27 taxa. During the current period, spring (20 taxa) and summer (21 taxa) richness were moderate and lower than the historic median richness.

MCI values have had a moderate range (33 units) at this site, typical of a site in the (upper) mid reaches of a ringplain stream in more open farmland. The median value (124 units) has been typical of mid reach sites elsewhere on the ringplain. The spring score (135 units) was significantly higher than the historic median while summer score (122 units) was not significantly different to the historical median but significantly lower than the spring score (Stark, 1998). These scores categorised this site as having 'very good' generic health (Table 3) in spring and summer. The historical median score (124 units) placed this site in the 'very good' category for the generic health.

3.2.4.1.2 Predicted stream 'health'

The Punehu Stream site at Wiremu Road is 4.4 km downstream of the National Park boundary at an altitude of 270 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 115 for this site. The historical site median and summer score were not significantly different to the distance predictive value while the spring score was significantly higher (Stark, 1998). The REC predicted MCI value (Leathwick, et al. 2009) was 121 units. Again, the historical site median and summer score were not significantly different to the predictive value while the spring score was significantly higher (Stark, 1998)

3.2.4.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 67). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Punehu Stream at Wiremu Road.

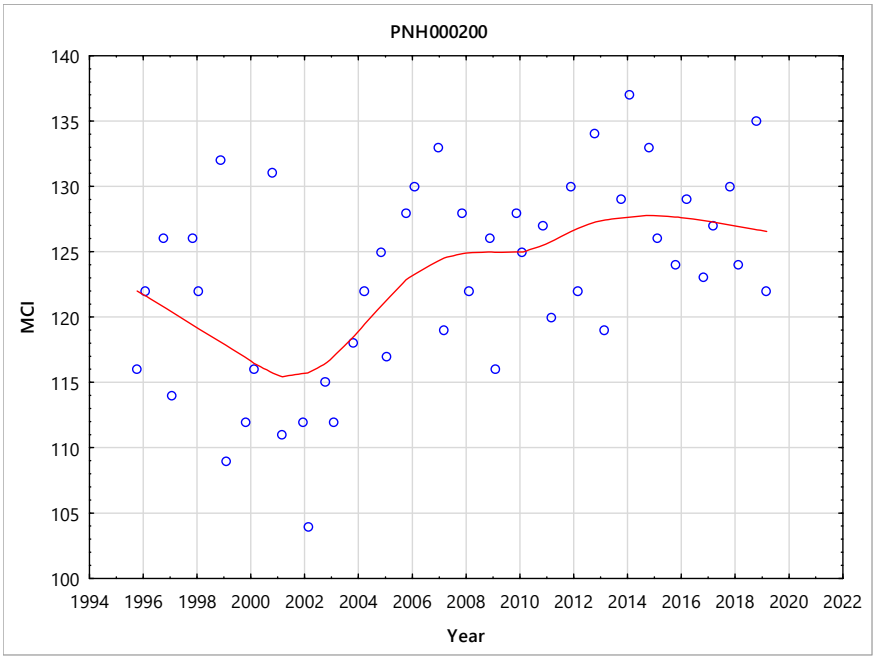


Figure 67 LOWESS trend plot of MCI data at the Wiremu Road site, Punehu Stream

A steady increase in MCI scores had been apparent between 2002 and 2007, and again since 2010, resulting in the positive trend in scores over the entire period which has been statistically highly significant (FDR p < 0.01 level). The trendline range (13 units) has been of ecological importance, particularly since 2002 (coincident with localised riparian fencing and planting of the true left-bank of the stream). Overall, the trendline range was indicative of 'very good' generic stream health (Table 3) apart from a short period of 'good' health from 1997 to 2005.

The ten-year trend showed a slight positive trend, however unlike the trend for the full dataset this was of no statistical or ecological significance.

3.2.4.2 SH 45 site (PNH000900)

3.2.4.2.1 Taxa richness and MCI

Forty-six surveys have been undertaken at this lower reach site at SH 45 in the Punehu Stream between October 1995 and February 2018. These results are summarised in Table 38, together with the results from the current period, and illustrated in Figure 68.

Table 38 Results of previous surveys performed in the Punehu Stream at SH 45 together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		March 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
PNH000900	46	10-26	21	70-114	90	22	98	18	88

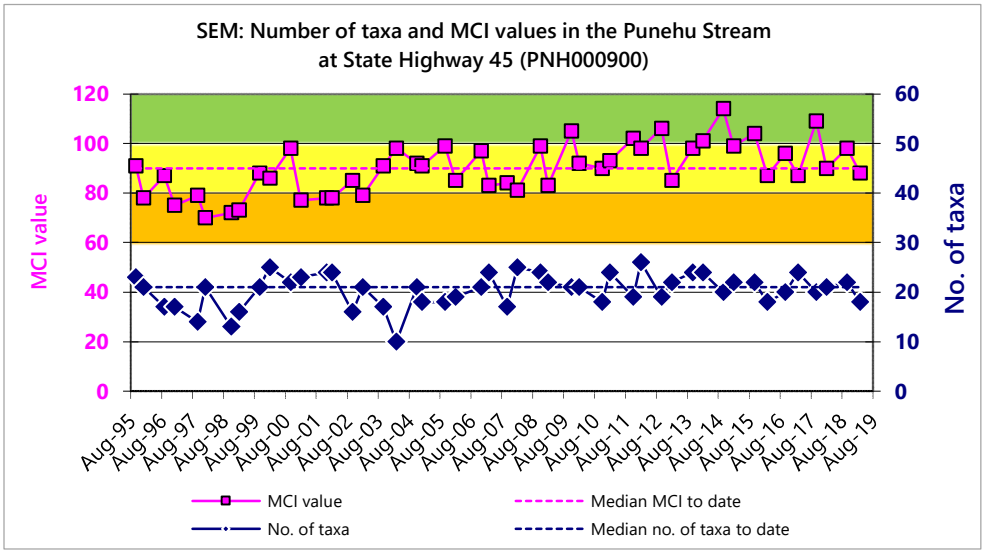


Figure 68 Numbers of taxa and MCI values in the Punehu Stream at SH 45

A wide of richness (10 to 26 taxa) has been found with a median richness of 21 taxa, relatively typical of richness in the lower reaches of ringplain streams and rivers. During the current period, spring (22 taxa) and summer (18 taxa) richness were moderate and similar to the historical median.

MCI scores have had a relatively wide range (44 units) at this site, typical of sites in the lower reaches of ringplain streams. The median value (90 units) also has been relatively typical of lower reach sites elsewhere on the ringplain. The spring (98 units) and summer (88 units) scores were not significantly different to the historical median (Stark, 1998). These scores categorised this site as having 'fair' health in spring and summer (Table 3). The historical median score (90 units) placed this site in the 'fair' category for generic health.

3.2.4.2.2 Predicted stream 'health'

The Punehu Stream site at SH 45 is 20.9 km downstream of the National Park boundary at an altitude of 20 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict a MCI value of 98 for this site. The historical site median, spring and summer score were not significantly different to the distance predictive value (Stark, 1998). The REC predicted MCI value (Leathwick, et al. 2009) was 100 units. The historical site median and spring score were not significantly different to this value while the summer score was significantly lower (Stark, 1998).

3.2.4.2.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 102). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on all the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Punehu Stream at SH 45.

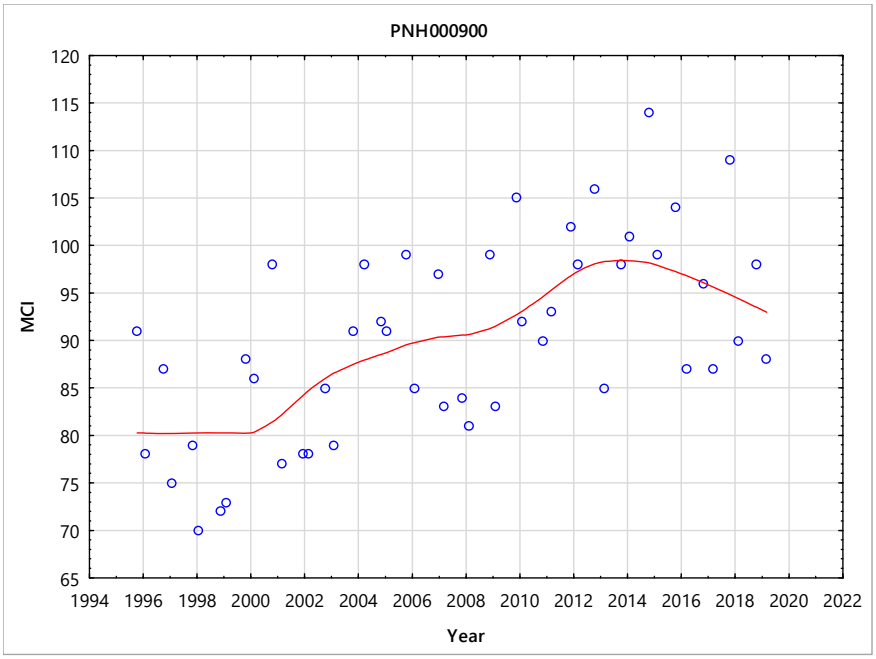


Figure 69 LOWESS trend plot of MCI data at the SH 45 site, Punehu Stream for the full dataset with Mann-Kendall test for the full and ten-year dataset

This site had a strong positive trend over the entire monitoring period, which was statistically significant ($p < 0.01$) after FDR application. The trendline range of scores (18 units) has been ecologically important over this period with scores mainly indicative of 'fair' generic stream health (Table 3).

In contrast to the full dataset, the ten-year trend was negative but this was not ecological or statistical significant.

3.2.4.3 Discussion

The Punehu Stream at the SEM sites was found to have moderate taxa richness which was consistent with the results from past surveys. The upper mid-reach (Wiremu Road) site had 'very good' macroinvertebrate community health while the lower reach (SH 45) site had 'fair' macroinvertebrate community health.

MCI scores typically significantly fell in a downstream direction by 34 units, over a stream distance of 16.5 km through the (upper) mid to lower reaches of this stream. Issues have occurred on occasions with consented dairy shed discharge compliance and cumulative impacts of such discharges in the Mangatawa Stream sub-catchment in the local vicinity of the lower site (TRC, 2011 and Fowles, 2014). Changes in macroinvertebrate community structure at the lower site, especially when compared with the upper mid-reach site, reflect ongoing issues with nutrient enrichment.

The time trend analysis showed significant positive trends for both sites for the full dataset indicating that over time macroinvertebrate community health has been significantly improving at both sites. However, while the ten-year trend for the upper site was positive, but non-significant, the lower site had a negative non-significant trend. Further declines in macroinvertebrate health at the lower site would indicate that

previous improvements made in the lower catchment have been eroded with agricultural impacts the likely cause of any decline.

3.2.5 Tangahoe River

The Tangahoe River is an eastern hill country river flowing in a southerly direction with a river mouth located east of Hawera. Three sites were included in the SEM programme in 2007 for the purpose of monitoring long-term land use changes (afforestation) particularly in the upper-mid catchment. The Fonterra, Hawera dairy factory abstracts water from the river in the lower catchment for processing purposes. Two of the three sites are in the upper to mid, shallow gradient, reaches of the river (the upstream site within 4 km of the headwaters) with the third site in the lower reaches, some 4 km from the coast.

3.2.5.1 Upper Tangahoe Valley Road site (TNH000090)

3.2.5.1.1 Taxa richness and MCI

Twenty-two surveys have been undertaken at this upper reach site in the Tangahoe River between December 2007 and February 2018. These results are summarised in Table 39, together with the results from the current period, and illustrated in Figure 70.

Table 39 Results of previous surveys performed in the Tangahoe River at upper Tangahoe Valley Road, together with 2018-2019 results

Site code	SEM data (2007 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		March 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
TNH000090	22	14-31	23	90-107	100	15	96	29	93

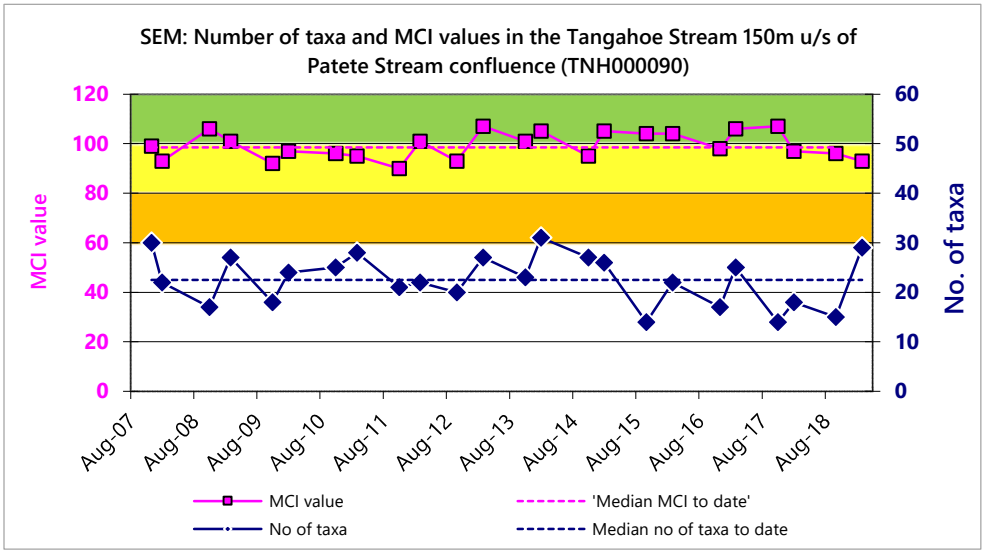


Figure 70 Numbers of taxa and MCI values in the Tangahoe River at Upper Tangahoe Valley Road

A relatively wide range of richness (14 to 31 taxa) has been found with a moderate median richness of 23 taxa. During the current period, spring (15 taxa) and summer (29 taxa) taxa richness differed substantially from the median and from each other.

MCI values have had a relatively narrow range (17 units) at this site, typical of scores at sites toward the upper reaches of streams and rivers. The spring (96) units) and summer (93 units) scores were not

significantly different to the historical median score, although the summer MCI score was towards the lower end of the recorded range. These scores categorised this site as having 'fair' (spring and summer) health generically (Table 3). The historical median score (100 units) placed this site in the 'good' category for the generic method of assessment.

3.2.5.1.2 Predicted stream 'health'

The Tangahoe River site at upper Tangahoe Valley Road, at an altitude of 85 m asl, is toward the upper reaches of this low gradient river draining an eastern hill country catchment. The REC predicted MCI value (Leathwick, et al. 2009) was 110 units and therefore the historical median was not significantly different but the spring and summer scores were significantly lower than the predictive value.

3.2.5.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) was produced (Figure 71). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was performed on the full SEM results (2007-2019) and the most recent ten-years of results (2009-2019) from the site in the Tangahoe River at upper Tangahoe Valley Road.

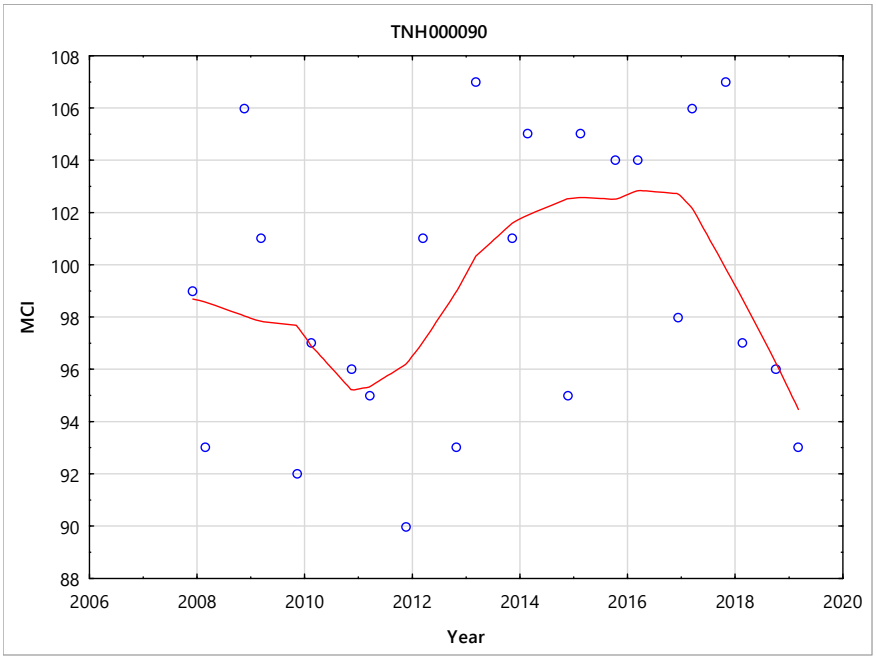


Figure 71 LOWESS trend plot of MCI data in the Tangahoe River for the upper Tangahoe Valley site for the full dataset with Mann-Kendall test for full and ten-year dataset

There was a small, positive, but non-significant trend for this hill country catchment site toward the upper reaches. The trendline range (8 units) was of limited ecological importance to date. The trendline range indicated 'fair' health from 2007-2013 before improving to 'good' health from 2014 to 2017, and decreasing to 'fair' health in recent years coincident with forestry operations in the catchment taking place in 2017.

There was a non-significant positive trend in MCI scores over the most recent ten-year period, congruent with the only slightly larger full dataset. The trendline range indicated 'fair' health from 2009-2013 before improving to 'good' health from 2014 to 2017, and decreasing to 'fair' health in recent years.

3.2.5.2 Tangahoe Valley Road bridge site (TNH000200)

3.2.5.2.1 Taxa richness and MCI

Twenty-two surveys have been undertaken at this mid reach site in the Tangahoe River between December 2007 and February 2018. These results are summarised in Table 40, together with the results from the current period, and illustrated in Figure 72.

Table 40 Results of previous surveys performed in the Tangahoe River at Tangahoe Valley Road Bridge, together with 2018-2019 results

Site code	SEM data (2007 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		March 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
TNH000200	22	17-35	25	92-111	103	26	101	29	99

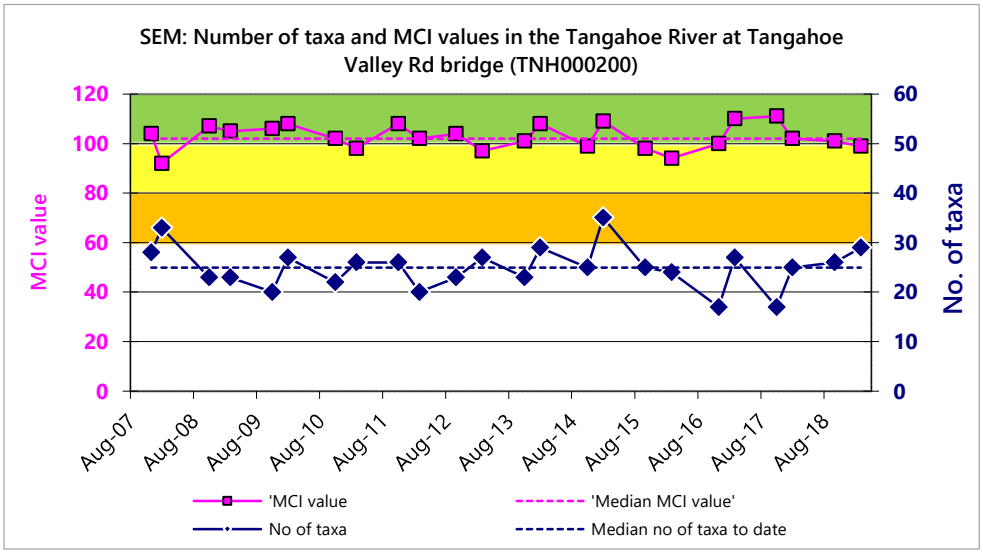


Figure 72 Numbers of taxa and MCI values in the Tangahoe River at Tangahoe Valley Road Bridge

A moderate range of richness (17 to 33 taxa) has been found with a relatively good median richness of 25 taxa (typical of richness in the mid-reaches of hill country rivers). During the current period, spring richness (26 taxa) and summer richness (29 taxa) were similar to the historical median.

MCI values have had a moderate range (19 units) at this site, typical of a site in the mid-reaches of hill country streams and rivers. The spring (101 units) and summer (99 units) scores were not significantly different to the historical median (103 units). These scores categorised this site as having 'good' (spring) and 'fair' (summer) health generically (Table 3). The historical median score (103 units) placed this site in the 'good' category for the generic assessment of health.

3.2.5.2.2 Predicted stream 'health'

The Tangahoe River site at Tangahoe Valley Road Bridge, at an altitude of 65 m asl, is in the mid reaches of a river draining a hill country catchment. The REC predicted MCI value (Leathwick, et al. 2009) was 108 units. The historical, spring and summer scores were not significantly different to this predictive value either (Stark, 1998).

3.2.5.2.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) was produced (Figure 73). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was performed on the full SEM results (2007-2019) and the most recent ten-years of results (2009-2019) from the site in the Tangahoe River at the Tangahoe Valley Road Bridge.

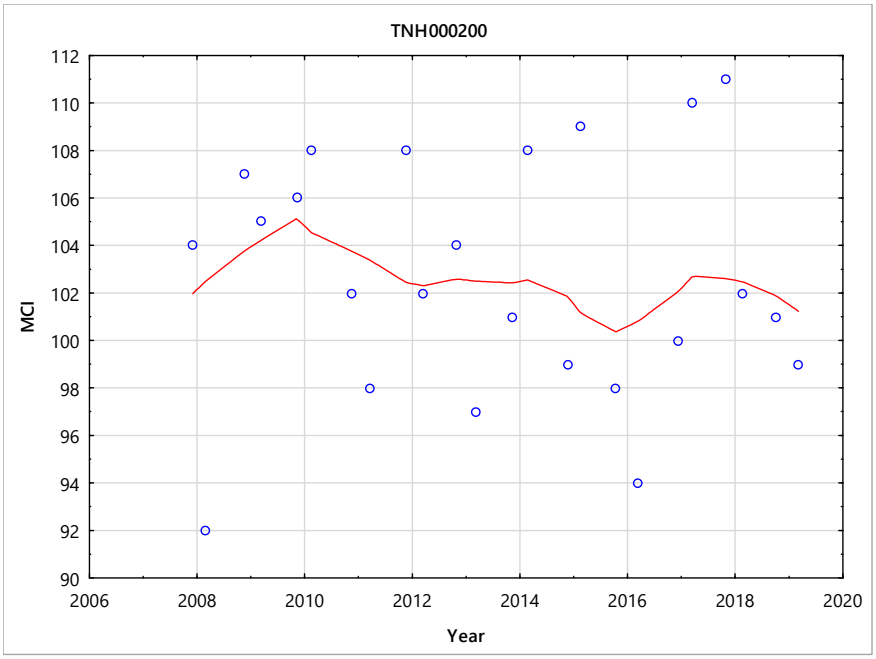


Figure 73 LOWESS trend plot of MCI data in the Tangahoe River for the Tangahoe Valley Road bridge site for the full dataset with Mann-Kendall test for the full and ten-year dataset

There was a very small, negative, non-significant trend for this mid river reach, hill country catchment site. The trendline range (5 units) over the period has been of limited ecological importance. The trendline range has indicated 'good' generic river health.

There was also a very small, negative, non-significant trend in MCI scores over the most recent ten-year period, congruent to the full dataset. The trendline for the most recent ten-year period was indicative of 'good' health.

3.2.5.3 Site downstream of railbridge (TNH000515)

3.2.5.3.1 Taxa richness and MCI

Twenty-two surveys have been undertaken at this lower reach site in the Tangahoe River between December 2007 and February 2018. These results are summarised in Table 41, together with the results from the current period, and illustrated in Figure 74.

Table 41 Results of previous surveys performed in the Tangahoe River d/s of railbridge, together with 2018-2019 results

Site code	SEM data (2007 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		March 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
TNH000515	22	14-26	20	78-104	94	21	94	17	79

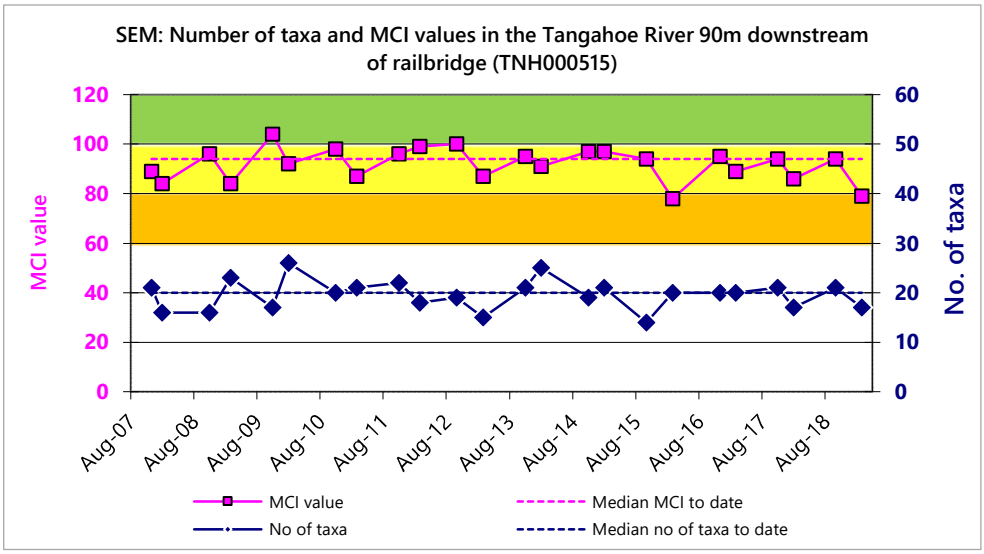


Figure 74 Numbers of taxa and MCI values in the Tangahoe River downstream of the railbridge

A moderate range of richness (14 to 26 taxa) have been found with a slightly higher than typical median richness of 20 taxa for a site in the lower reaches of a hill country river. During the current period, spring (21 taxa) and summer (17 taxa) richness were similar to the median richness.

MCI values also have had a moderate range (26 units) at this site, narrower than typical of sites in the lower reaches of hill country streams and rivers. The spring score (94 units) was very similar to the historical median while the summer (79 units) score was significantly lower and was only one unit higher than the lowest score recorded to date at the site. These scores categorised this site as having 'fair' health in spring and 'poor' health in summer (Table 3). The historical median score (94 units) placed this site in the 'fair' category for the generic health.

3.2.5.3.2 Predicted stream 'health'

The Tangahoe River site downstream of the railbridge, at an altitude of 15 m asl, is in the lower reaches of a river draining a hill country catchment. The REC predicted MCI value (Leathwick, et al. 2009) was 95 units and therefore the historical median and spring score were not significantly different to the predictive value but the summer score was significantly lower (Stark, 1998).

3.2.5.3.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) was produced (Figure 75). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was performed on the full SEM results (2007-2019) and the most recent ten-years of results (2009-2019) from the site in the Tangahoe River downstream of the railbridge.

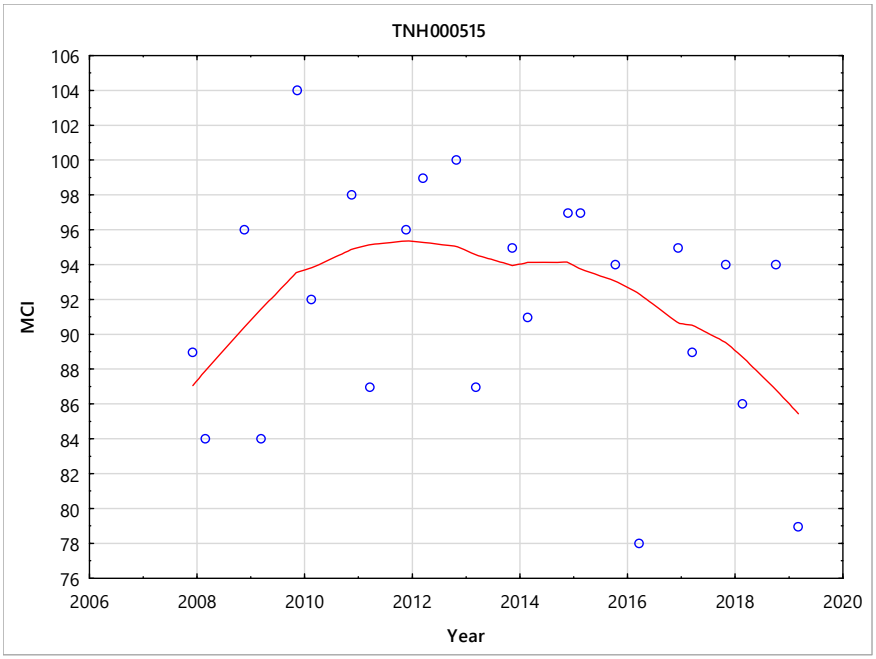


Figure 75 LOWESS trend plot of MCI data for the Tangahoe River site downstream of the railbridge for the full dataset with Mann-Kendall test for the full and ten-year dataset

There was a non-significant negative trend for this lower river reach, hill country catchment site. The trendline range (10 units) has bordered on ecologically important but overall there has been no real overall change over the monitored period. However, the trendline indicates there has been changes over time, with improvement at the site followed by decline. The trendline range have indicated 'fair' generic river health over the period to date.

There was a non-significant negative trend in MCI scores over the most recent ten-year period, congruent with the full dataset, with a decline in the trendline from 2012 onwards, this trend was statistically significant before FDR. The trendline for the most recent ten-year period was indicative of 'fair' health.

3.2.5.4 Discussion

The Tangahoe River at the SEM sites was found to have moderate to moderately low taxa richness. The upper site had lower than usual taxa richness for spring, probably due to a logging operation which may have reduced taxa richness. Both the middle and lowers sites had typical taxa richness.

The upper reach (upper Tangahoe Valley Road) site had 'fair' macroinvertebrate community health during spring and summer. The middle site at the Tangahoe Valley Road Bridge had 'good' to 'fair' macroinvertebrate community health with results slightly higher than the upper site which was a typical result. The lower reach site at the railbridge had 'fair' to 'poor' macroinvertebrate community health with the summer score quite low for the site.

MCI scores fell in a downstream direction in both spring (by two units) and in summer (by 14 units), over a distance of 30.2 km (and decrease in elevation of 70 m) though MCI scores actually improved from the upper to middle site. The improvement in macroinvertebrate health would be related to better quality habitat present at the middle site which has a riffle with a cobbles/ boulder substrate as opposed to the upper site with a clay dirt substrate. Using the long-term median SEM MCI scores for each site (Appendix II), there is normally an improvement in MCI scores between the upper reach (Upper Tangahoe Valley Road) and the mid-reach (Tangahoe Valley Road bridge) sites by six units. The decline between the mid-reach site and lower reach (railbridge) site has historically been nine units.

The time trend analyses showed no significant trends for any site indicating that macroinvertebrate health was not significantly improving or deteriorating though a relatively small time range of twelve years may be contributing to the lack of significance. However, the lower site for the most recent ten years was significant before FDR application, though after FDR the p-value was not that close to being $p < 0.05$. It was suggestive that if the site has low MCI scores in the future that the trend will become significant indicating deterioration at the site.

3.2.6 Timaru Stream

Timaru Stream is a ringplain stream arising within Egmont National Park and flows in a westerly direction. There are two SEM sites situated on the stream. In the 2008-2009 period severe headwater erosion events had impacted upon the macroinvertebrate communities of the upper reaches of this stream in particular (TRC, 2009).

3.2.6.1 Carrington Road site (TMR000150)

3.2.6.1.1 Taxa richness and MCI

Forty-five surveys have been undertaken at this upper reach site in the Timaru Stream inside the National Park boundary at Carrington Road between October 1995 and February 2018. These results are summarised in Table 42, together with the result from the current period, and illustrated in Figure 76.

Table 42 Results of previous surveys performed in the Timaru Stream at Carrington Road, together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
TMR000150	45	8-34	26	119-152	138	24	131	27	130

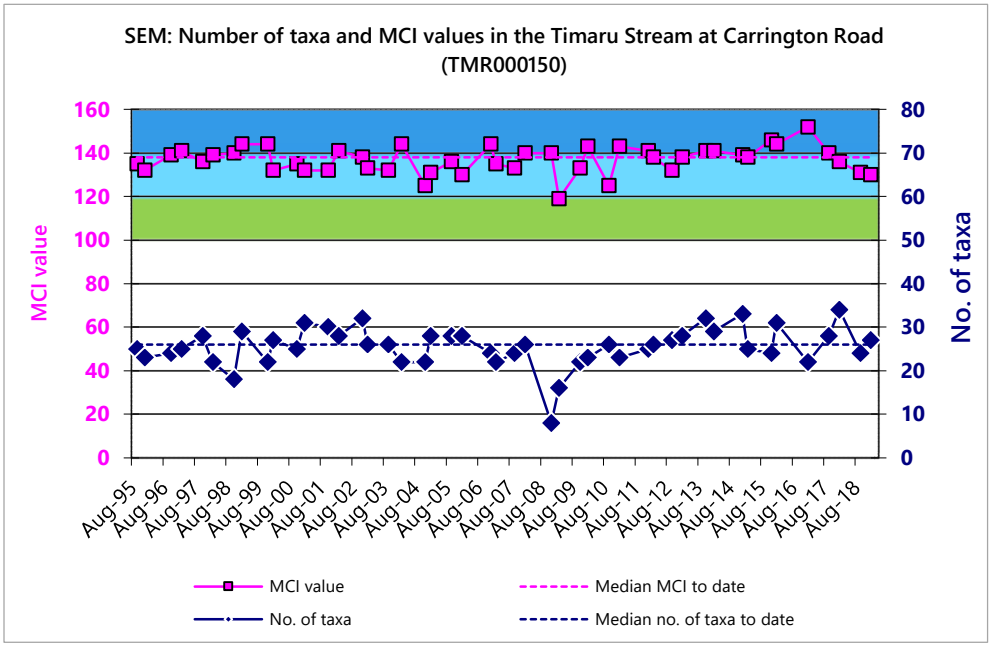


Figure 76 Numbers of taxa and MCI values in the Timaru Stream at Carrington Road

Taxa richness was typically moderately high for the site (median richness of 26 taxa) with only one low result in December 2008 (eight taxa) due to headwater erosion effects over the 2008-2009 period which

markedly reduced richness. The median richness was similar to the typical richness (28 taxa) in ringplain streams and rivers near the National Park boundary at similar altitudes. During the current period, spring (24 taxa) and summer (27 taxa) richness were both similar to the historical median.

MCI values have had a wider range (33 units) at this site than typical of a site near the National Park boundary due to the low value (119 units) after the 2008-2009 headwater erosion period. However, the median value (138 units) is slightly higher than typical upper reach sites elsewhere on the ringplain. The spring (131 units) and summer (130 units) scores were slightly lower but not significantly different from the historical median. The scores categorised this site as having 'very good' (spring and summer) health generically (Table 3). The historical median score (138 units) placed this site in the 'very good' category for the generic health.

3.2.6.1.2 Predicted stream 'health'

The Timaru Stream at Carrington Road is within the National Park boundary at an altitude of 420 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 132 for this site. The historical site median (138 units) and spring and summer scores were not significantly different to the predictive value (Stark, 1998). The REC predicted MCI value (Leathwick, et al. 2009) was 141 units. The historical site median and spring score were not significantly different to this value but the summer score was significantly lower at this pristine site.

3.2.6.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 77). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was performed on all the SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Timaru Stream at Carrington Road.

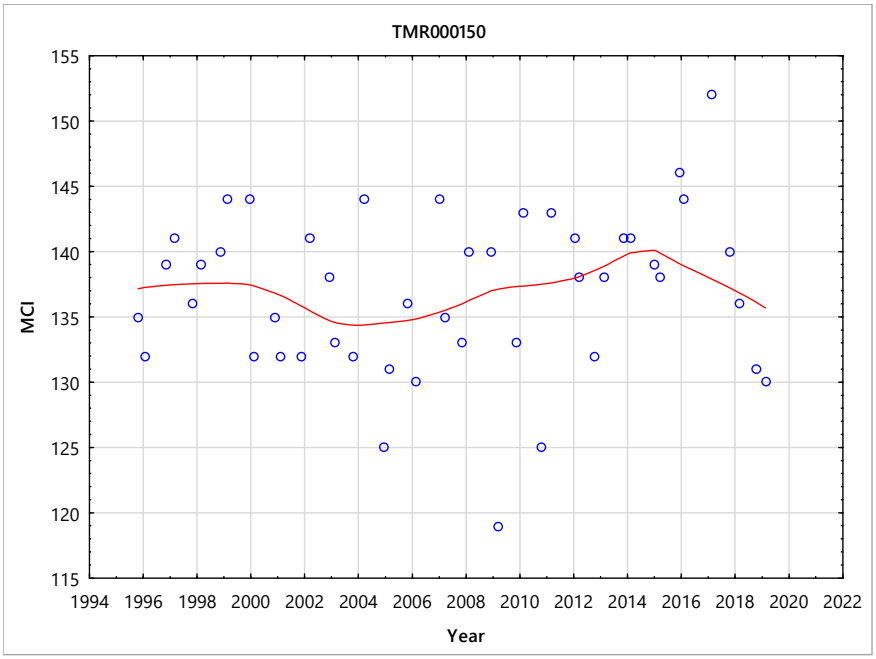


Figure 77 LOWESS trend plot of MCI data at the Carrington Road site for the full dataset with Mann-Kendall test for the full and ten-year dataset

There was a small, positive, non-significant trendover the full data set. The trendline had a range over six units which was not ecologically important. The trendline scores have been indicative of 'very good' generic stream health from the data available (Table 3).

The ten-year period also showed a minor negative trend of neither ecological or statistical significance.

3.2.6.2 SH45 site (TMR000375)

3.2.6.2.1 Taxa richness and MCI

Forty-five surveys have been undertaken in the Timaru Stream at this lower, mid-reach site at SH45 between October 1995 and February 2018. These results are summarised in Table 43, together with the results from the current period, and illustrated in Figure 78.

Table 43 Results of previous surveys performed in the Timaru Stream at SH45, together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2017		Feb 2018	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
TMR000375	45	13-35	27	89-120	103	25	110	22	88

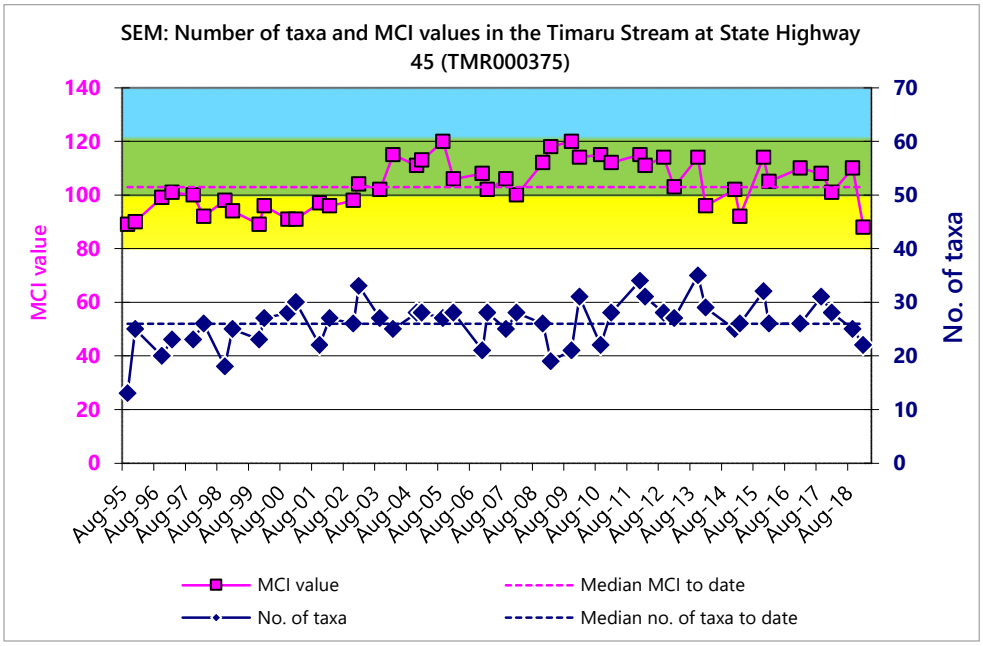


Figure 78 Numbers of taxa and MCI values in the Timaru Stream at State Highway 45

An unusually wide range of richness (13 to 35 taxa) has been found with a median richness of 27 taxa which was higher than typical richness in the mid reaches of ringplain streams and rivers. During the current period spring (25 taxa) and summer (22 taxa) richness were similar to the historical median.

MCI values have had a slightly wider range (31 units) at this site than typical of sites in the mid reaches of ringplain streams. The median value (103 units) was very similar to the median calculated from mid reach sites on the ringplain. The spring (110 units) were not significantly different to the historical median but the summer score (88 units) was significantly lower than both the historic median and spring score (Stark, 1998). The scores categorised this site as having 'good' health in spring and 'fair' health in summer (Table 3). The historical median score (103 units) placed this site in the 'good' category for the generic health.

3.2.6.2.2 Predicted stream 'health'

The Timaru Stream at SH45 is 10.9 km downstream of the National Park boundary at an altitude of 100 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park

boundary (Stark and Fowles, 2009), predict a MCI value of 105 for this site. The historical site median and spring score were not significantly different to the predictive value but the summer score was significantly lower. The REC predicted MCI value (Leathwick, et al. 2009) was 117 units. The historical site median and summer score were significantly lower than this value, while the spring score was not significantly different to this value.

3.2.6.2.3 Temporal trends in data

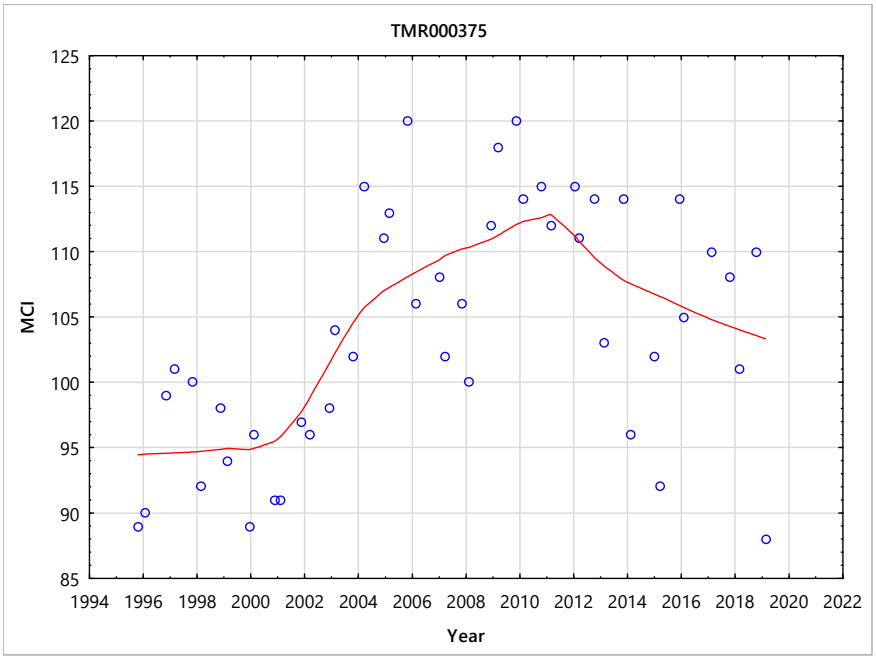


Figure 79 LOWESS trend plot of MCI data at the SH45 site for the full dataset with Mann-Kendall test for the full and ten-year dataset

The trendline had a highly significant improvement over time though since 2012 there has been a decrease in MCI scores. The trendline had a range of 18 units, an ecologically important range. The trendline indicated an improvement in generic stream 'health' (Table 3) from 'fair' to 'good'.

In contrast to the full dataset, the ten-year period showed a strong declining trend. This trend was statistically significant before FDR adjustment but not after FDR adjustment. If the present trend continues then it will likely become significant after FDR adjustment, indicating a significant decline at the site.

3.2.6.3 Discussion

The spring and summer surveys indicated that the upper site had 'very good' health while the lower site had 'good' to 'fair' health.

The MCI scores fell in a downstream direction by 21 units in spring and by 42 units in summer, over a stream distance of 10.9 km downstream from the National Park boundary. This was typical for Timaru Stream and was likely due to cumulative impacts throughout the middle catchment affecting the bottom site.

Time trend analysis indicated no change in macroinvertebrate community health over the full or ten-year dataset for the upper site, which was expected given that the site was unlikely to change as it was in a national park. The lower site showed a significant positive improvement over the full time period, which contrasted with the nearly significantly, negative, trend for the ten-year period. The site had mature riparian native vegetation and the site itself appears to have had minimal change over the entire monitoring period.

Therefore, improvements and declines in macroinvertebrate health at the site were likely due to changes in water quality, driven most likely by inputs from the agricultural dominated middle catchment.

3.2.7 Waiau Stream

The Waiau Stream is a small, lowland stream flowing in a northerly direction with a mouth situated east of Waitara. One SEM site is located in the mid reach of the stream.

3.2.7.1 Inland North site (WAI000110)

3.2.7.1.1 Taxa richness and MCI

Thirty-eight surveys have been undertaken in this mid-reach site in the Waiau Stream between February 1998 and February 2018. These results are summarised in Table 44, together with the results from the current period, and illustrated in Figure 80.

Table 44 Results of previous surveys performed in Waiau Stream at Inland North Road, together with the 2018-2019 results

Site code	SEM data (1998 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WAI000110	38	17-30	21	79-101	91	24	94	19	84

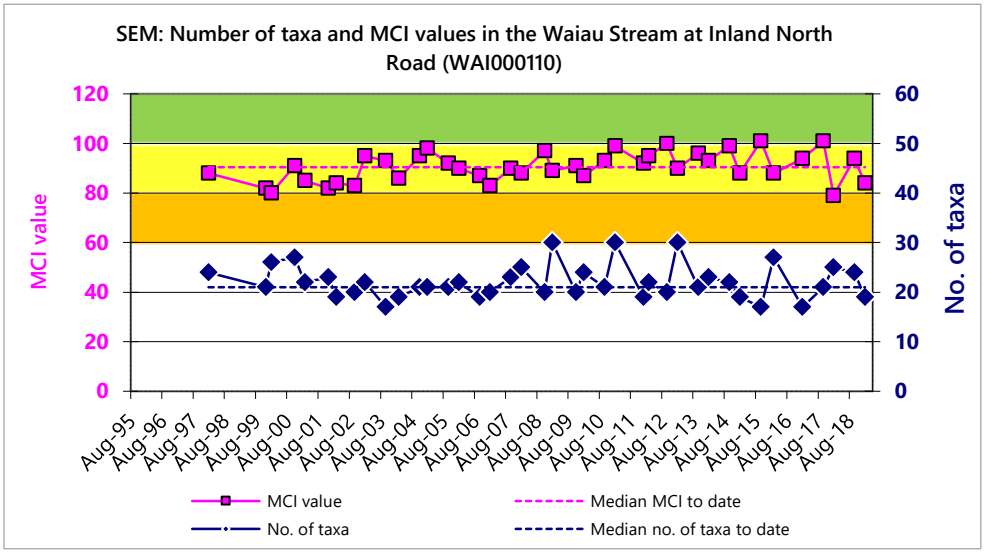


Figure 80 Numbers of taxa and MCI values in the Waiau Stream at the Inland North Road site

A moderate range of richness (17 to 30 taxa) has been found, with a median richness of 21 taxa, a typical richness in small lowland coastal streams. During the current period, the spring (24 taxa) and summer (19 taxa) richness were similar to the historic median richness.

MCI values have had a moderate range (22 units) to date at this site. The median value (91 units) is more typical of scores at sites in the lower reaches of small lowland streams and rivers. The spring (94 units) and summer (84 units) scores were not significantly different to the historic median and each other through the summer score was the second lowest score recorded at the site since 2007, the lowest being the previous summer score. The score categorised this site as having 'fair' health in spring and summer (Table 3). The

historical median score (91 units) placed this site in the 'fair' category for the generic method of assessment.

3.2.7.1.2 Predicted stream 'health'

The Waiau Stream rises at an elevation of less than 100 m asl as seepage beyond the ringplain and the site at Inland North Road is in the mid reaches at an altitude of 50 m asl. The REC predicted MCI value (Leathwick, et al. 2009) was 91 units. The historical site median, spring and summer scores were not significantly different from the REC predicted value.

3.2.7.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 81). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1998-2019) and the most recent ten-years of results (2009-2019) from the site in the Waiau Stream at Inland North Road.

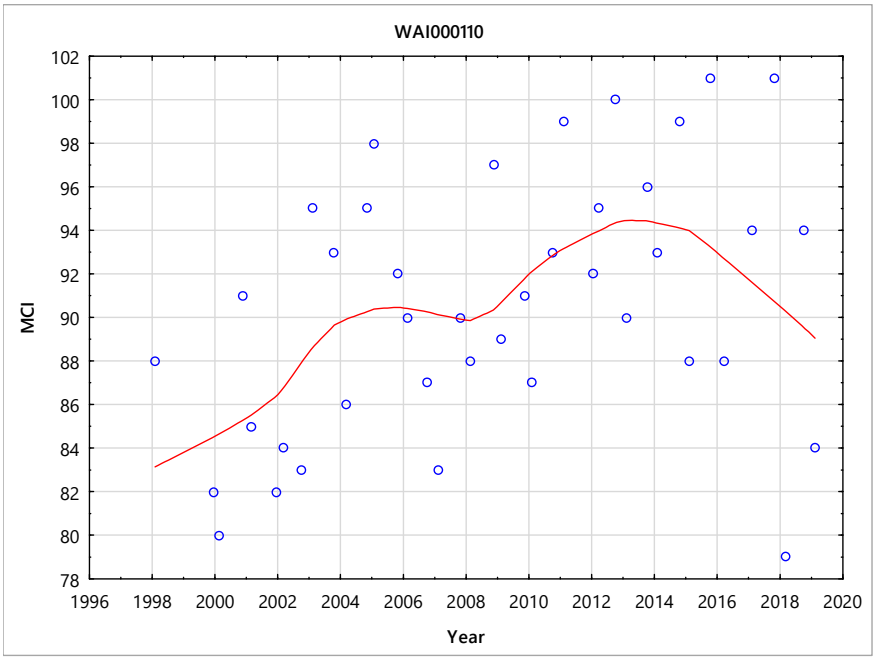


Figure 81 LOWESS trend plot of MCI data at the Inland North Road site, Waiau Stream for the full dataset with the full and ten-year dataset

A significant positive temporal trend in MCI scores has been found (FDR p = 0.02) over the monitoring term at this site. The trend had two dips where scores declined and the current period is in the second of the two dips. The trendline range of scores (11 units) has been of significant ecological importance. Trendline scores have been indicative of 'fair' generic stream health (Table 3) throughout the period.

The ten-year period, shows a minor negative trend, which is neither statistically or ecologically significant.

3.2.7.2 Discussion

Taxa richness was moderate and typical for this site. Both surveys indicated that the macroinvertebrate community was in 'fair' health though the summer survey was towards the lower end of the range recorded at this site. There was usually some seasonal variation with summer scores five units lower than spring scores, probably due to low, stable, flows in combination with higher temperatures and more sunlight contributing towards macrophyte and periphyton growth at the site.

3.2.8 Waimoku Stream

The Waimoku Stream is a small ringplain stream with a source inside Egmont National Park in the Kaitake Ranges and flows in an easterly direction. There are two SEM sites situated on the stream in the upper and lower reaches.

3.2.8.1 Lucy's Gully site (WMK000100)

3.2.8.1.1 Taxa richness and MCI

Thirty-seven surveys have been undertaken at this upper reach site in the Kaitake Ranges between December 1999 and February 2018. These results are summarised in Table 45, together with the results from the current period, and illustrated in Figure 82.

Table 45 Results of previous surveys performed in the Waimoku Stream at Lucy's Gully, together with the 2018-2019 results

Site code	SEM data (1999 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WMK000100	37	22-38	31	121-141	131	21	127	18	119

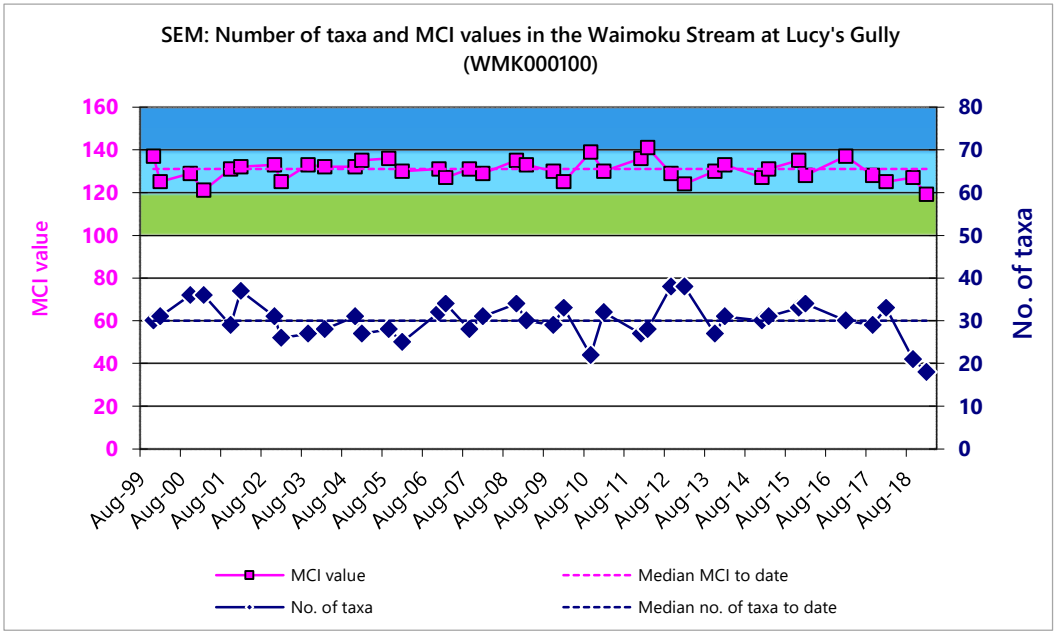


Figure 82 Numbers of taxa and MCI values in the Waimoku Stream at Lucy's Gully

A moderate range of richness (22 to 38 taxa) has been found, with a median richness of 31 taxa which is more representative of typical richness in the upper reaches of ringplain streams and rivers. During the current period the spring (21 taxa) and summer (18 taxa) richness were very substantially lower than the historic median richness by 10 to 13 taxa respectively. Furthermore, both spring and summer richness were the lowest recorded to date at the site.

MCI values also have had a moderate range (20 units) at this site, slightly wider than typical of a site in the upper reaches of a ringplain stream. The median value (131 units) however, has been typical of upper reach sites elsewhere on the ringplain. The spring (127 units) score was not significantly different from the historical median but the summer score (119 units) was significantly lower and also the lowest recorded score to date for this site (Stark, 1998). This score categorised this site as having 'very good' health in spring

and 'good' health in summer (Table 3). The historical median score (131 units) placed this site in the 'very good' health category.

3.2.8.1.2 Predicted stream 'health'

The Waimoku Stream site at Lucy's Gully is within the Kaitake Ranges of the National Park boundary but at an altitude of 160 m asl and only 4 km from the coast. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 132 for this site. The historical site median and spring score were not significantly different to this value while the summer score was significantly lower. The REC predicted MCI value (Leathwick, et al. 2009) was 128 units. The historical site median, spring and summer scores were not significantly different to the REC predictive score.

3.2.8.1.3 Temporal trends in data

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 83). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1999-2019) and the most recent ten-years of results (2009-2019) from the site in the Waimoku Stream at Lucy's Gully.

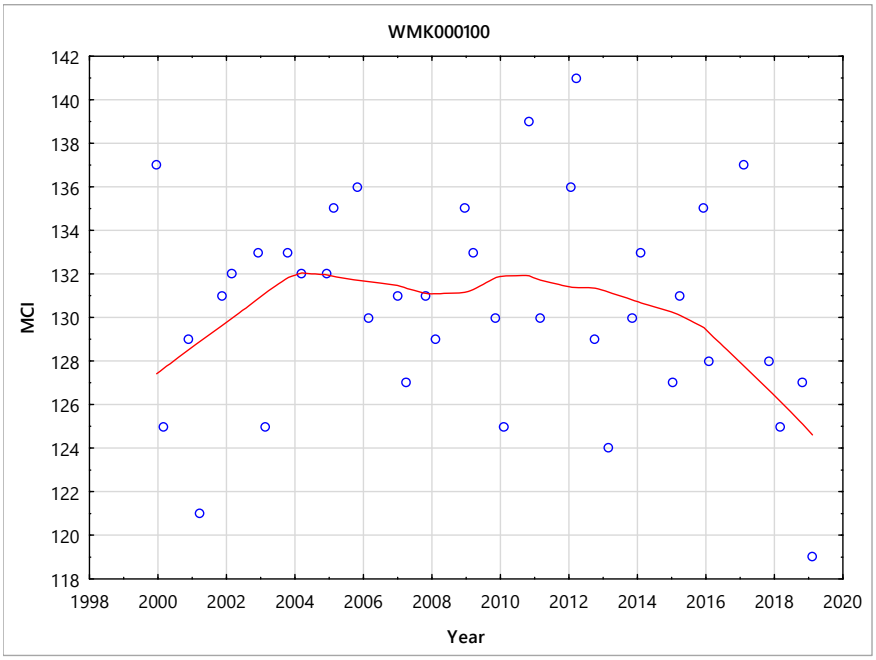


Figure 83 LOWESS trend plot of MCI data at the Lucy's Gully site, Waimoku Stream for the full dataset with Mann-Kendall test for the full and ten-year dataset

There was a weak, negative, non-significant trend in MCI scores over the entire monitoring period at this pristine site within the National Park. The trendline range (seven units) has been of minor ecological importance and has continuously indicated 'very good' generic stream health (Table 3).

The ten-year period also shows a negative trend that was not statistically or ecologically significant.

3.2.8.2 Oakura Beach site (WMK000298)

3.2.8.2.1 Taxa richness and MCI

Thirty-seven surveys have been undertaken at this lower reach site just upstream of Oakura Beach in the Waimoku Stream between December 1999 and February 2018. These results are summarised in Table 46, together with the results from the current period, and illustrated in Figure 84.

Table 46 Results of previous surveys performed in the Waimoku Stream at Oakura Beach together with 2018-2019 results

Site code	SEM data (1999 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WMK000298	37	10-29	21	75-105	92	19	98	20	97

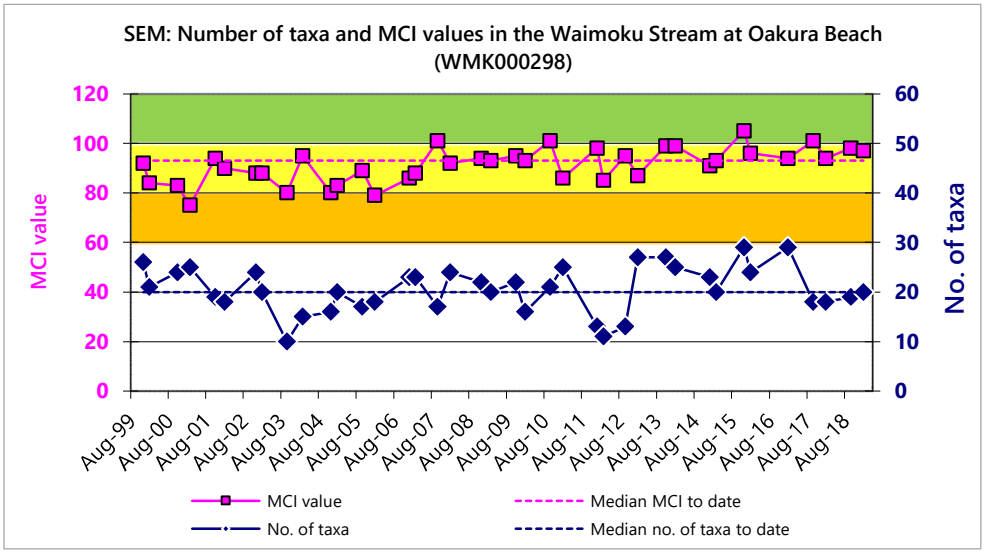


Figure 84 Numbers of taxa and MCI values in the Waimoku Stream at Oakura Beach

A wide range of richness (10 to 29 taxa) has been found; wider than might be expected, with a median richness of 21 taxa, which was more representative of typical richness in ringplain streams and rivers in the lower reaches. During the current period, spring (19 taxa) and summer (20 taxa) richness were similar to the historic median taxa richness.

MCI scores have had a relatively wide range (30 units) at this site, typical of sites in the lower reaches of ringplain streams. The spring (98 units) and summer (97 units) scores were slightly higher but not significantly different to the historical median. The scores categorised this site as having 'fair' health (Table 3). The historical median score also categorised the site as having 'fair' health generically.

3.2.8.2.2 Predicted stream 'health'

The Waimoku Stream Oakura Beach site is at an altitude of only 1 m asl and is also only 4 km downstream of the National Park boundary. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 116 for this site. The historical site median (92 units) is a significant 24 units lower than the predictive distance value. The spring and summer scores were also significantly lower than the distance predictive value. The REC predicted MCI value (Leathwick, et al. 2009) was 103 units. The historical site median was significantly lower than the REC predictive value but the spring and summer scores were not significantly different.

3.2.8.2.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 85). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1999-2019) and the most recent ten-years of results (2009-2019) from the site in the Waimoku Stream at Oakura Beach.

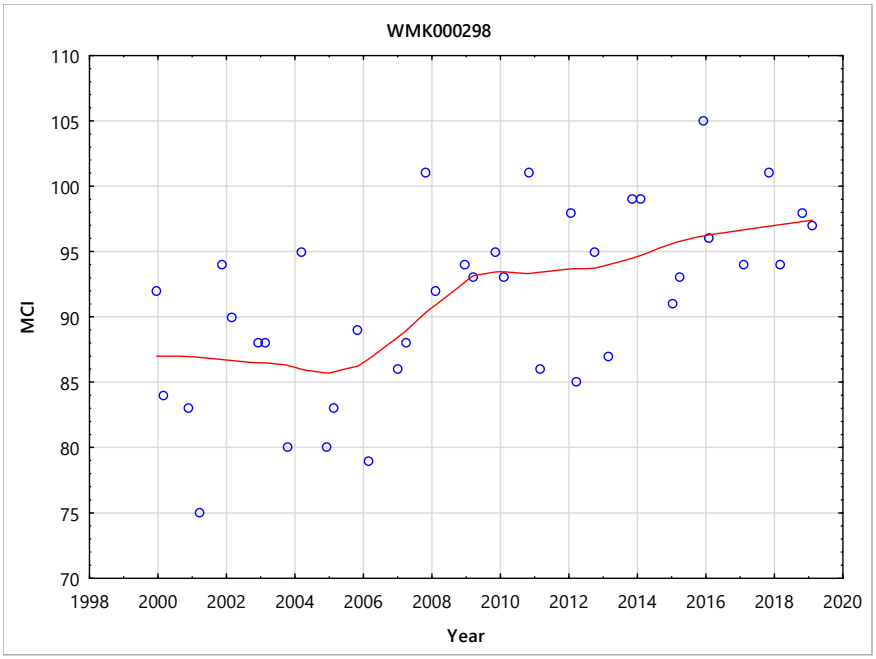


Figure 85 LOWESS trend plot of MCI data at the Oakura Beach site, Waimoku Stream for the full dataset with Mann-Kendall test for the full and ten-year dataset

A positive, highly significant trend in MCI scores has been recorded during the entire monitoring period (FDR p < 0.01) indicating a significant improvement in macroinvertebrate health. The trendline range of scores (12 units) has been ecologically important and has consistently indicated 'fair' generic stream health at this site in the lower reaches of the stream.

The ten-year period also shows a positive trend, however this was neither ecologically or statistically significant.

3.2.8.3 Discussion

Taxa richness was atypically moderate at the upper site and typically moderate at the lower site. The upper site is in the national park within mature native forest and always has higher taxa richness than that recorded during the current monitoring year. The low taxa richness was probably due to the low flows at the time of the survey. A record time since 7x median flow fresh of 182 days was recorded indicating low preceding rainfall. The spring survey indicated that the macroinvertebrate community at the upper site was in 'very good' health while the summer survey recorded 'good' health, but had the lowest recorded result to date at the site. Again, this was likely due to low flows. The lower site had typical MCI scores indicating 'fair' health. MCI scores fell in a downstream direction in spring and summer by 29 and 22 units respectively, over a short stream distance of only 4.0 km downstream from the National Park boundary. This was a large decrease in condition for a relatively short distance and greater than what would be expected given the relatively intact upper catchment. This was likely due to a combination of factors including poorer habitat quality at this urban stream site, along with poorer water quality.

The time trend analysis indicated no trends at the upper site which would be expected given its pristine nature. The lower site had a significant positive trend over the full dataset indicating that macroinvertebrate health had improved though improvements may have plateaued over the last ten-years. Increases in the amount of riparian fencing and planting of waterways in the catchment have probably contributed to this improvement.

3.2.9 Waingongoro River

The Waingongoro River is a large ringplain river with a source inside Egmont National Park. The river flows in a southerly direction and there are six SEM sites situated along the length of the river.

3.2.9.1 Site near National Park boundary (WGG000115)

3.2.9.1.1 Taxa richness and MCI

Forty-six surveys have been undertaken at this upper reach site, 700m downstream of the National Park boundary in the Waingongoro River, between October 1995 and March 2018. These results are summarised in Table 47, together with the results from the current period, and illustrated in Figure 86.

Table 47 Results of previous surveys performed in the Waingongoro River 700m downstream of the National Park, together with 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WGG000115	46	23-40	31	122-144	133	30	136	27	133

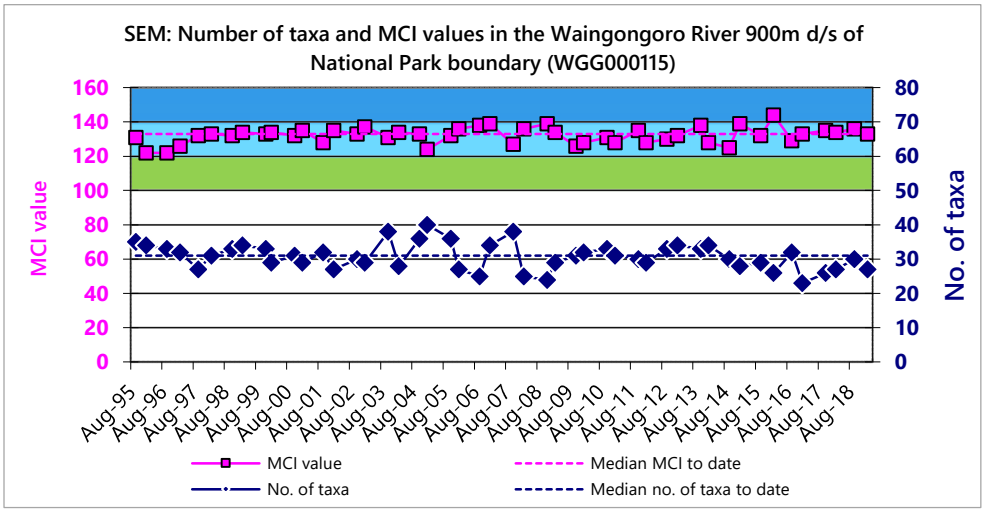


Figure 86 Numbers of taxa and MCI values in the Waingongoro River 700 m d/s National Park

A relatively wide range of richness (23 to 40 taxa) has been found with a high median richness of 31 taxa, typical of richness in ringplain streams and rivers near the National Park boundary. During the current period, spring (30 taxa) and summer (27 taxa) richness were slightly less than the historical median.

MCI values have had a moderate range (22 units) at this site, typical of a National Park boundary site. The median value (133 units) has also been typical of upper reach sites elsewhere on the ringplain. The spring (136 units) and summer (133 units) scores were not significantly different from the historical median. The MCI scores categorised this site as having 'very good' health generically (Table 3). The historical median score (133 units) placed this site in the 'very good' category for generic health.

3.2.9.1.2 Predicted stream 'health'

The Waingongoro River site near the National Park is 0.7 km downstream of the National Park boundary at an altitude of 540 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 132 for this site. The historical site median, spring and summer scores were not significantly different to the distance predictive value. The REC

predicted MCI value (Leathwick, et al. 2009) was 131 units. Again, the historical median, spring and summer and scores were also all not significantly different to this value.

3.2.9.1.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 87). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Waingongoro River near the National Park.

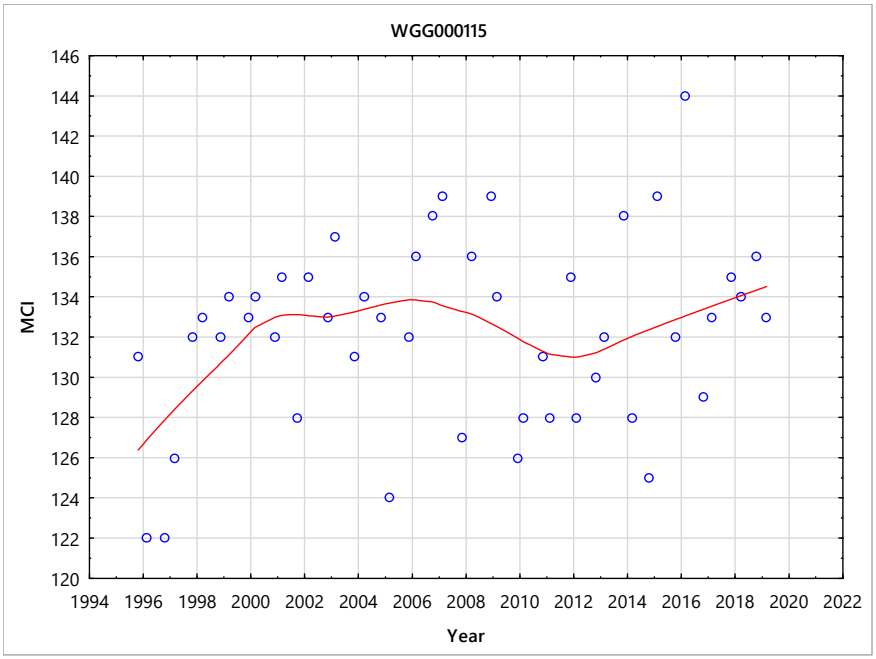


Figure 87 LOWESS trend plot of MCI data at the site near the National Park, Waingongoro River

A positive, non-significant trend has been found over the entire period. Previously, prior to 2008, there had been a statistically significant improvement over the earlier period (1995-2007). After 2007 there was some decline followed by some recent improvement but the overall trendline range of scores (eight units) was of minor ecological importance. Throughout the period, the trend has indicated 'very good' generic river health.

Congruent with the full dataset there was a non-significant positive trend in MCI scores over the most recent ten-year period after FDR. In particularly there was an increase in the trendline from 2012 onwards. This trend was significant prior to FDR adjustment. The trendline for the most recent ten-year period was indicative of 'very good' health.

3.2.9.2 Opunake Road site (WGG000150)

3.2.9.2.1 Taxa richness and MCI

Forty-six surveys have been undertaken in the Waingongoro River at this upper mid-reach site at Opunake Road (approximately 7km downstream of the National Park) between October 1995 and March 2018. These results are summarised in Table 48, together with the results from the current period, and illustrated in Figure 88.

Table 48 Results of previous surveys performed in the Waingongoro River at Opunake Road together with 2018-2019 results.

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WGG000150	46	22-39	27	119-139	129	24	128	26	119

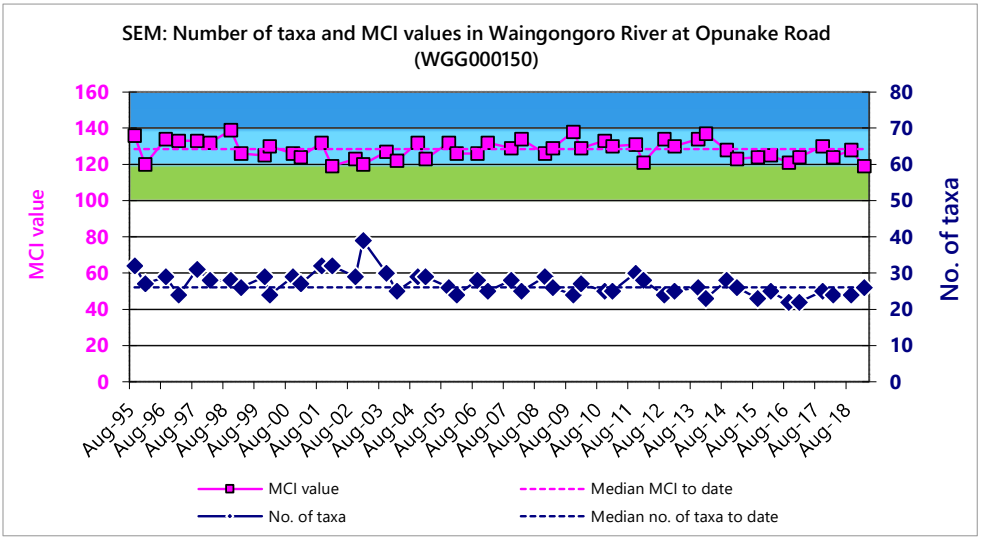


Figure 88 Numbers of taxa and MCI values in the Waingongoro River at Opunake Road

A relatively wide range of richness (22 to 39 taxa) has been found; wider than might be expected, with a median richness of 27 taxa. During the current period spring (24 taxa) and summer (26 taxa) richness were slightly lower than the historical median.

MCI values have had a moderate range (20 units) at this site, typical of sites in the upper mid reaches of ringplain rivers. The median value (129 units) has been higher than typical of upper, mid reach sites elsewhere on the ringplain. The spring (128 units) and summer (119 units) scores were not significantly lower than the median value or each other (Stark, 1998). These scores categorised this site as having 'very good' (spring) and 'good' (summer) health generically (Table 3). The historical median score placed this site in the 'very good' category for generic health.

3.2.9.2.2 Predicted stream health

The Waingongoro River at Opunake Road is 7.2km downstream of the National Park boundary at an altitude of 380 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict a MCI value of 110 for this sites. The historical site median and spring score were significantly higher than this value and the summer score was not significantly different (Stark, 1998). The REC predicted MCI value (Leathwick, et al. 2009) was 124 units. The historical site median, spring and summer values were not significantly different from this value.

3.2.9.2.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 89). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Waingongoro River at Opunake Road.

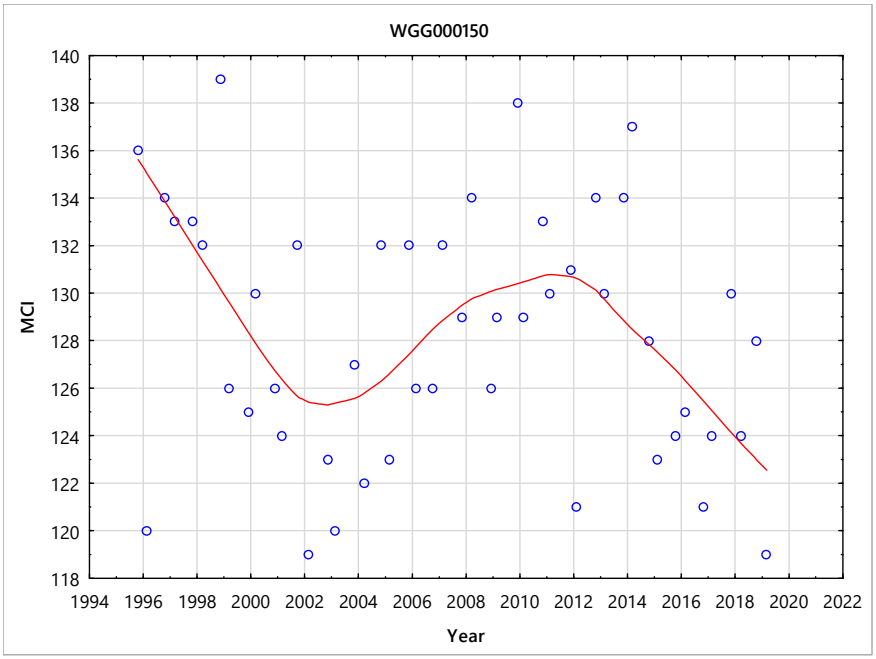


Figure 89 LOWESS trend plot of MCI data at the Opunake Road site, Waingongoro River

A non-significant negative trend in MCI scores has occurred in the upper mid-reaches of the river (some seven km below the National Park). The trendline range of scores (13 units) has been of minor ecological importance over the entire monitoring period. Localised erosion had caused sediment deposition on the riverbed during 1999 with a subsequent five year decline in MCI scores. This decline ceased with a gradual improvement in MCI scores towards earlier levels over the latter twelve years. The erosion event was very localised and site specific, as corresponding biological and physiochemical monitoring data showed no significant trends at the nearest downstream site (Eltham Road). The trendline has again started to decline from 2012 onwards, possibly due to erosion again. The dry summer period with subsequent lack of freshes may also have contributed to the low summer MCI score. The trendline range of scores have been consistently indicative of 'very good' generic river health.

Congruent with the full dataset, there was a non-significant, but stronger, negative trend in MCI scores over the most recent ten-year period. The trendline was significant prior to FDR adjustment. The trendline for the most recent ten-year period was indicative of 'very good' health.

3.2.9.3 Eltham Road site (WGG000500)

3.2.9.3.1 Taxa richness and MCI

Forty-six surveys have been undertaken in the Waingongoro River at this mid-reach site at Eltham Road between October 1995 and March 2018. These results are summarised in Table 49, together with the results from the current period, and illustrated in Figure 90.

Table 49 Results of previous surveys performed in the Waingongoro River at Eltham Road, together with 2018-2019 results.

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WGG000500	46	15-29	22	93-125	103	24	112	24	109

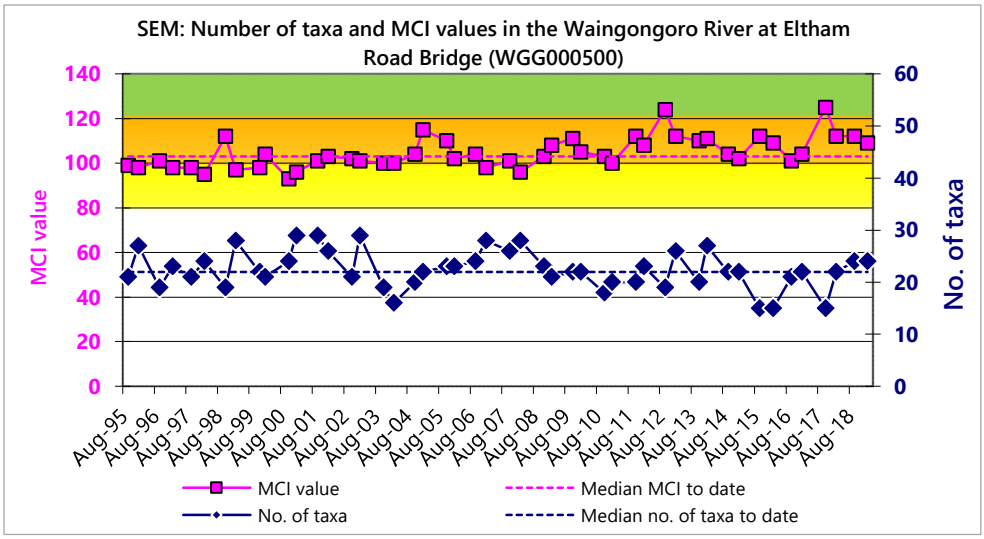


Figure 90 Numbers of taxa and MCI values in the Waingongoro River at Eltham Road

A wide range of richness (15 to 29 taxa) has been found with a median richness of 22 taxa, typical of richness in the mid reaches of ringplain streams and rivers. During the current period spring (24 taxa) and summer (24 taxa) richness were similar to the historical median.

MCI values have had a relatively wide range (33 units) at this site, more typical of sites in the mid reaches of ringplain rivers. The historical median value (103 units) has been typical of mid reach sites elsewhere on the ringplain. The spring (112 units) and summer (109 units) scores were not significantly higher than the historic median. These scores categorised this site as having 'good' health (Table 3). The historical median score (103 units) placed this site in the 'good' category for generic health.

3.2.9.3.2 Predicted stream 'health'

The Waingongoro River site at Eltham Road is 23.0 km downstream of the National Park boundary at an altitude of 200 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict a MCI value of 97 for this site. The historical site median score was not significantly different to the distance predictive value and the spring and summer scores were both significantly higher (Stark, 1998).

The REC predicted MCI value (Leathwick, et al. 2009) was 110 units. The historical median, spring and summer scores were not significantly different to this value.

3.2.9.3.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) was produced (Figure 91). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Waingongoro River at Eltham Road.

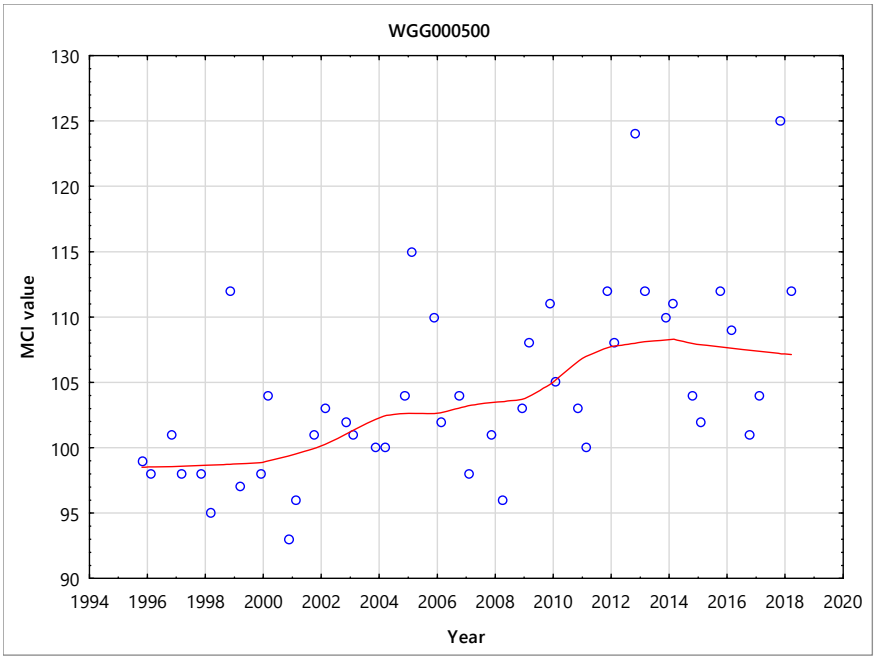


Figure 91 LOWESS trend plot of MCI data at the Eltham Road site, Waingongoro River

A significant positive temporal trend in MCI scores has been found over the entire period (FDR p< 0.01). This has been more pronounced since 2001 but scores plateaued for about three years before a more recent further improvement and another most recent plateau in scores. The trendline range of scores (10 units) has been of marginal ecological importance. The trendline MCI scores wre indicative of 'fair' generic health prior to 2002 and since then have been in the 'good' category.

There was a non-significant, positive trend in MCI scores over the most recent ten-year period. The trendline for the most recent ten-year period was indicative of 'good' health.

3.2.9.4 Stuart Road site (WGG000665)

3.2.9.4.1 Taxa richness and MCI

Forty-six surveys have been undertaken in the Waingongoro River at this mid-reach site at Stuart Road between October 1995 and March 2018. These results are summarised in Table 50, together with the results from the current period, and illustrated in Figure 92.

Table 50 Results of previous surveys performed in the Waingongoro River at Stuart Road, together with spring 2018 and summer 2019 results

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WGG000665	46	14 - 30	20	77-111	96	20	108	24	88

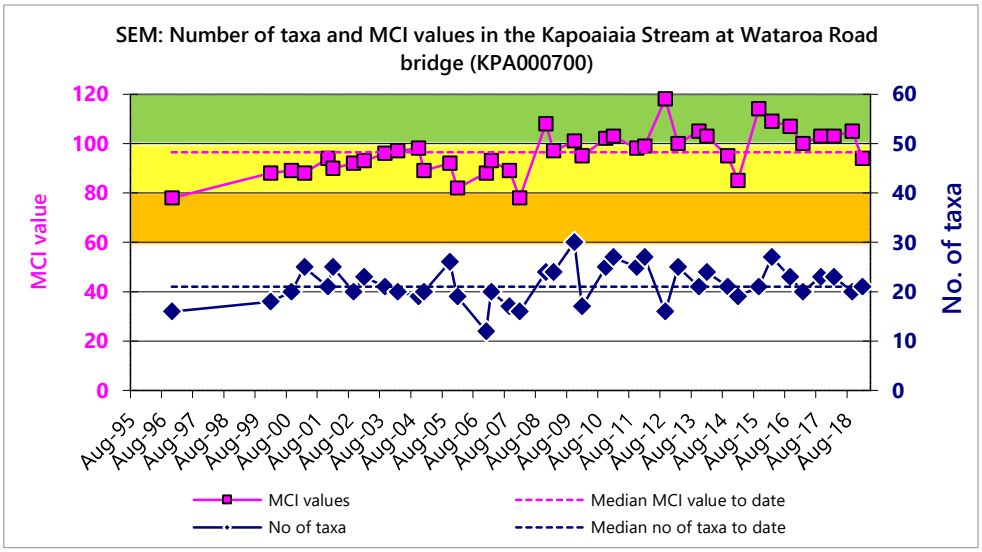


Figure 92 Numbers of taxa and MCI values in the Waingongoro River at Stuart Road

A wide range of richness (14 to 30 taxa) has been found with a median richness of 20 taxa (more representative of typical richness in the mid reaches of ringplain streams and rivers). During the current period spring (20 taxa) and summer (24 taxa) richness were the same/ similar to the historical median (20 taxa).

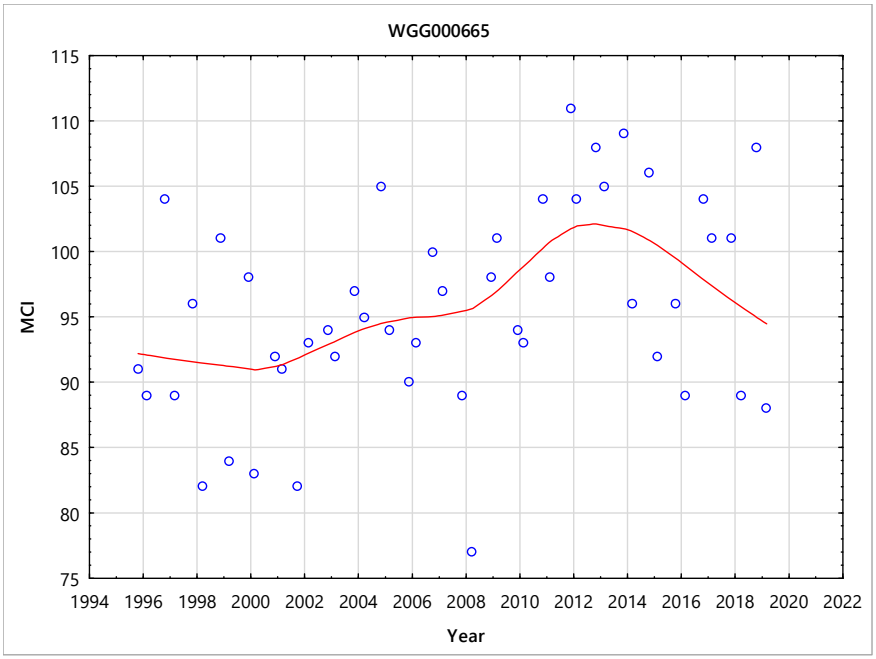
MCI values have had a moderately wide range (34 units) at this site, typical of sites in the mid reaches of ringplain rivers. The median value (96 units) has been lower than typical of mid reach sites elsewhere on the ringplain. The spring (108 units) score was significantly higher than the historic median while the summer (88 units) score was not significantly different to the historical median but significantly lower than the spring score. These scores categorised this site as having 'good' (spring) and 'fair' (summer) health generically (Table 3). The historical median score (96 units) placed this site in the 'fair' category for generic health.

3.2.9.4.2 Predicted stream 'health'

The Waingongoro River site at Stuart Road is 29.6 km downstream of the National Park boundary at an altitude of 180 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict MCI value of 94 for this site. The historical site median and summer survey scores were not significantly different to the distance predictive value and the spring score was significantly higher (Stark, 1998). The REC predicted MCI value (Leathwick, et al. 2009) was 102 units. The historical median and spring scores were not significantly different to the REC predictive value but the summer score was significantly lower (Stark, 1998).

3.2.9.4.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 93). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Waingongoro River at Stuart Road.



N = 48
Kendall tau = 0.269
p value = 0.01
FDR p = 0.02

N = 20
Kendall tau = -0.166
p value = 0.31
FDR p = 0.57

Figure 93 LOWESS trend plot of MCI data at the Stuart Road site, Waingongoro River

A positive significant trend in MCI scores has been found over the entire period (FDR p = 0.02). There has been an improvement in MCI scores since 2002 (coincident with summer diversion of the treated meatworks wastes discharge at Eltham from the river to land irrigation) and particularly most recently (since 2009) following the diversion of treated municipal Eltham wastewater out of the catchment (to the Hawera WWTP and ocean outfall). However, since 2013 scores have declined sharply. The trendline range of scores (12 units) has also been ecologically importance. The trendline has been indicative of 'fair' generic river health apart from a brief period where it was at 'good' generic health from 2011 to 2015.

In contrast to the full dataset, there was a non-significant, negative trend in MCI scores over the most recent ten-year period, due to the decline in MCI scores since 2013. The trendline has been indicative of 'fair' generic river health apart from a brief period where it was at 'good' generic health from 2011 to 2015.

3.2.9.5 SH45 site (WGG000895)

3.2.9.5.1 Taxa richness and MCI

Forty-six surveys have been undertaken in the Waingongoro River at this lower reach site at SH45 between October 1995 and March 2018. These results are summarised in Table 51, together with the results from the current period, and illustrated in Figure 94.

Table 51 Results of previous surveys performed in the Waingongoro River at SH45, together with spring 2018 and summer 2019 results

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WGG000895	46	13 - 25	21	73-106	95	15	88	20	96

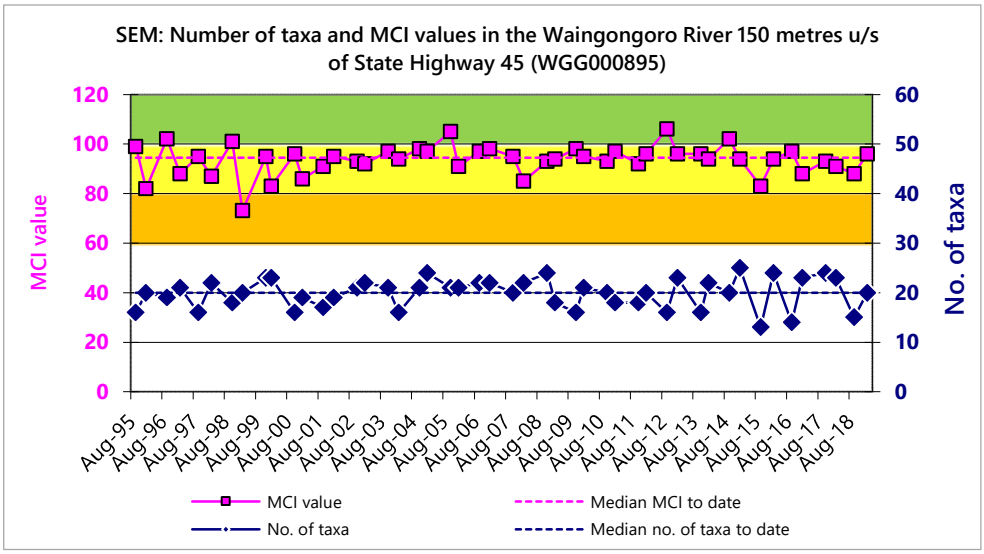


Figure 94 Numbers of taxa and MCI values in the Waingongoro River 150 m u/s of SH45

A moderate range of richness (13 to 25 taxa) has been found with a median richness of 21 taxa which was more representative of typical richness in the lower reaches of ringplain streams and rivers. During the current period, spring (15 taxa) richness was slightly lower than the historic median and summer (20 taxa) richness was the same as the historical median (20 taxa).

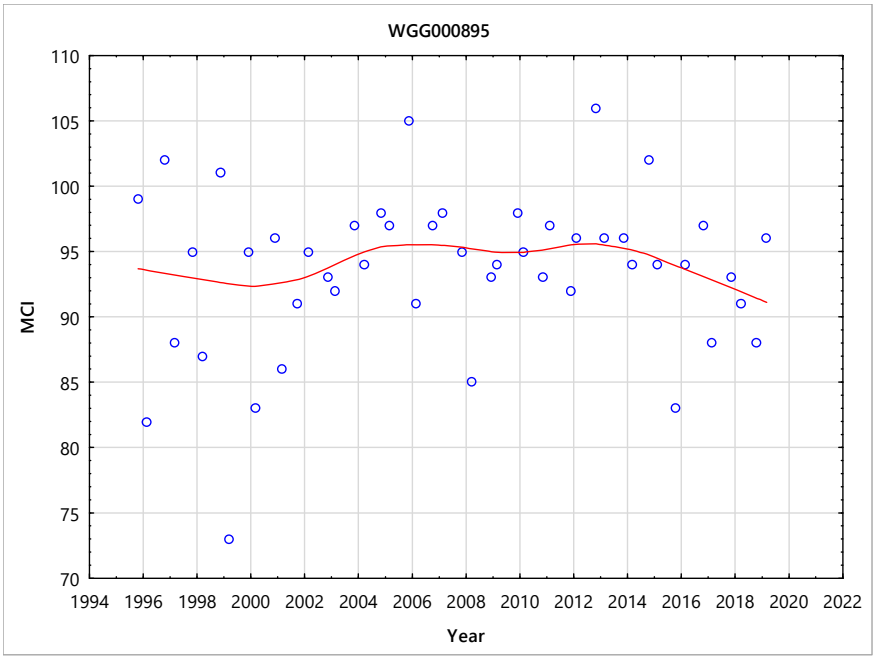
MCI values have had a wide range (33 units) at this site, more typical of sites in the lower reaches of ringplain streams and rivers. The median value (95 units) has been higher than typical of scores at lower reach sites elsewhere on the ringplain. The spring (88 units) and summer (96 units) scores were not significantly different to the historical median. These scores categorised this site as having 'fair' health (spring and summer) generically (Table 3). The historical median score (95 units) placed this site in the 'fair' category for generic health.

3.2.9.5.2 Predicted stream 'health'

The Waingongoro River site at SH45 is 63.0 km downstream of the National Park boundary at an altitude of 40 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict MCI values of 85 for this site. The historical site median and spring score were not significantly different from the distance predictive value and the summer score was significantly higher (Stark, 1998). The REC predicted MCI value (Leathwick, et al. 2009) was 92 units. The historical, spring and summer scores were not significantly different to this value (Stark, 1998).

3.2.9.5.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 95). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Waingongoro River at SH45.



N = 48
Kendall tau = 0.022
p value = 0.83
FDR p = 0.88

N = 20
Kendall tau = -0.305
p value = 0.06
FDR p = 0.31

Figure 95 LOWESS trend plot of MCI data for the SH45 site, Waingongoro River

A very small, non-significant, positive trend in MCI scores has been found over the entire period. A general plateauing in the trend has occurred since 2005. The narrow trendline range (five units) of scores has not been ecologically important. The range of trendline scores have consistently indicated 'fair' generic river health throughout the period.

In contrast to the full dataset, there was a non-significant, negative trend in MCI scores over the most recent ten-year period, with a small increase from 2008 to 2014 followed by a slightly larger decrease in MCI scores. The trendline has been indicative of 'fair' generic river health over the most recent ten-year period.

3.2.9.6 Ohawe Beach site (WGG000995)

3.2.9.6.1 Taxa richness and MCI

Forty-six surveys have been undertaken in the Waingongoro River at this lower reach site at Ohawe Beach between October 1995 and March 2018. These results are summarised in Table 52, together with the results from the current period, and illustrated in Figure 96.

Table 52 Results of previous surveys performed in the Waingongoro River at the Ohawe Beach site, together with spring 2018 and summer 2019 results

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WGG000995	46	12 - 25	18	69-100	91	21	97	17	79

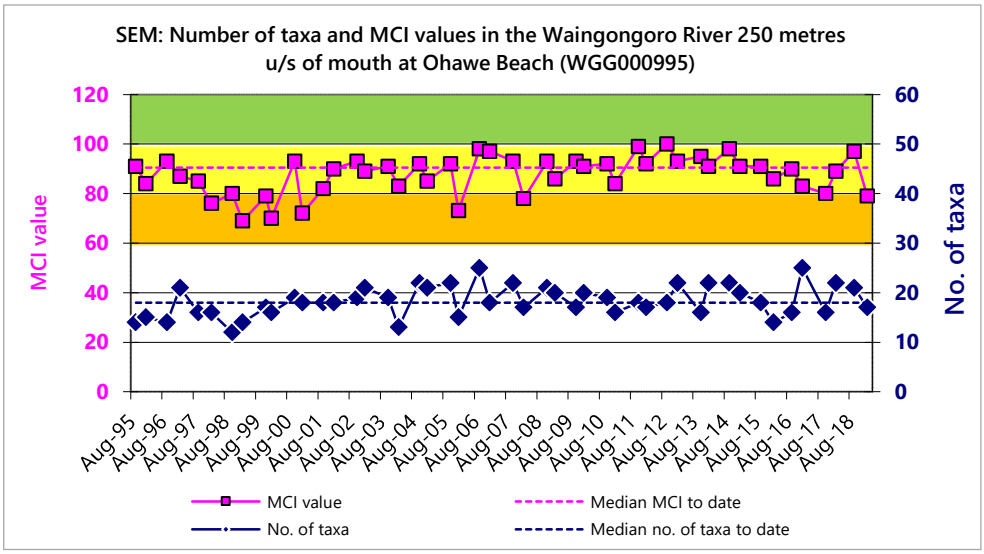


Figure 96 Numbers of taxa and MCI values in the Waingongoro River at the Ohawe Beach site

A wide range of richness (12 to 25 taxa) has been found, with a median richness of 18 taxa. During the current period, spring (21 taxa) and summer (17 taxa) richness were similar to the historical richness.

MCI values have had a relatively wide range (31 units) at this site, typical of sites in the lower reaches of ringplain streams and rivers. The median value (91 units) has been more typical of scores at lower reach sites elsewhere on the ringplain. The spring (97 units) score was not significantly different to the historic median but the summer (79 units) score was significantly lower. These scores categorised this site as having 'fair' health in spring and 'poor' health in summer (Table 3). The historical median score (91 units) placed this site in the 'fair' category for generic health.

3.2.9.6.2 Predicted stream 'health'

The Waingongoro River at the Ohawe Beach site is 66.6km downstream of the National Park boundary at an altitude of 5 m asl. Relationships for ringplain streams and rivers developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict a MCI value of and 85 for this site. The historical median and summer score were not significantly different to predictive value and the spring score was significantly higher (Stark, 1998). The REC predicted MCI value (Leathwick, et al. 2009) was 95 units. The historical and spring scores were not significantly different to this value but the summer score was significantly lower (Stark, 1998).

3.2.9.6.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 97). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Waingongoro River at Ohawe Beach.

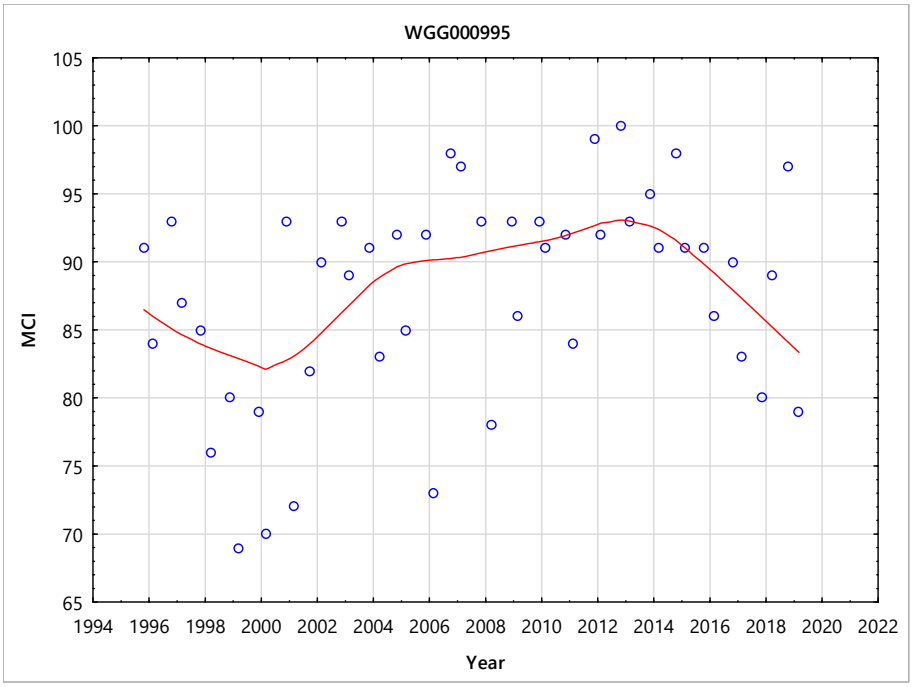


Figure 97 LOWESS trend plot of MCI data at the Ohawe Beach site, Waingongoro River

There was a non-significant positive trend over the entire. There has been improvement since 2001, followed by a sharp decrease recently since 2014. The trendline range of scores (10 units) has been of marginal ecological importance. Trendline scores were consistently indicative of 'fair' generic river health.

In contrast to the full dataset, there was a non-significant, negative trend in MCI scores over the most recent ten-year period. Before FDR application, the negative trend was significant. This was due to the decrease after 2014. The trendline was indicative of 'fair' generic river health but is heading towards 'poor' health.

3.2.9.7 Discussion

Taxa richness varied among sites and seasonally but no real trend was apparent between sites or between spring and summer.

The surveys indicated that the macroinvertebrate community at the upper two sites were generally in 'very good' health, the middle two sites were in 'good' to 'fair' health, and the bottom two sites were generally in 'fair' health. The MCI scores consistently fell in a downstream direction between sites in this agriculturally dominated landscape with the upper site and the furthest downstream lower reaches site by 39 units in spring and 54 units in summer, over a river distance of 65.9 km. These seasonal falls in MCI scores were typical and always occurred to varying extents. The particularly dry summer for the current year likely contributed to the slightly larger than normal seasonal differences.

The time trend analysis indicated no significant trends at the upper two sites which would be expected given their relatively pristine nature. The middle two sites had significant positive trends over the full dataset indicating improvements in macroinvertebrate health but these improvements have plateaued over the last ten-years. The lowest two sites had no significant trends though the lowest site had a significant negative trend before FDR application for the most recent ten-year period. The lower middle site in particular, but also the two lower sites, would have benefitted from the summer diversion of the treated meatworks wastes discharge at Eltham from the river to land irrigation and later in 2009 the diversion of treated municipal Eltham wastewater out of the catchment to the Hawera WWTP and ocean outfall. However, recently some concerns about the impact the Eltham meatworks was having on water quality (e.g.

phosphorus levels) have arisen and this may potentially be one cause of the negative trends at the three most bottom for the most recent ten year period.

3.2.10 Waiokura Stream

Two sites in this small, southerly flowing ringplain seepage-sourced stream, were included in the SEM programme in recognition of a long-term collaborative study of the effects of best-practice dairy-farming initiatives being evaluated in five dairying catchments throughout the country (Wilcock et al, 2009). Fonterra, Kapuni lactose factory also irrigates wastewater to land in the mid reaches of this catchment. One site is located upstream of the irrigation area (in mid-catchment) and the other site approximately ten km further downstream toward the lower reaches of the stream. Some consent monitoring data have been collected from the upper site since 2003 whereas the downstream site was established for biological temporal trend purposes in the 2008-2009 period to provide an additional monitoring component of the collaborative study.

3.2.10.1 Skeet Road site (WKR000500)

3.2.10.1.1 Taxa richness and MCI

Twenty-seven surveys have been undertaken, between 2003 and March 2018, at this mid-reach, partially shaded site in the Waiokura Stream, draining open developed farmland upstream of the Fonterra, Kapuni wastewater irrigation area. These results are summarised in Table 53, together with the results from the current period, and illustrated in Figure 98.

Table 53 Results of previous surveys performed in the Waiokura Stream at Skeet Road, together with 2018-2019 results

Site code	SEM data (2003 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WKR000500	27	18 - 29	23	88-114	100	27	112	19	104

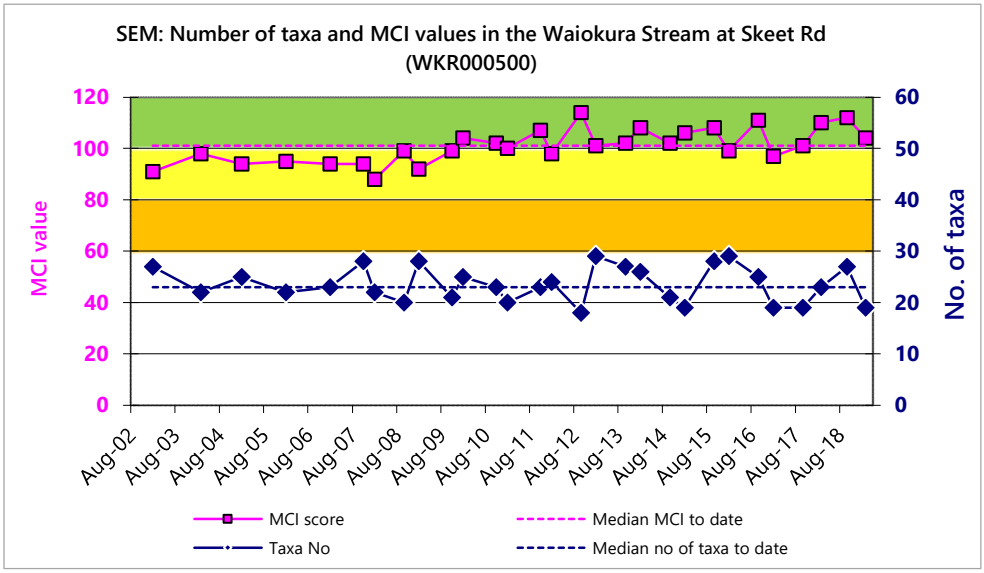


Figure 98 Numbers of taxa and MCI values in the Waiokura Stream at Skeet Road

A relatively narrow range of richness (18 to 29 taxa) has been found to date with a median richness of 23 taxa more typical of richness in the mid reaches of ringplain streams rising outside the National park

boundary. During the current period spring (27 taxa) and summer (19 taxa) richness were similar to the historical median of 23 taxa though eight taxa different from each other.

MCI values have had a moderate range (26 units) at this site, more typical of mid reach sites on the ringplain, although the monitoring period has been relatively short to date. The historical median value (100 units) has been typical of mid-reach sites in streams rising outside the National Park elsewhere on the ringplain. The spring (112 units) score was significantly higher than the historical median and the summer (104 units) score was not significantly different to the historical median (Stark, 1998). The scores categorised this site as having 'good' (spring and summer) health generically (Table 3). The historical median score (100 units) placed this site in the 'good' category for generic health.

3.2.10.1.2 Predicted stream 'health'

The Waiokura Stream rises below the National Park boundary and the site at Skeet Road is in the mid-reaches at an altitude of 150m asl. The REC predicted MCI value (Leathwick, et al. 2009) was 97 units. The historical median and summer score were not significantly different, while the spring score was significantly higher (Stark, 1998).

3.2.10.1.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 99). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (2003-2019) and the most recent ten-years of results (2009-2019) from the site in the Waiokura Stream at the site on Skeet Road.

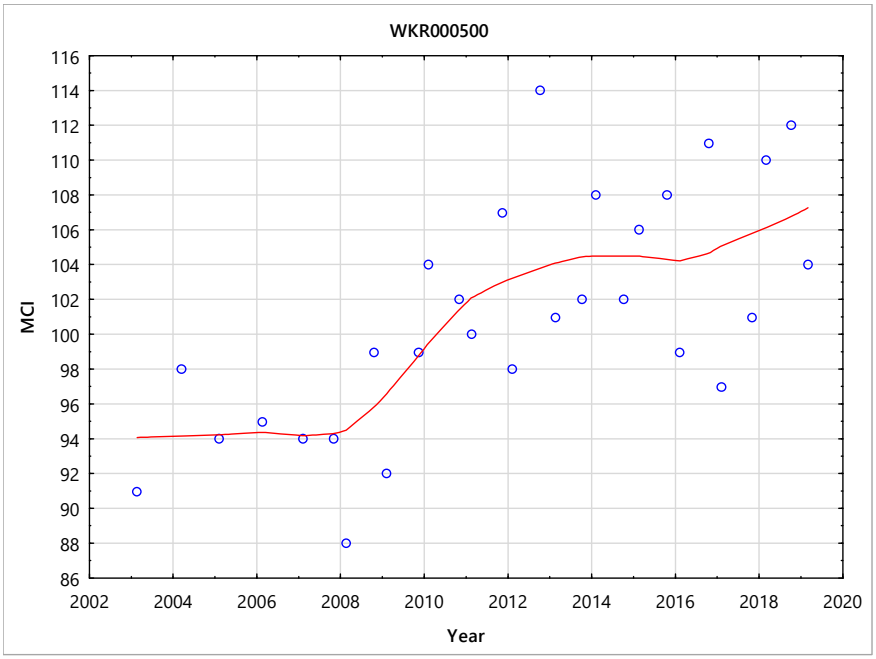


Figure 99 LOWESS trend plot of MCI data in the Waiokura Stream at the Skeet Road site for the full dataset with Mann-Kendall test for the full and ten-year dataset

This site shows a statistically significant positive trend (FDR p < 0.01). Since 2009, there has been relatively strong temporal improvement in MCI scores at this site, with a plateau between 2014 and 2016. The trendline range of MCI scores (13 units) was of ecological importance. Increases in scores may have been related to improvements in farming practices and/or wastes disposal in the rural catchment between the stream's seepage sources (below the National Park) and mid reaches at Skeet Road, although the shorter duration and less frequent initial monitoring must be noted.

Trendline MCI scores have been indicative of 'fair' generic stream health for the first eight years of the period improving to the 'good' health category over the most recent seven years.

The ten-year period shows a positive trend, congruent with the full dataset, however this trend was not statistically significant.

3.2.10.2 Manaia golf course site (WKR000700)

3.2.10.2.1 Taxa richness and MCI

Twenty-two surveys have been undertaken at this more recently established lower reach site in the Waiokura Stream at Manaia between 2007 and March 2018. These results are summarised in Table 54 together with the results from the current period, and illustrated in Figure 100.

Table 54 Results of previous surveys performed at Waiokura Stream at Manaia golf course, together with 2018-2019 results

Site code	SEM data (2007 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		Mar 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WKR000700	22	16-27	23	92-109	98	20	102	27	100

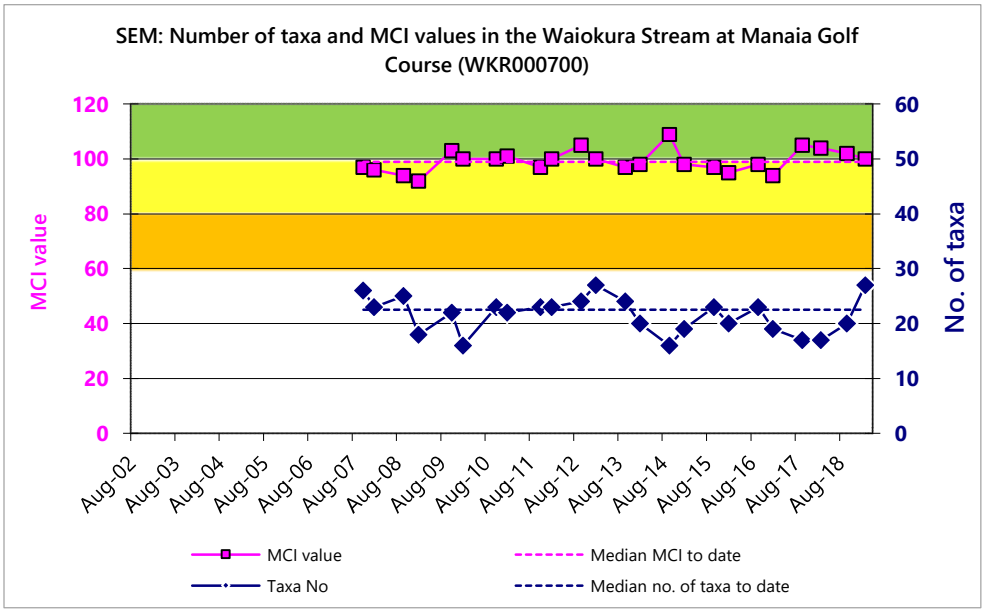


Figure 100 Numbers of taxa and MCI values in the Waiokura Stream at Manaia Golf course

A moderate range of richness (16 to 27 taxa) has been found, with a median richness of 23 taxa (more representative of typical richness for the lower reaches of ringplain streams rising outside the National Park boundary). During the current period spring (20 taxa) and summer (27 taxa) richness were similar to the historical median but seven taxa apart.

MCI values have had a narrow range (17 units) at this site partly due to the short duration of the monitoring period to date. The median value (98 units) has been slightly higher than typical of similar lower reach sites elsewhere on the ringplain. The spring (102 units) and summer (100 units) scores were not significantly different to the historical median score. These scores categorised this site as having 'good' (spring and summer) health generically (Table 3). The historical median score (98 units) placed this site in the 'fair' category for generic health.

3.2.10.2.2 Predicted stream 'health'

The Waiokura Stream rises below the National Park boundary and the site at the Manaia golf course is in the lower reaches at an altitude of 70 m asl. The REC predicted MCI value for this site (Leathwick, et al. 2009) was 95 units. The historical median, spring and summer scores were not significantly different from the REC predictive value.

3.2.10.2.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 101). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was performed on the entire SEM data (2007-2019) and the most recent ten-years of SEM results (2009-2019) from the site in the Waiokura Stream at Manaia golf course.

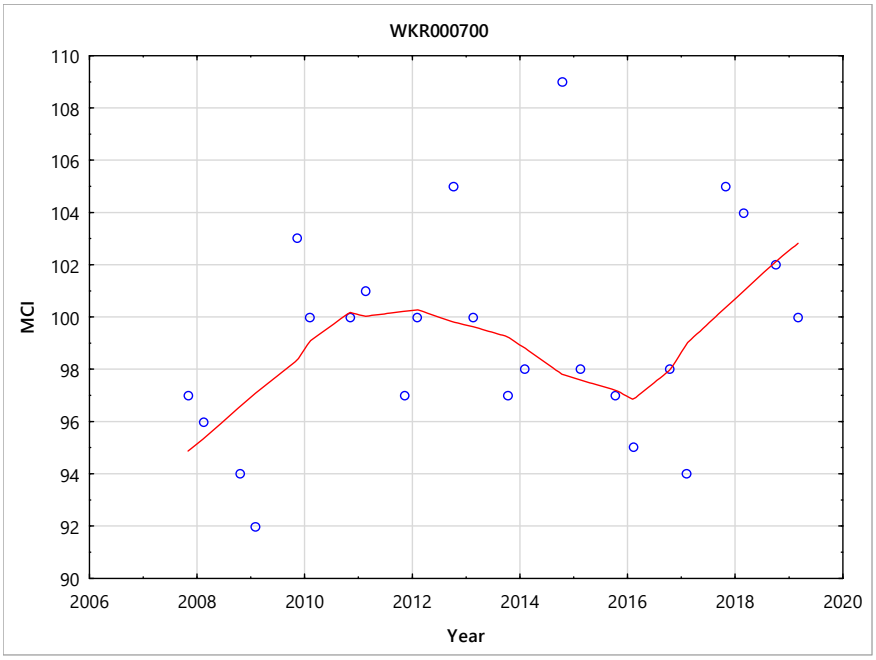


Figure 101 LOWESS trend plot of MCI data in the Waiokura Stream for the Manaia golf course for the full dataset with Mann-Kendall test for the full and ten-year dataset

A positive, non-significant trend of improvement in MCI scores since 2009 to that found at the upstream site (at Skeet Road) was identified at this site at the Manaia golf course (although more stable since 2010). The relatively narrow range of scores (eight units) has no ecological importance to date.

The trendline range indicated 'fair' generic stream health for two years of the monitoring period, improved to 'good' stream health for about three years before falling to 'fair' stream health until returning to 'good' stream health this past monitoring period.

The ten-year period had a positive trend. As with the full dataset, this was neither statistically or ecologically significant.

3.2.10.3 Discussion

Taxa richness for both surveys were moderate at both sites and similar to historical medians.

The surveys indicated that the macroinvertebrate community at both sites were in 'good' health and in typical condition. The MCI score decreased by nine units in spring and decreased by four units in summer in a downstream direction over the 9.7 km reach, between the more open farmland mid-reach site (Skeet

Road) and the lower reach Manaia golf course site. This was despite some improvement in habitat provided by patches of riparian vegetation cover through the golf course.

The time trend analysis indicated a significant positive trend after FDR adjustment at the upper site over the full period. There have been farming initiatives to improve water quality in the catchment, which appear to have succeeded in improving macroinvertebrate health at the upper site. In contrast, the lower site had a weak positive trend. This result may be influenced by the shorter monitoring period at the lower site. There were no significant trends at either site over the most recent ten-year period.

3.2.11 Waiongana Stream

The Waiongana Stream has a source within Egmont National Park and flows in an easterly direction with a mouth just east of Bell Block. There are two sites on the stream used for SEM surveys.

3.2.11.1 State Highway 3a site (WGA000260)

3.2.11.1.1 Taxa richness and MCI

Forty-five surveys have been undertaken at this mid reach site in the Waiongana Stream between October 1995 and February 2018. These results are summarised in Table 55, together with the results from the current period, and illustrated in Figure 102.

Table 55 Results of previous surveys performed in the Waiongana Stream at SH3A together with the 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WGA000260	45	9-31	24	82-112	97	22	99	25	90

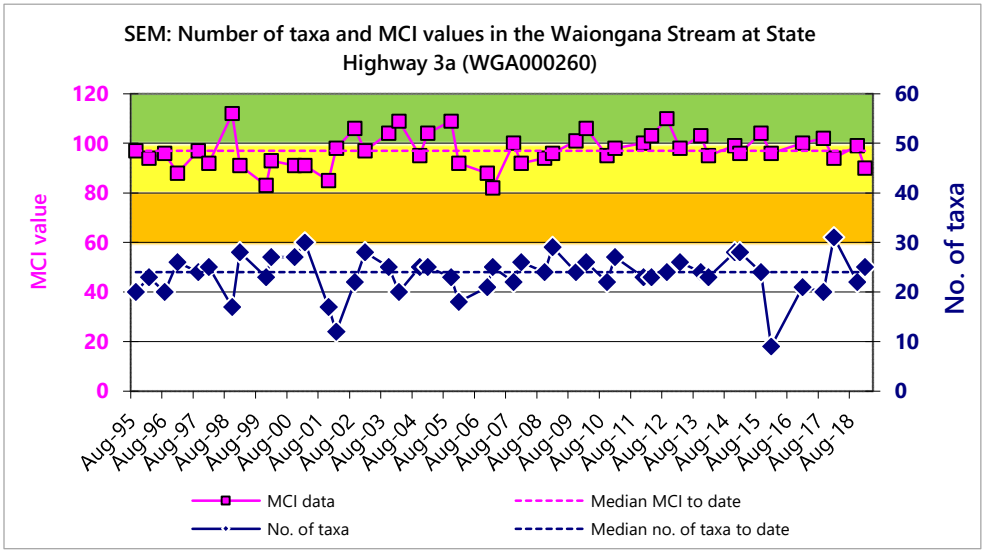


Figure 102 Numbers of taxa and MCI values in the Waiongana Stream at State Highway 3A

A wide range of richness (9 to 30 taxa) has been found; with a median richness of 24 taxa (more representative of typical richness in the mid-reaches of ringplain streams and rivers. During the current period, the spring (22 taxa) and summer (25 taxa) richness were similar to the historical median.

MCI values have also had a relatively wide range (30 units) at this site, relatively typical of a site in the mid reaches of a ringplain stream. The median value (97 units) also has been typical of mid-reach sites

elsewhere on the ringplain. The spring (99 units) and summer (90 units) surveys were not significantly different to the historical median. These scores categorised this site as having 'fair' health in spring and summer (Table 3). The historical median score (97 units) placed this site in the 'fair' category.

3.2.11.1.2 Predicted stream 'health'

The Waiongana Stream site at SH3a is 16.1 km downstream of the National Park boundary at an altitude of 140 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 100 for this site. The historical site median, spring and summer scores were not significantly different from this value. The REC predicted MCI value (Leathwick, et al. 2009) was 99 units. Again, the historical site median, srping and summer scores were also not significantly different to this value.

3.2.11.1.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 103). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was performed on the entire SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Waiongana Stream at SH3A.

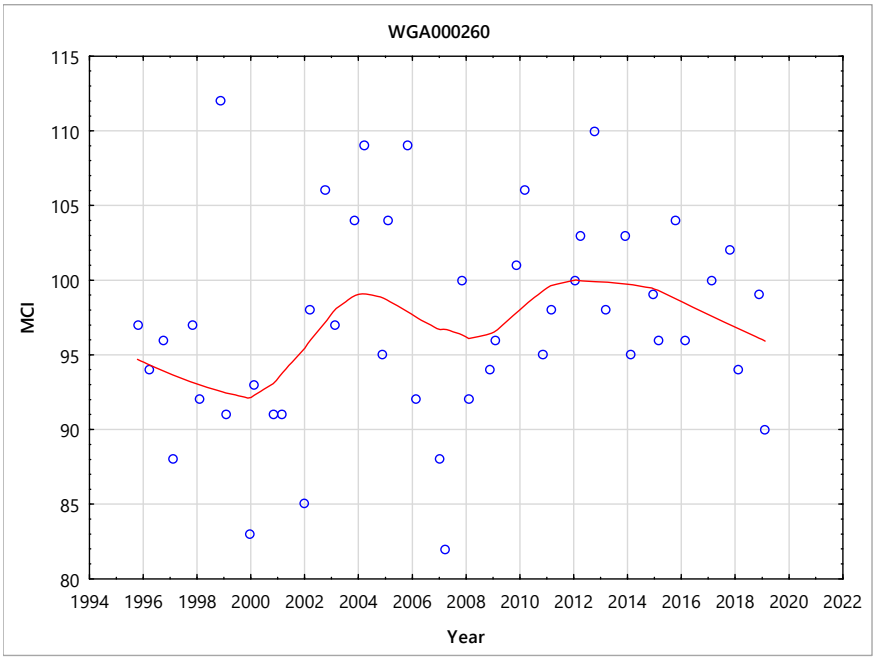


Figure 103 LOWESS trend plot of MCI data at the SH3A site

There has been a non-significant positive trend in the MCI scores with a steady improvement in scores between 2001 and 2004 followed by a decline in scores until 2008, and another steady increase until 2012, where subsequently another gradual decline is evident. This site's trendline had a range of eight units indicative of minor ecologically important variability over the period. Overall, the trendline was indicative of 'fair' generic stream health for the majority of the period, improving toward 'good' 'health' briefly in 2011 and 2012.

There was a non-significant negative trend in MCI scores over the most recent ten-year period, with a decline in the trendline from 2012 onwards. The trendline for the most recent ten-year period was indicative of 'fair' health.

3.2.11.2 Devon Road site (WGA000450)

3.2.11.2.1 Taxa richness and MCI

Forty-five surveys have been undertaken at this lower reach site, at SH45 in the Waiongana Stream, between October 1995 and February 2018. These results are summarised in Table 56, together with the results from the current period, and illustrated in Figure 104.

Table 56 Results of previous surveys performed in the Waiongana Stream at Devon Road together with spring 2018 and summer 2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WGA000450	45	12-29	22	72-102	89	21	90	21	82

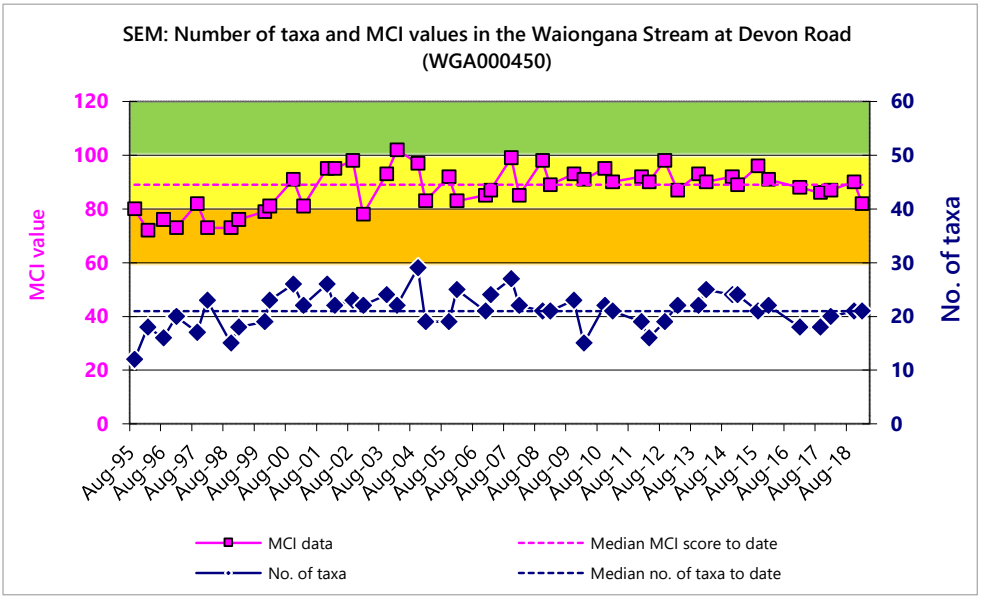


Figure 104 Numbers of taxa and MCI values in the Waiongana Stream at Devon Road

A wide range of richness (12 to 29 taxa) has been found with a median richness of 22 taxa, more representative of typical richness in ringplain streams and rivers in the lower reaches. During the current period, spring (21 taxa) and summer (21 taxa) richnesses were similar to the historic median.

MCI scores have had a relatively wide range (30 units) at this site typical of sites in the lower reaches of ringplain streams. The median value (89 units) also has been typical of lower reach sites elsewhere on the ringplain. The spring (90 units) and summer (82 units) scores were not significantly different from the historical median or to each other. These scores categorized this site as having 'fair' (spring and summer) health (Table 3). The historical median score (89 units) placed this site in the 'fair' category for generic health.

3.2.11.2.2 Predicted stream 'health'

The Waiongana Stream at Devon Road is 31.2 km downstream of the National Park boundary at an altitude of 20 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict MCI values of 93 for this site. The historical site median and spring score were not significantly different from this value but the summer score was significantly lower.

The REC predicted MCI value (Leathwick, et al. 2009) was 88 units. The historical site median, spring and summer scores were also not significantly different to this value.

3.2.11.2.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 105). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Waiongana Stream at Devon Road.

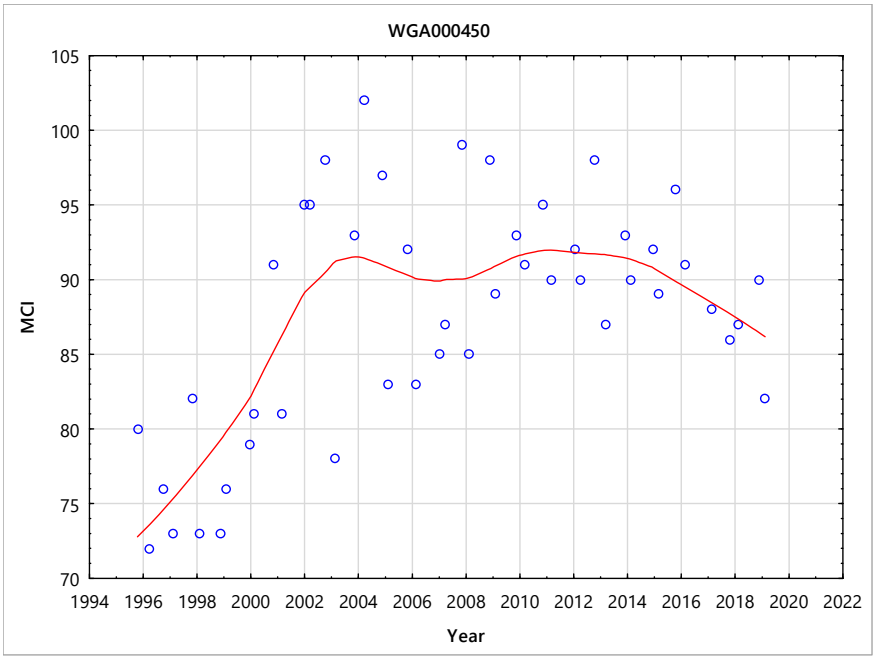


Figure 105 LOWESS trend plot of MCI data at the Devon Road site

MCI scores at this site have shown a statistically significant (FDR p =0.02) improvement over the period, despite little change since 2003. The trendline has varied over an ecologically important range of 19 units. This trend of improvement in stream 'health' at this site is much more pronounced than the trend at the site some 15 km upstream, indicating that activities in the catchment between these two sites have had a significant influence on the bottom site. Overall, the trendline has indicated significant improvement in generic stream 'health' from consistently 'poor' prior to 2000 to 'fair' where it has remained.

There was a non-significant negative trend in MCI scores over the most recent ten-year period, in contrast with the full dataset with a decline in the trendline from 2011 onwards. There was a significant decline prior to FDR application. The trendline for the most recent ten-year period was indicative of 'fair' health.

3.2.11.3 Discussion

Taxa richness for both sites were moderate and typical. The surveys indicated that the mid-reach (SH3a) site and the lower reach (Devon Road) were in 'fair' health. MCI scores typically decreased in a downstream for both spring (by nine units) and summer (by eight units) surveys, over a stream distance of 15.1 km. The decrease in score was probably attributable to diffuse and point source discharges that have caused nutrient enrichment.

The time trend analysis indicated non-significant trends at the upper site and a significant positive trend after FDR adjustment at the lower site over the entire monitoring period. Improvement has been coincident with a reduction in consented NPDC water abstraction and tighter control of an upstream piggery's waste loadings into the stream. However, there was a significant negative trend for the site prior to FDR adjustment over the most recent 10-year period suggesting a more recent decline in macroinvertebrate

health which may become significant if the trend persists. This decline mirrors that of the upper site but was more pronounced.

3.2.12 Waitara River

The Waitara River is Taranaki's largest river with significant catchment areas in both the eastern hill country and on the eastern side of the Taranaki ringplain. Two SEM sites are situated on the mainstream of the Waitara River.

3.2.12.1 Autawa Road site (WTR000540)

3.2.12.1.1 Taxa richness and MCI

This is the fourth set of surveys at this recently established middle reach site in the Waitara River, with surveys carried out between October 2015 and February 2018. These results are summarised in Table 57 and illustrated in Figure 106.

Table 57 Results of previous surveys performed in the Waitara River at Autawa Results with spring 2018 and summer 2019 results

Site code	SEM data (2015 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WTR000540	6	19-26	24	95-110	99	24	108	20	93

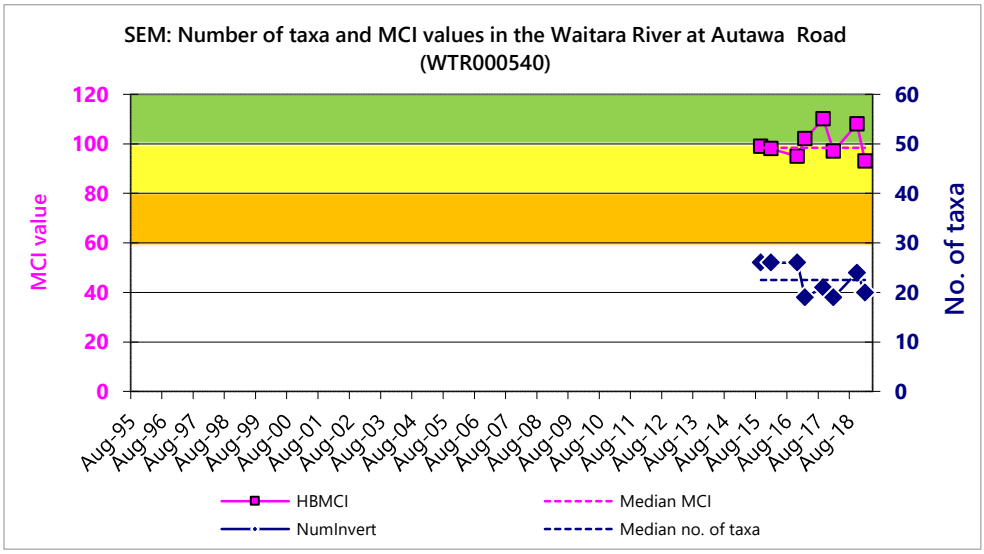


Figure 106 Numbers of taxa and MCI values in the Waitara River at Autawa Road

Slight variation in taxa richness (seven taxa) has been found with a median richness of 24 taxa. The low variation was to be expected given the small number of surveys that have been undertaken at the site. A moderate richness of 24 taxa was recorded for the spring survey with a lower, but still moderate taxa richness of 20 taxa recorded for the summer survey.

MCI values have had a relatively narrow range (15 MCI units) at this site. The median value (99 units) was slightly higher than typical lower reach sites elsewhere although lower reach sites in large hill country rivers tended to have had lower MCI values. The spring (108 units) and summer (93 units) were not significantly different to the historical median score though significantly different from each other. The summer score was the lowest score recorded to date for the site. These scores categorised this site as having 'good' health

in spring and 'fair' health in summer (Table 3). The historical median score (99 units) placed this site in the 'fair' category for generic health.

3.2.12.1.2 Predicted stream 'health'

The Waitara River site at Autawa Road, at an altitude of 100 m asl, is in the middle reaches the river draining a catchment comprised of eastern hill country. The REC predicted MCI value (Leathwick, et al. 2009) was 110 units. The historical median and summer score were significantly lower than this value and the spring score was not significantly different to this value.

3.2.12.1.3 Temporal trends

There is insufficient data to perform a time trend analysis for the site.

3.2.12.2 Mamaku Road site (WTR000850)

3.2.12.2.1 Taxa richness and MCI

Forty-five surveys have been undertaken at this lower reach site in the Waitara River between November 1995 and February 2018. These results are summarised in Table 58, together with the results from the current period, and illustrated in Figure 107.

Table 58 Results of previous surveys performed in the Waitara River at Mamaku Road together with spring 2018-2019 results

Site code	SEM data (1995 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WTR000850	45	8-32	18	64-107	86	19	93	9	64

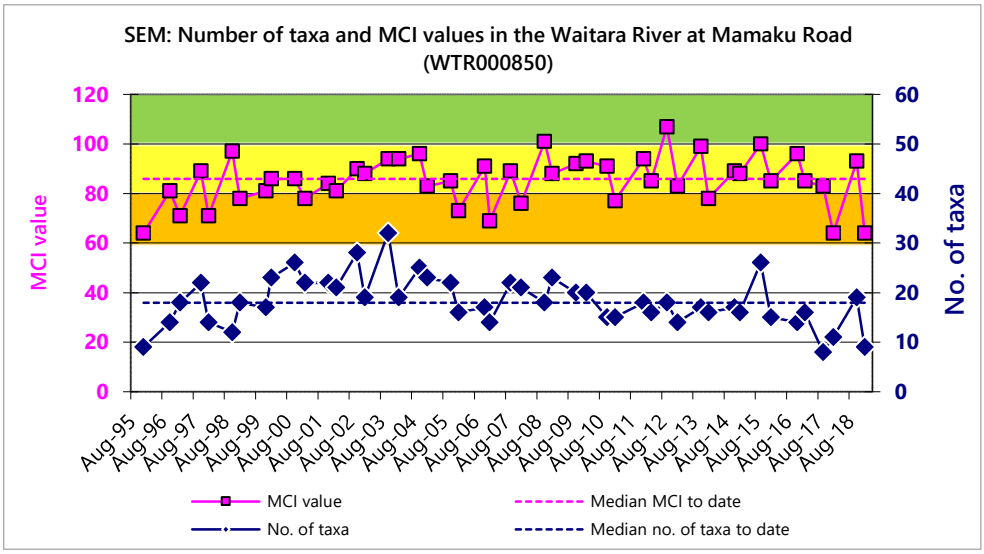


Figure 107 Numbers of taxa and MCI values in the Waitara River upstream of Methanex at Mamaku Road

A very wide range of richness (8 to 32 taxa) has been found with a moderate median richness of 18 taxa which was more representative of typical richness in the lower reaches of streams and rivers. During the current period, spring richness (19 taxa) was similar to the historical median but summer richness (9 taxa) was substantially lower and the second lowest taxa richness recorded to date at the site.

MCI values have had a very wide range (43 units) at this site which has not been unusual for sites in the lower reaches of large rivers. The historical median value (86 units) has also been typical of lower reach sites elsewhere although lower reach sites in large hill country rivers tended to have had lower MCI values. The spring score (93 units) was not significantly different to the historical median, but the summer score (64 units) score was significantly lower than this historical median and was the equal lowest MCI score recorded at this site to date (Stark, 1998). These scores categorised this site as having 'fair' (spring) and 'poor' (summer) health generically (Table 3). The historical median score (86 units) placed this site in the 'fair' category.

3.2.12.2.2 Predicted stream 'health'

The Waitara River site at Mamaku Road, at an altitude of 15 m asl, is in the lower reaches of a river draining a catchment comprised of both hill country and ringplain sub-catchments. The REC predicted MCI value (Leathwick, et al. 2009) was 98 units. The historical site median and summer score were significantly lower than this value while the spring score was not significantly different.

3.2.12.2.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) was produced (Figure 108). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1996-2019) and the most recent ten-years of results (2009-2019) from the site in the Waitara River at Mamaku Road.

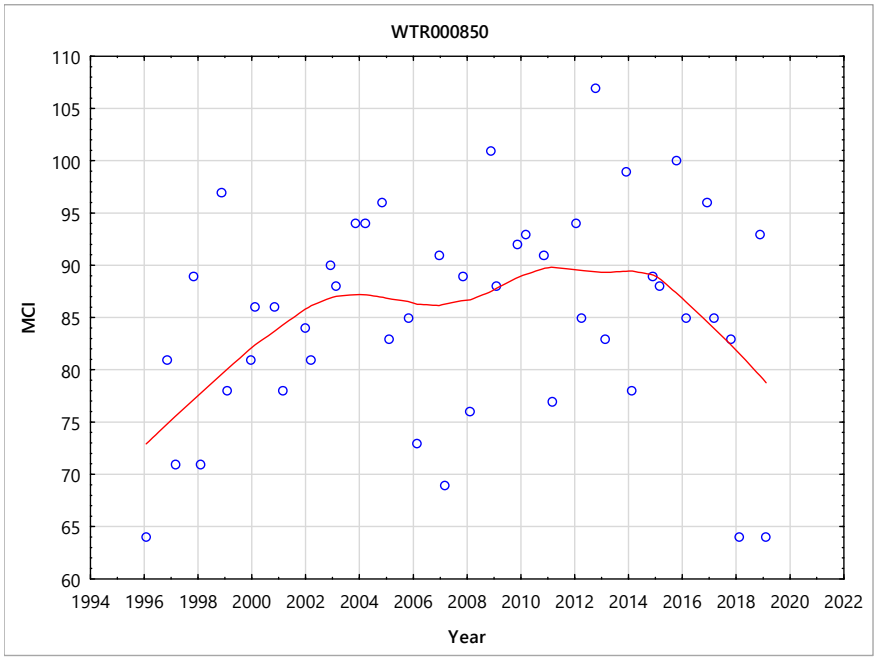


Figure 108 LOWESS trend plot of MCI data for the Mamaku Road site, Waitara River

There was a non-significant positive trend for the entire period. The trendline range (17 units) has been ecologically important over the period. The trendline has been indicative of a general improvement from 'poor' (in the first few years) to 'fair' generic river health but for the current period has declined back to 'poor' generic health.

There was a non-significant negative trend in MCI scores over the most recent ten-year period, in contrast with the full dataset, with a decline in the trendline from 2011 onwards. The trendline for the most recent ten-year period was indicative of 'fair' health health but for the current period has declined back to 'poor' generic health.

3.2.12.3 Discussion

Taxa richness for the upper site was moderate but the lower site had unusually low richness for the summer survey. The summer survey richness of nine taxa was the lowest recorded taxa richness to date while the taxa richness of 11 taxa for the summer survey was the third lowest richness to date.

The upper site had a new record low result for MCI but as there were only nine previous surveys this result was not unexpected. However, of far more concern, and coincident with the low summer taxa richness, was the lower site summer MCI score which was the equal lowest recorded to date for the site and indicated 'poor' health. The exact same score was recorded the previous summer indicating that it was not an aberrant result. Based on the taxa composition of the survey which contained a very abundant midge and caddisfly, acute pollution was unlikely. A combination of the long, dry summer period and nutrient enrichment has caused extensive algae to form in the riffle, which was observed at the time of sampling, is probably the main reason for the low score.

There was a downstream deterioration in macroinvertebrate health, 15 MCI units in spring and 29 MCI units in summer. The decrease in score was probably attributable to diffuse and point source discharges that have caused sedimentation and nutrient enrichment.

The time trend analysis found no significant trends over the full or ten-year datasets and it appears that there has been no significant change in macroinvertebrate community health though it should be noted the full dataset had a positive trend while the most recent ten-year period had a negative trend.

3.2.13 Waiwhakaiho River

The Waiwhakaiho River has a source inside Egmont National Park and flows in an easterly direction with its mouth situated in the city of New Plymouth. An additional site was established in the upper reaches of the Waiwhakaiho River for the 2002-2003 SEM programme, to complement the three sites in the central to lower reaches of this large ringplain river, in recognition of its importance as a water resource and particularly its proximity to New Plymouth city. The site was established a short distance inside the National Park boundary at an elevation of 460 m asl.

3.2.13.1 National Park site (WKH000100)

3.2.13.1.1 Taxa richness and MCI

Thirty-one surveys have previously been undertaken at this upper reach site just inside the National Park boundary in the Waiwhakaiho River between November 2002 and March 2018. These results are summarised in Table 59, together with the result from the current period, and illustrated in Figure 109.

Table 59 Results of previous surveys performed in the Waiwhakaiho River at National Park together with the 2018-2019 results

Site code	SEM data (2002 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WKH000100	31	4-29	19	115-147	130	21	139	33	126

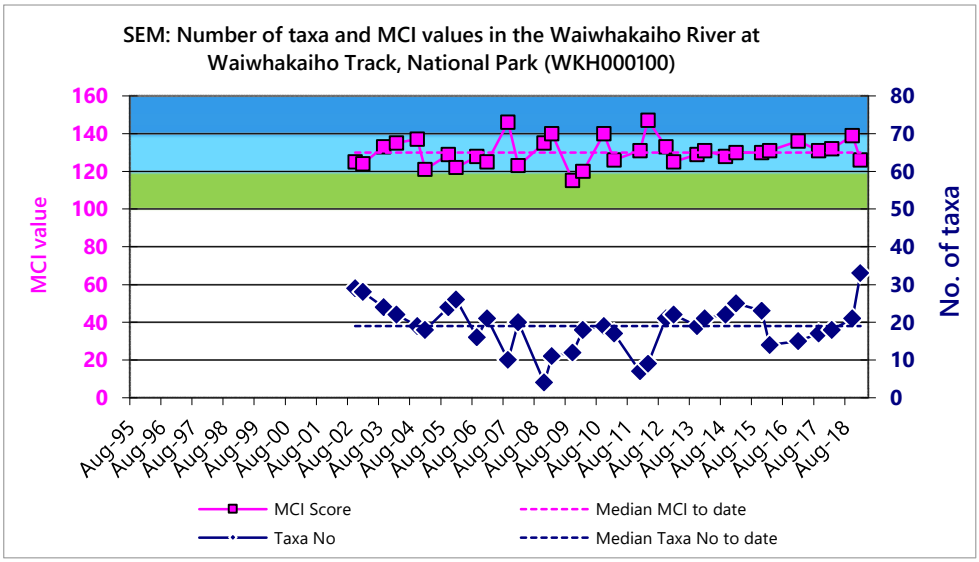


Figure 109 Numbers of taxa and MCI values in the Waiwhakaiho River at Egmont National Park

A wide range of richness (4 to 29 taxa) has been found, wider than might be expected due to headwater erosion effects over the 2008-2009 period with a median richness of 19 taxa, much lower than typical richness in ringplain streams and rivers near the National Park boundary. During the current period, spring (21 taxa) and summer (33 taxa) richness were similar to the median richness.

MCI values have had a wider range (32 units) at this site than typical of a National Park boundary site, due in part to an atypically very high value in 2008 following a marked drop in richness and low values after the 2008-2009 headwater erosion period. The spring (139 units) and summer (126 units) scores were not significantly different to the historical median but were significantly different to each other. The scores categorised this site as having 'very good' (spring and summer) health generically. The historical median score (130 units) placed this site in the 'very good' category for health.

3.2.13.1.2 Predicted stream 'health'

The Waiwhakaiho River site at the National Park is just inside the National Park boundary at an altitude of 460 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009) predict a MCI value of 132 for this site. The historical site median, spring and summer scores were not significantly different to the distance predictive value. The REC predicted MCI value (Leathwick, et al. 2009) was 137 units. The historical site median and spring score were not significantly different to this value but the summer score was significantly lower.

3.2.13.1.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 110). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (2002-2019) and the most recent ten-years of results (2009-2019) from the site in the Waiwhakaiho River at the National Park.

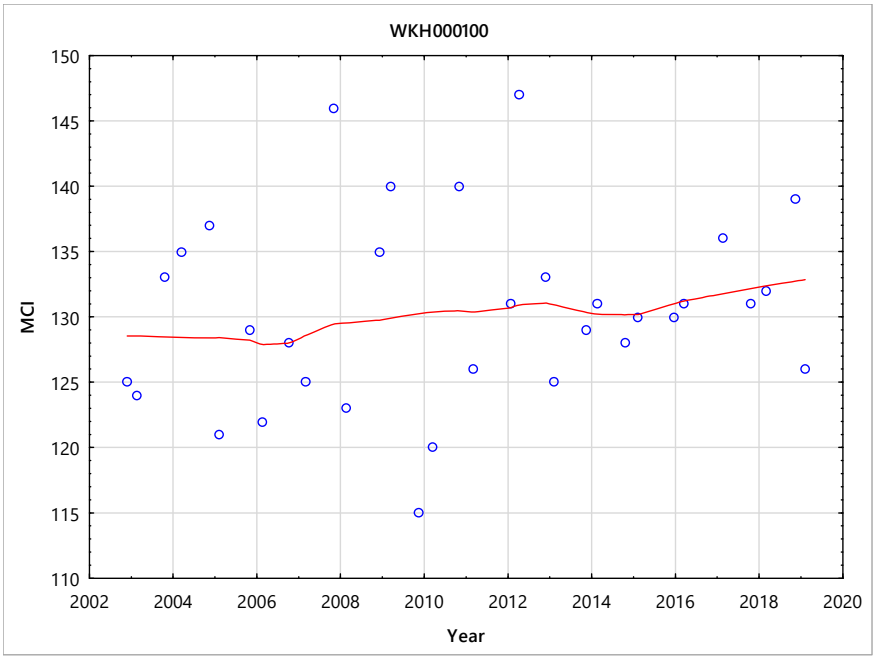


Figure 110 LOWESS trend plot of MCI data at the National Park site

No significant temporal trend in MCI scores has been found over the entire monitoring period at this site within the National Park. The trendline has a range of only five units and has consistently indicated 'very good' generic river health over the period.

There was a non-significant positive trend in MCI scores over the most recent ten-year period, congruent with the full dataset. The trendline for the most recent ten-year period was indicative of 'very good' health.

3.2.13.2 Egmont Village site (WKH000500)

3.2.13.2.1 Taxa richness and MCI

Forty-five surveys have been undertaken in the Waiwhakaiho River at this mid-reach site at SH 3, Egmont Village (above the Mangorei Power Scheme) between October 1995 and March 2018. These results are summarised in Table 60, together with the results from the current period, and illustrated in Figure 111.

Table 60 Results of previous surveys performed in the Waiwhakaiho River at Egmont Village together with the 2018-2019 results

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WKH000500	45	14-32	22	87-125	111	20	103	25	96

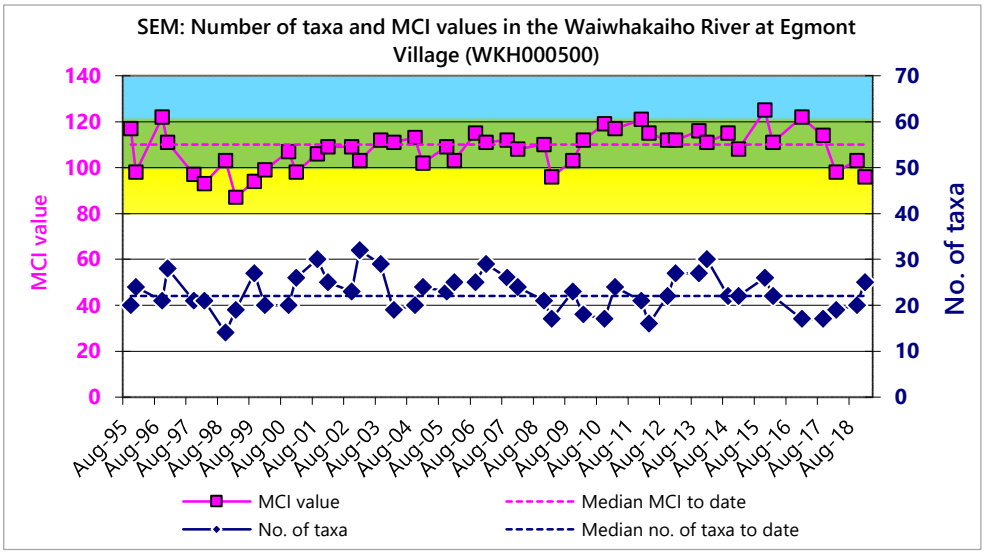


Figure 111 Numbers of taxa and MCI values in the Waiwhakaiho River at Egmont Village

A wide range of richness (14 to 32 taxa) has been found; wider than might be expected, with a median richness of 22 taxa (more representative of typical richness in the mid reaches of ringplain streams and rivers. During the current period the spring (20 taxa) and summer (25 taxa) surveys had moderate richness and were similar to the historical median.

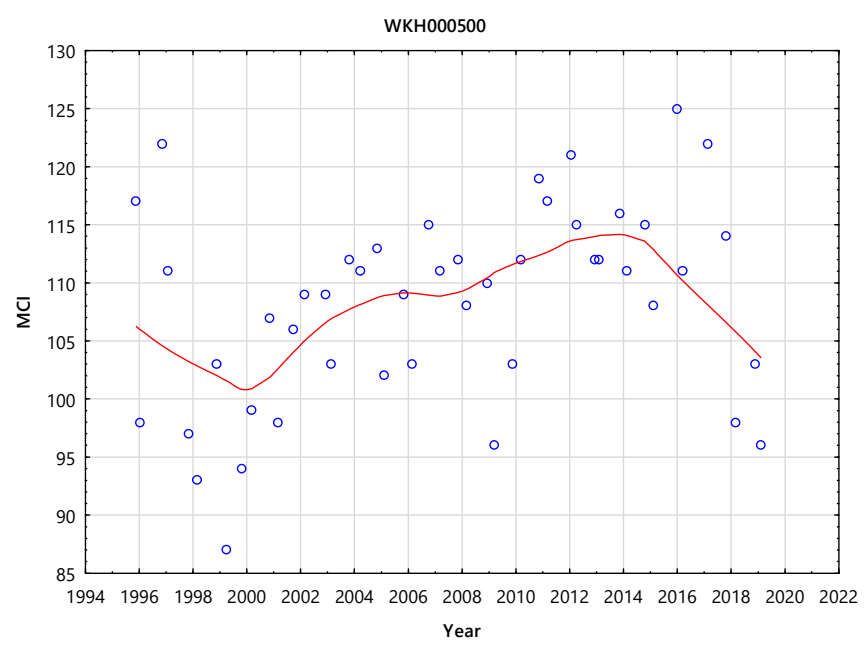
MCI values have had a slightly wider range (38 units) at this site than typical of sites in the mid reaches of ringplain rivers but the median value (111 units) has been relatively typical of mid reach sites elsewhere on the ringplain. The spring (103 units) score was not significantly lower than the historical median but the summer score (96 units) was significantly lower than the historical median. The scores categorised this site as having 'good' (spring) and 'fair' (summer) health generically. The historical median score (111 units) placed this site in the 'good' category for generic health.

3.2.13.2.2 Predicted stream 'health'

The Waiwhakaiho River site at Egmont Village is 10.6 km downstream of the National Park boundary at an altitude of 175 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict a MCI value of 105 for this site. The historical site median, spring and summer scores were not significantly different to the distance predictive value. The REC predicted MCI value (Leathwick, et al. 2009) was 115 units. The historical site median was not significantly different to this value but the spring and summer scores were significantly lower.

3.2.13.2.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 112). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on entire SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Waiwhakaiho River at Egmont Village.



N = 47
Kendall tau = 0.261
p level = 0.01
FDR p = 0.02

N = 19
Kendall tau = -0.268
p level = 0.11
FDR p = 0.40

Figure 112 LOWESS trend plot of MCI data at the Egmont Village site

A significant positive trend in MCI scores (FDR p = 0.02) has been found during the entire monitoring period indicating an overall improvement in macroinvertebrate health at the site. After some initial deterioration in scores, there has been a steady improvement from 1999 to 2016, where recently there has been a decline in scores. The trendline had a range of 13 units indicating some ecological variability and has consistently indicated 'good' generic river health over the period.

In contrast to the full dataset, there was a non-significant negative trend in MCI scores over the most recent ten-year period. The trendline for the most recent ten-year period was indicative of 'good' health.

3.2.13.3 Constance Street site (WKH000920)

3.2.13.3.1 Taxa richness and MCI

Forty-five surveys have been undertaken in the Waiwhakaiho River at this lower reach site at Constance Street, New Plymouth (below the Mangorei Power Scheme), between 1995 and March 2018. These results are summarised in Table 61, together with the results from the current period, and are illustrated in Figure 113.

Table 61 Results of previous surveys performed in the Waiwhakaiho River at Constance Street, New Plymouth, together with 2018-2019 results

Site code	SEM data (1995 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WKH000920	45	12-29	20	71-110	94	16	89	7	60

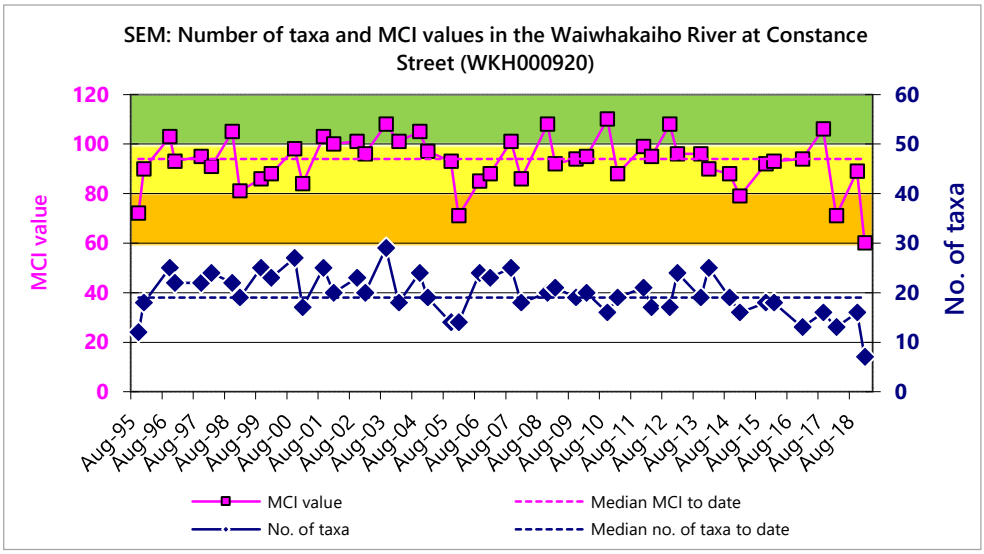


Figure 113 Numbers of taxa and MCI values in the Waiwhakaiho River at Constance Street

A wide range of richness (12 to 29 taxa) has been found with a median richness of 20 taxa which was more representative of typical richness in the lower reaches of ringplain streams and rivers. During the current period, spring (16 taxa) and summer (7 taxa) richness were four and 13 taxa lower than the median richness respectively. The summer richness of only seven taxa was the lowest recorded taxa richness to date at the site and furthermore was nearly half the previous lowest result of 12 taxa.

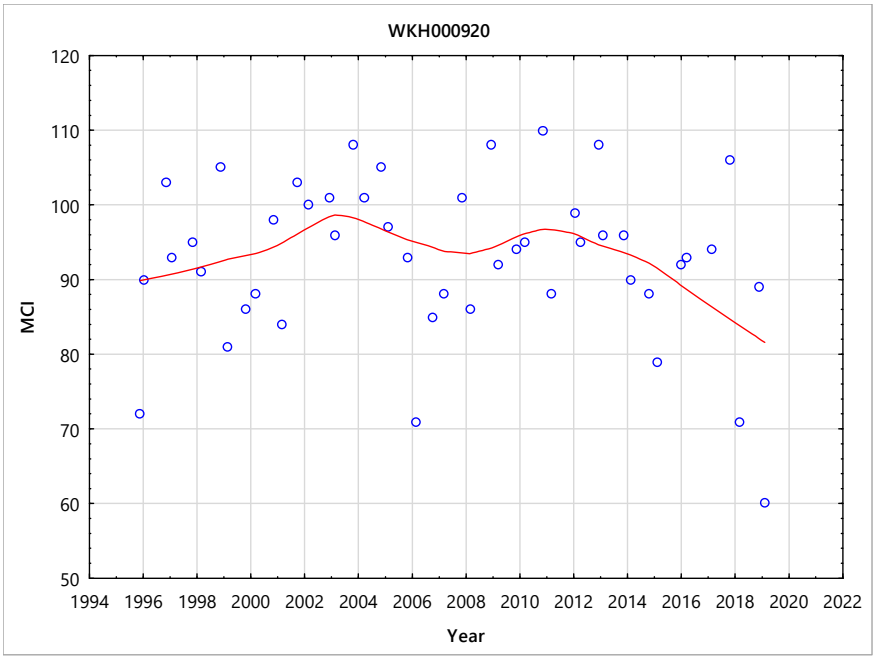
MCI values have had a wide range (39 units) at this site. The median value (94 units) has been relatively typical of scores at lower reach sites elsewhere on the ringplain. The spring (89 units) score was not significantly different to the historical median but the summer (60 units) score was significantly lower than the historical median and spring score and was the lowest score recorded at this site to date by a significant 11 units. There was a large decrease of 29 units between spring and summer, suggesting a rapid deterioration in water quality between the two sampling dates. The MCI scores categorised this site as having 'fair' (spring) and 'poor' (summer) health generically (Table 3). The historical median score (95 units) placed this site in the 'fair' category.

3.2.13.3.2 Predicted stream 'health'

The Waiwhakaiho River site at Constance Street, New Plymouth is 26.6 km downstream of the National Park boundary at an altitude of 20 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict a MCI value of 95 for this site. The historical site median and spring score was not significantly different to the distance predictive value while the summer score was significantly lower (Stark, 1998). The REC predicted MCI value (Leathwick, et al. 2009) was 97 units. The historical site median and spring scores were not significantly different to this value, while the summer score was again significantly lower.

3.2.13.3.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 114). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1995-2019) and the most recent ten-years of results (2009-2019) from the site in the Waiwhakaiho River at Constance Street.



N = 47
Kendall tau = -0.057
p level = 0.57
FDR p = 0.65

N = 19
Kendall tau = -0.349
p level = 0.04
FDR p = 0.22

Figure 114 LOWESS trend plot of MCI data at the Constance Street site

The overall negative trend in MCI scores has not been statistically significant for the period, due mainly to some decline and subsequent recovery in scores after 2003 and again since 2011. The trendline had a range of 16 units which indicates variability of ecological importance. Improvements from 1995 to 2003 may be due to a small increase in summer residual flows from the upstream HEPS, but conversely, the declines from 2011 may also be linked to an increase in the permitted take of the HEPS, among other factors. The trendline range indicated 'fair' generic river health for the entire period.

There was a non-significant negative trend in MCI scores over the most recent ten-year period with a decline in the trendline evident from 2011 onwards. The trendline was significant before FDR adjustment. The trendline for the most recent ten-year period was indicative of 'fair' health.

3.2.13.4 Site adjacent to Lake Rotomanu (WKH000950)

3.2.13.4.1 Taxa richness and MCI

Forty-three surveys have been undertaken in the Waiwhakaiho River at this lower reach site adjacent to Lake Rotomanu between November 1996 and March 2018. These results are summarised in Table 62, together with the results from the current period, and illustrated in Figure 115.

Table 62 Results of previous surveys performed in the Waiwhakaiho River the site adjacent to Lake Rotomanu, together with the 2018-2019 results

Site code	SEM data (1996 to March 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Nov 2018		Feb 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WKH000950	43	12-30	21	70-111	89	15	84	8	80

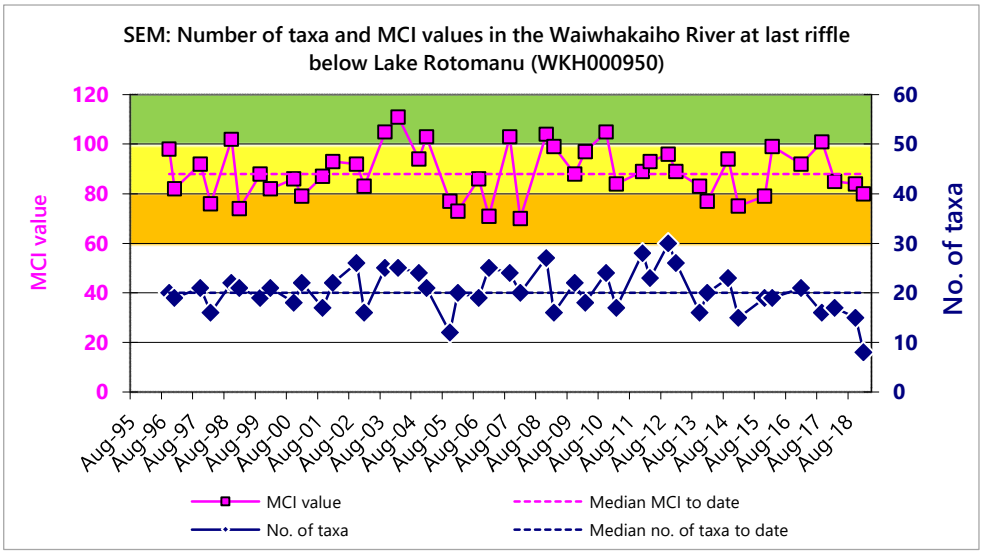


Figure 115 Numbers of taxa and MCI values in the Waiwhakaiho River at Lake Rotomanu

A wide range of richness (12 to 30 taxa) has been found; wider than might be expected, with a median richness of 21 taxa. During the current period spring (15 taxa) taxa was lower than the historical median while and summer (8 taxa) richness far lower than the historical median richness and was the lowest taxa richness recorded at the site to date.

MCI values have had a wide range (41 units) at this site but typical of variable scores at sites in the lower reaches of ringplain streams. The median value (89 units) has been relatively typical of lower reach sites elsewhere on the ringplain. The spring (84 units) and summer (80 units) scores were not significantly different from the historical median (Stark, 1998). The scores categorised this site as having 'fair' health. The historical median score (89 units) placed this site in the 'fair' generic health category (Table 3).

3.2.13.4.2 Predicted stream 'health'

The Waiwhakaiho River at the site adjacent to Lake Rotomanu is 28.4 km downstream of the National Park boundary at an altitude of 2 m asl. Relationships for ringplain streams developed between MCI and distance from the National Park boundary (Stark and Fowles, 2009), predict a MCI value of 94 for this site. The historical site median and spring and summer score were not significantly different to the distance predictive value but the summer score was significantly lower. The REC predicted MCI value (Leathwick, et al. 2009) was 97 units. The historical site median was not significantly different to the distance predictive value but both the spring the summer scores were significantly lower than the REC predictive value.

3.2.13.4.3 Temporal trends

A LOWESS trend plot with a moving average (tension 0.4) trendline was produced (Figure 116). A non-parametric statistical trend analysis of the MCI data using the Mann-Kendall test was then performed on the entire SEM results (1996-2019) and the most recent ten-years of results (2009-2019) from the site in the Waiwhakaiho River adjacent to Lake Rotomanu.

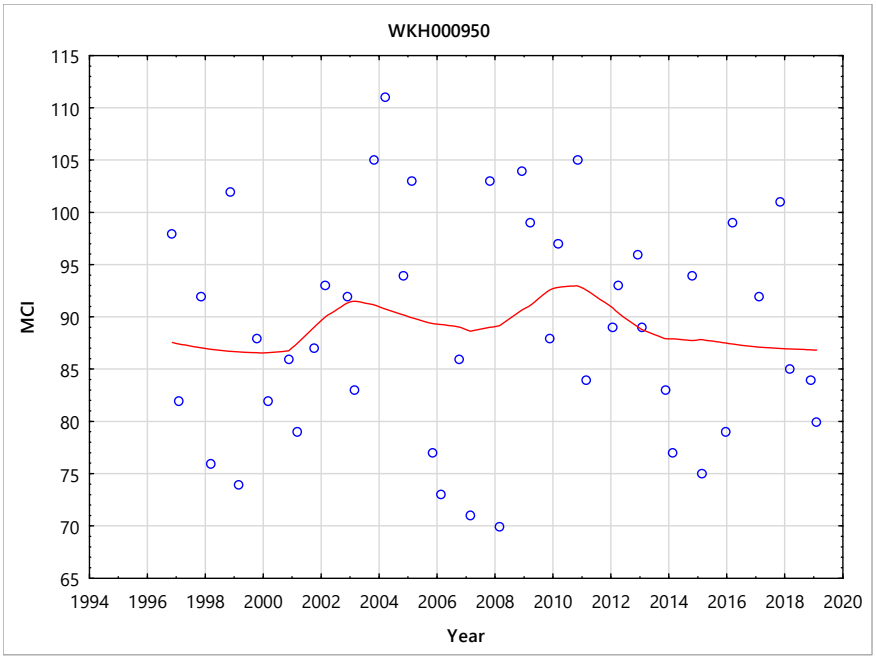


Figure 116 LOWESS trend plot of MCI data at the site adjacent to Lake Rotomanu

Overall, MCI scores have shown no statistically significant trend. There was an improvement from 1995 to 2003 but since 2004, there has been a steady decline in scores toward scores typically found in the first two years of the programme, followed by another improvement and subsequent decline. These are relatively similar trends to those found at the nearest upstream site (Constance St). The trendline covered a range of scores (six units) of marginal ecological importance which showed slightly more variability over the 2007 to 2015 period. The trendline indicated 'fair' generic stream 'health' throughout the period.

There was a non-significant negative trend in MCI scores over the most recent ten-year period. The trendline for the most recent ten-year period was indicative of 'fair' health.

3.2.13.5 Discussion

Taxa richness differed markedly between sites and between spring and summer surveys but generally decreased in a downstream direction. Richness was substantially lower than usual at the two lower sites during summer with both sites recording new record low richness. Very low taxa richness is often associated with poor water quality, either from chronic or acute pollution.

The surveys indicated that the upper site had a macroinvertebrate community in 'very good' health while the site near Egmont Village had typical 'good' health during spring but only 'fair' health during summer. The two lowest sites had 'fair' health in spring and 'poor' and 'fair', but only one unit away from 'poor', health in summer. Of particular concern was the Constance St site which had experienced its lowest ever MCI score of only 60 units, which was a significant 11 units lower than its next lowest score recorded score, and only one unit off the 'very poor' category. This poor result was coincident with the record low taxa richness at the site and was possibly due to poor preceding water quality. However, the dry summer period had caused widespread periphyton. The bottom site based on its taxa richness also seems to have been affected but not to the same degree as the Constance St site.

The MCI score consistently decreased in a downstream direction with an overall decrease of a highly significant 55 MCI units in spring and 46 MCI units, over a river distance of 28.7 km.

The time trend analysis indicated a positive significant trend for Egmont Village for the full data set while no other significant trends after FDR application occurred at other sites though there was a significant negative trend before FDR application at the Constance St site. The upper site was unlikely to change in condition as

it is in a National Park while the two lower sites are in the city of New Plymouth were subjected to urban and industrial sources of pollution as well as fluctuating flows from a hydro scheme. The site at Egmont Village has an upstream area dominated by agriculture and significant improvements in macroinvertebrate health at this site was likely due to improvements in farming practices. However, physiochemical trends show significantly increasing phosphorus and nitrate at the site, a key algal nutrient, and this may also be contributing to recent negative declines.

3.2.14 Whenuakura River

The Whenuakura River has a catchment that is in Eastern Hill country, with the lowest portion in the Taranaki southern marine terrace. The river flows in a southerly direction, with a mouth between the townships of Patea and Waverly. One site in this river was included in the SEM programme in 2015, for the purpose of monitoring an additional site in the Eastern Hill country. The site is located in the lower reaches of the river, at an altitude of approximately 20 m; some ten km from the coast.

3.2.14.1 Whenuakura River at Nicholson Road site (WNR000450)

3.2.14.1.1 Taxa richness and MCI

This is the fourth year of monitoring at this lower reach site in the Whenuakura River. The results from previous surveys, and the current period, are presented in Table 63, and illustrated in Figure 117.

Table 63 Results of previous surveys performed in the Whenuakura River at Nicholson Road, together with 2018-2019 results

Site code	SEM data (2015 to February 2018)					2018-2019 surveys			
	No of surveys	Taxa numbers		MCI values		Oct 2018		March 2019	
		Range	Median	Range	Median	Taxa no	MCI	Taxa no	MCI
WNR000450	6	17-32	18	81-94	88	16	99	21	71

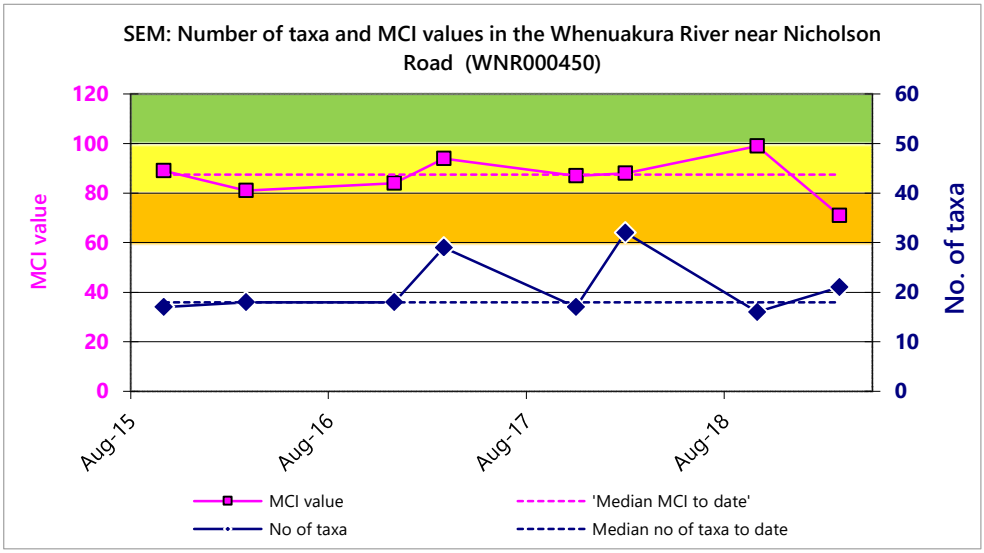


Figure 117 Numbers of taxa and MCI values in the Tangahoe River at Upper Tangahoe Valley Road

During the current period, spring (16 taxa) and summer (21 taxa) richness were moderate but the spring score represented a new minimum for the site, even though it was only two taxa different from the historical median.

Historical MCI values have had a narrow range (13 units) at this site, which was expected given only six surveys have been completed at the site. The historic median value (88 units) was slightly higher than was typical of mid reach sites elsewhere as recorded at 'control' sites located at similar altitudes in hill country rivers and streams. The spring (99 units) and summer (71 units) scores were both significantly different from each other and to the historical median with the spring score representing a new maximum for the site and the summer score a new minimum. Again, as there have been so few surveys conducted at the site new minimum and maximum values are likely to be regularly recorded in the first few years of monitoring. The scores categorised this site as having 'fair' health in spring and 'poor' health in summer. The historical median classified this site as having 'fair' health (Table 3).

3.2.14.1.2 Predicted stream 'health'

The Whenuakura River at Nicholson Road, at an altitude of 20 m asl, is toward the lower reaches of this low gradient river draining an eastern hill country catchment. The REC predicted MCI value (Leathwick, et al. 2009) was 109 units and therefore the historical median and summer scores were both significantly lower than this value and the spring score was not significantly different (Stark, 1998).

3.2.14.1.3 Temporal trends in data

There was insufficient data to perform time trend analysis which requires a minimum of ten years data.

3.2.14.2 Discussion

Taxa richness were moderate during spring and summer with minor seasonal variation of five taxa. The spring taxa richness represented a new low but given this was very similar to the current historical median was of no consequence. The site was in 'fair' health during both spring and summer at the time of surveys. However, there was significant variation in MCI score between the spring and summer surveys with new maximum and minimum scores recorded. In particular, the summer score was ten units lower than the next lowest value and even for such a small dataset would appear to be an atypically low score.

4 General discussion and conclusions

The detection of trends in the biological data requires a data set of suitable period and collected using rigid, acceptable protocols, to be statistically valid e.g. a minimum of ten-years of spring and summer surveys. With 24 years of data available for most sites, temporal trend analyses have been updated further within this report. For the fourth time, there has also been analysis presented of the results from the most recent ten-year period for each site where available. This represents a compromise between degree of certainty in any apparent trends, and an indication of current as distinct from historical directions of travel. Other comments in relation to the data collected in the period 1995 to 2019, are presented briefly below. These data are summarised in Appendix II and illustrated in Figure 118 to Figure 124.

4.1 Macroinvertebrate fauna communities

In general terms, data have indicated that the macroinvertebrate communities at sites in upper reaches of catchments have been comprised of a greater proportion of taxa that are 'sensitive' to the effects of nutrient enrichment or a poorer state of habitat, compared with communities in the mid and lower reaches of catchments. These changes in community composition have resulted from the effects of nutrient enrichment, sedimentation, turbidity, increased sunlight (less riparian shading and potentially wider rivers), higher temperatures, increased algal and macrophyte growth, lower water levels, and less aeration (mixing) resulting in lower dissolved oxygen.

Taxa richness: (number of different taxa) at most sites in these streams and rivers more often showed higher richness in the upper reaches of catchments. However, a range of factors may influence taxa richness, and some upper sites were negatively affected by headwater erosion events. Taxa richness can sometimes be increased by mild nutrient enrichment and therefore care needs to be taken when interpreting taxa richness results. However, taxa richness is very useful when determining the presence or effects of pollution events as releases of toxic discharges will invariably lower richness. At middle and lower reach sites there was more seasonal variability in richness, probably as a result of greater seasonal changes in periphyton and to a lesser extent macrophyte biomass. Seasonal richness often have tended to be higher in summer than in spring, particularly at lower reach sites.

Macroinvertebrate community index: sites in the middle and the lower reaches of streams and rivers generally had lower summer MCI scores than spring MCI scores as evidenced by overall decreases in mean scores by twelve and nine units respectively whereas mean seasonal scores at upper reach sites decreased by only four units for the current monitoring year. These differences were due to the reasons outlined above, and possibly due to lifecycle patterns as well. Some taxa will be present in spring as large nymphs but will not be recorded in summer samples as they will be at an egg or first instar (usually impossible to ID to genus) stage. This has resulted in additional less 'sensitive' taxa being present and/or increases in the presence of lower scoring 'tolerant' taxa in summer surveys.

Furthermore, the results from the 2018-2019 have shown that:

- The mean (106 units) and median (102 units) spring MCI scores were higher than the mean (97 units) and median (94 units) summer MCI scores.
- A paired two sample t-test of spring and summer MCI scores showed that there was highly significant seasonal variation ($N = 59$, t-value = 7.07, $p < 0.01$).
- At upper reach sites there was an decrease in average MCI score of four MCI units in summer which was not statistically significant ($N = 8$, t-value = 1.42, $p < 0.10$).
- At mid reach sites, a decrease in average MCI score of nine units in summer was highly statistically significant (($N = 28$, t-value = 5.62, $p < 0.01$).

- At lower reach sites, a decrease in average MCI scores of 12 units in summer was highly significant (N = 23, t-value = 4.66, $p < 0.01$).
- The historical spring medians (average 104 MCI units) were significantly higher, by three MCI units on average, than the historical summer medians (average 101 MCI units) (N = 59, t-value = 7.69, $p < 0.01$)

There were three new maxima and eight new minima MCI scores recorded during the 2018-2019 period. This result was considerably worse than the seven new maxima and one new minima recorded in the preceding 2017-2018 period. One of the three new maxima and one of the eight new minima were from one of the two sites established in the 2015-2016 period and hence was of little comparative significance.

Furthermore, seven sites in summer had 'poor' scores and one site had a 'very poor' score while only two sites in spring had 'poor' scores, which were in the Mangati Stream. The Mangati Stream is known to have a variety of water quality issues and therefore the stream typically has poor scores.

4.1.1 Spring and summer MCI values vs median values and predictive scores

The MCI scores from the spring and summer surveys are compared with the historical medians generated from 23 years of data (1995-2018) from the SEM programme and with two predictive scores (summarised in Appendix II): modelled based on distance from the National Park, and referenced against equivalent REC sites (national). Those sites' median MCI scores which deviated significantly (> 10 MCI units) from predicted scores are listed individually in Appendix II.

4.1.2 Spring surveys

4.1.2.1 Historical SEM

Forty-nine of the 59 sites had spring MCI scores which were not significantly different (within ten units) to their historical medians. Ten sites had a significantly better than normal scores and there were no sites that had significantly worse than normal scores (Figure 118). In addition, 14 sites had scores that were between six to ten units higher and four sites had scores that were between four to ten units lower than historical spring medians. This indicates slightly better than average results for the spring period.

Spring MCI scores relation to SEM historical median values

Figure 118 Spring MCI scores in relation to SEM historical spring median values

4.1.2.2 Predictive TRC ringplain distance model (distance from Egmont National Park)

Predictive scores have been developed for ringplain sites (38 sites) with their sources inside the National Park in relation to distance from the National Park (Stark and Fowles, 2009). Spring scores have been assessed against predicted scores for distance in Figure 119.

Spring MCI scores relation to predicted downstream distance scores

Figure 119 Spring MCI scores in relation to predicted downstream distance scores

Twenty-five of the 38 sites had spring MCI scores which were not significantly different (within ten units) to their predicted MCI scores based on distance from the National Park. Twelve sites had spring MCI scores more than ten units above the distance predicted values while only one site had a score significantly lower than predicted. Five sites had a score between six to ten units above the predicted value while three sites had a score between six to ten units below the distance predictive value. Again, this indicates slightly better than average results for the spring period with more sites significantly better than predictive results than significantly worse.

4.1.2.3 Spring MCI scores in relation to the REC predictive score

Leathwick (2009, pers comm.) has developed predictive scores based upon the River Environmental Classification (REC) system for New Zealand rivers and streams (Snelder et al, 2004). REC classifies and maps river and stream environments in a national spatial framework for management purposes.

Spring MCI scores have been compared with the REC predictions for all sites surveyed in spring. REC predictions are calculated by averaging current MCI scores for a particular REC segment type as well as taking into account other additional environmental and physical factors (see Leathwick, 1998).

Seven sites had spring MCI scores more than ten units above predicted values (Figure 120) and nine sites had values significantly lower than predicted values. A further seven sites had scores between six to ten units above the predicted value and five sites had scores between six to ten units below the predicted value. Generally, REC predictive scores are higher than historical and distance predictive scores and therefore current survey results do not perform as well against them compared with the other two predictive measures.

Spring MCI scores relation to REC predictive values

Figure 120 Spring MCI scores in relation to REC predictive values

4.1.3 Summer surveys

4.1.3.1 Historical SEM

A majority (47 of 59 sites) of sites' faunal communities' MCI scores were similar to (within 10 units) historical SEM site median scores (Figure 121). There were no significantly higher scores found while twelve sites had MCI scores significantly lower than their respective historical median score. A further seven sites had scores between six to ten units above the long-term value and 14 sites had scores between six to ten units below the long-term value.

Summer MCI scores relation to SEM historical median values

Figure 121 Summer MCI scores in relation to SEM historical median values

This indicates that summer macroinvertebrate health was significantly poorer than usual. This could be attributed to the drier than usual summer period which had very low flows and long times between when a survey was undertaken and time since the last significant fresh.

4.1.3.2 Predictive TRC ringplain distance model

Summer scores for each ringplain site (38 sites) have been assessed against predicted scores (Stark and Fowles, 2009) for distance from the National Park boundary for those ringplain sites with sources inside the National Park. A majority (24 of 38 sites) of sites' faunal communities' MCI scores were similar to (within 10 units) their distance-based predictive scores (Figure 122).

Summer MCI scores relation to predicted downstream distance scores

Figure 122 Summer MCI scores in relation to predicted downstream distance scores

Four sites had scores more than ten units above predicted values and ten sites had scores more than ten units below predicted values. A further six sites had scores between six to ten units above the predicted value and ten sites had scores between six to ten units below the predicted value. Again, this could be attributed to the drier than usual summer period. All the sites with a greater than 10 units decrease from predicted distance had a significant negative relationship between 3x and/or 7x days since a median flow fresh and MCI scores. This, in combination with the long recession periods between freshes and sampling for the current summer period would explain the poorer than usual scores.

4.1.3.3 Summer MCI scores in relation to the REC predictive scores

Summer MCI scores have been compared with the REC predictions for all 59 sites. REC predictions were calculated by averaging current MCI scores for a particular REC segment type as well as taking into account other additional environmental and physical factors (see Leathwick, 1998).

Summer MCI scores relation to REC predictive values

Figure 123 Summer MCI scores in relation to REC predictive values

One site had a summer MCI score more than ten units above predicted values (Figure 123) with 28 sites significantly lower than predicted. A further three sites had scores between six to ten units above the predicted value and 14 sites had scores between six to ten units below the predicted value.

Generally, REC predictive scores are higher than historical and distance predictive scores and therefore current survey results do not perform as well against them compared with the other two predictive measures. As Taranaki summer MCI scores are usually lower than spring scores this discrepancy is further exasperated.

4.1.3.4 Predictive value overview

The general seasonal trend in MCI scores is summarised in Table 64, which provides the percentages of sites' scores in relation to historical medians and predicted scores.

Table 64 Percentages of spring and summer MCI scores for ringplain sites with sources arising in the National Park in relation to historical median, predicted distance from National Park boundary score (Stark and Fowles, 2009) and national REC-based scores (Leathwick, 1998)

Season	Spring			Summer		
Prediction	> 10 units higher	± 10 units	> 10 units lower	> 10 units higher	± 10 units	> 10 units lower
Median	17%	83%	0%	0%	80%	20%
Distance	32%	66%	3%	11%	63%	26%
REC	12%	73%	15%	2%	51%	47%

In general, MCI scores were more likely to be significantly higher than lower compared with historical medians in spring and significantly lower than higher for summer with the majority of sites not significantly different to its historical median.

Again, MCI scores were more likely to be significantly higher than lower for predictive distance scores in spring and significantly lower than higher for summer with the majority of sites not significantly different to predictive scores. Usually both spring and summers scores were significantly higher, which was probably due to sites having improved since the distance-based predictive equations were created using data from 1981-2006. However, the current summer scores were poorer than usual indicating a particularly poor summer result. The summer period had significantly longer than usual recession flows, as measured by days since 3x and 7x median flow fresh, than usual resulting in low flows and longer than usual times between bed moving freshes.

An analysis of the data where information on freshes is available indicates that stream health, as measured by MCI scores, was negatively correlated with the time between sampling and the last significant fresh. This was likely due to a variety of factors. Freshes scour and mobilise the streambed, removing periphyton mats and filaments whose biomass can accumulate to levels likely to have a negative impact on macroinvertebrate community health. In particular, more 'pollution tolerant' species graze on and inhabit excessive periphyton growths. Fine sediment will accumulate over time in even relatively energetic flows such as those found in riffles, which are targeted for sampling in the TRC SEM macroinvertebrate monitoring programme. In lower flows filling in of interstitial spaces in riffles, which are an important habitat for 'pollution sensitive' species such as EPT (mayflies, stoneflies and caddisflies), will remove that habitat and lead to poorer stream health. This loss of habitat is in conjunction with the loss of habitat from smothering of the streambed from periphyton. However, research focused on the 2019 drought in the Tasman Region found "when water quality is good, periphyton will not usually proliferate to nuisance levels and invertebrate diversity will be maintained during low flow conditions" (Shearer and James, 2020). Less flow could also result in less available wetted area which would decrease available habitat even with good water quality. This was considered an important hydrologic effect of the drought in the Tasman Region (Shearer and James, 2020), and though this would reduce total macroinvertebrate numbers in a stream less habitat would not necessarily reduce MCI scores, though other associated factors may have a significant effect.

Other factors such as nutrients and temperature can have important interactive and antagonistic effects and therefore the importance of the preceding hydrological regime will vary at the site level (Piggott et al.,

2015). Excessive periphyton will also cause increases in pH due to photosynthesis, which would make other contaminates, such as ammonia, more toxic. Furthermore, photosynthesis will cause diurnal changes in dissolved oxygen, with potentially supersaturated dissolved oxygen levels during daylight hours followed by large drop-offs in dissolved oxygen at night when the periphyton respires and uses oxygen. In addition, low stream flows could lead to greater diurnal temperature variation within a stream and thermal stress. Essentially, the dry weather could potentially cause changes to a range of a factors that will interact with each and other site specific factors resulting in a range of different effects that will influence local macroinvertebrate communities making cause and effect for specific variables difficult to ascertain, which is further compounded by correlation of variables not necessarily indicating causation.

The more recently created REC predictive scores showed a similar pattern except there was little difference between significantly higher versus significantly lower spring scores, with again the majority not significantly different. The summer results showed nearly as many sites were significantly lower than not significantly different with only one site significantly higher (Table 64). This again highlights that the summer results were particularly poor and that Taranaki sites were in not as good a condition as general NZ sites during the summer under review.

Sites were ranked based on the deviation from historical median compared with predictive values for distance from the National Park and REC values. This effectively indicates which sites are 'better than expected' or 'worse than expected' once the particular characteristics of the site are taken into account (to the extent that these characteristics are accounted for in the modelling). Table 65 provides the rankings on this basis of the best and poorest sites in the SEM programme.

Table 65 Ranking of five best and worst sites' based on deviation from historical medians from predictive scores

	Distance from National Park	REC
BEST	Waingongoro R @ Opunake Rd	Huatoki S @ Domain
	Manganui R. SH3	Patea R @ Barclay Rd
	Patea R @ Barclay Rd	Kapoaiaia S @ Wiremu Rd
	Kaupokonui S @ Opunake Rd	Katikara S @ coast
	Waingongoro R @ SH45	Waingongoro R @ Opunake Rd
WORST	Waimoku S @ coast	Mangaehu Rd @ Raupuha Rd
	Kapoaiaia S @ coast	Whenuakura R @ Nicholson RD
	Punehu S @ SH 45	Mangati S @ Bell Block
	Kapoaiaia S @ Wataroa Rd	Kaupokonui S @ u/s Lactose Co.
	Waiwhakaiho R @ coast	Mangawhero S @ Eltham

The majority of the best ranked sites were located higher up the catchment for both predictive measures but with some exceptions. The Waingongoro River site at SH45 is located in the lower reach close to the coast. The site has good riparian cover, cobble substrate and swift, well aerated flow which probably contributed to its better than predicted score. The Huatoki Stream in the Domain at New Plymouth also has extensive riparian cover provided by the Domain constituting intact native bush, but is excluded from the distance ranking as this stream is sourced outside of the National Park. The other notable exception is the coastal Katikara site. This site had some riparian vegetation but was otherwise unremarkable.

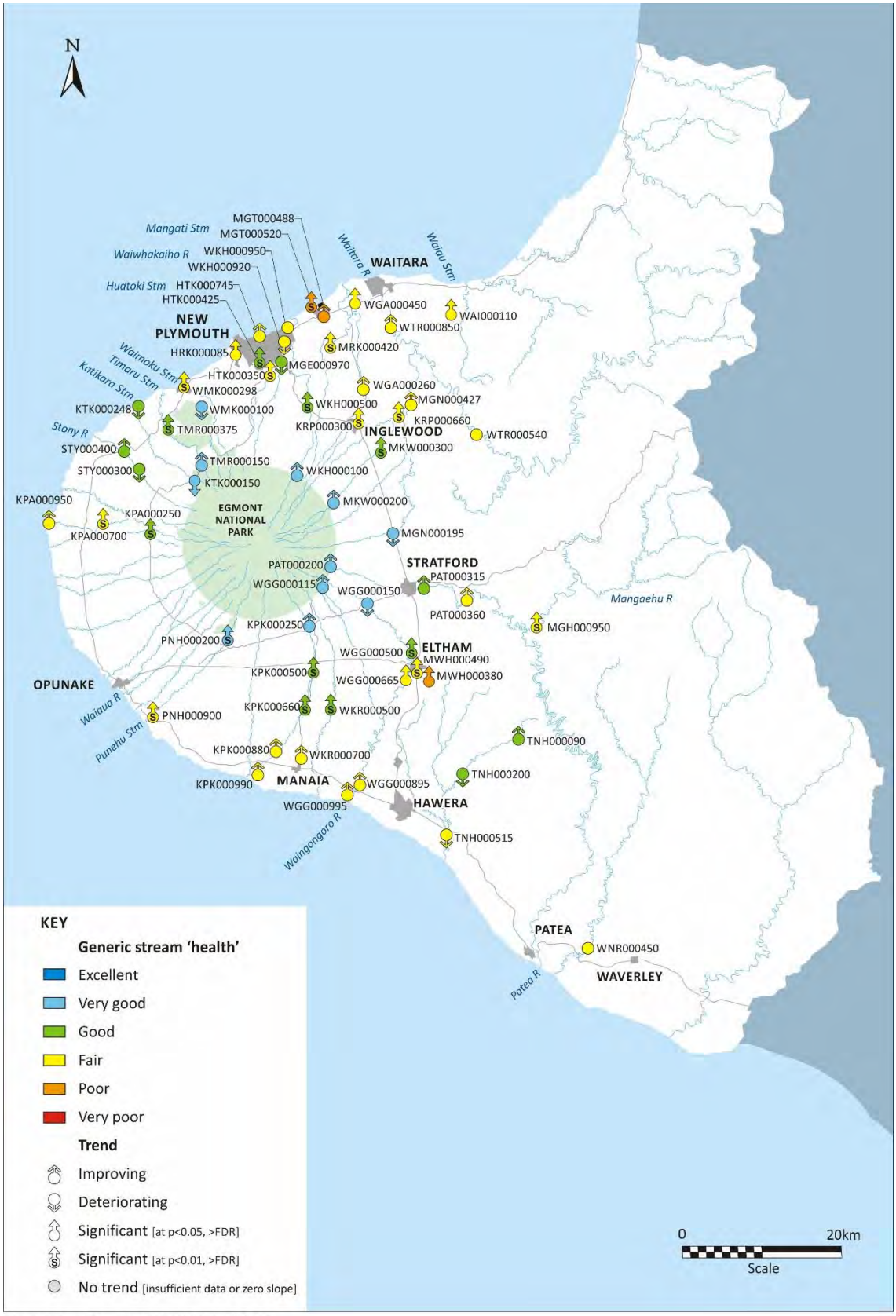
Sites in the lower reaches of shorter ringplain streams (e.g. Punehu, Kapoaiaia and, in particular the Waimoku Stream), have had historical median MCI scores showing the greatest disparity between actual and predicted scores for distance from the National Park (see Appendix II). Care needs to be used when

comparing actual scores with predictive scores as there is likely to be discrepancies, as predictive values are not likely to be perfect and give only a generalised indication of what a site's MCI score is expected to be.

The majority of the poorest ranked streams were located in the lower reaches of catchments with the Kapoaiaia Stream (with very limited riparian cover) notable for its poor ranking as demonstrated by the stream having two sites in the bottom five worst sites for the Distance predictive value. The Mangaehu River and the two small, non-National Park sourced streams (Mangati and Mangawhero), which used to receive significant point source discharges rank poorly in terms of the REC predictions. (Note: these streams and river sites were excluded from the distance predictive rankings as these catchments are located well away from the National Park).

4.1.4 Stream 'health' categorisation

A gradation of biological water quality conditions based upon ranges of MCI scores has been used to determine the 'health' generically (Table 3) of each site by utilising the historical median score. These assessments are summarised in Figure 124 along with the time trend analysis indicating whether a site was significantly improving, improving, stable, deteriorating or significantly deteriorating after FDR adjustment.



Generic biological health trends for SEM sites 95 to 19

Figure 124 Generic biological 'health' based on the historical median MCI and trends in biological quality for SEM sites

No sites had historical medians in 'excellent or 'very poor' health. Sites in 'very good' health were invariably close to the National Park with sites in 'good' health typically in mid-reach sites. Sites in the lower reaches of streams and rivers and Eastern Hill Country sites tended to be in 'fair' condition while two sites in Bell Block and one site in Eltham were in 'poor' condition.

The 'health' of streams in relation to the location of sites (upper, middle and lower reaches) in catchments is summarised in Table 66.

Table 66 Stream 'health' site assessments according to catchment reach in terms of historical median MCI score

'Health' grading (Median MCI score range)	Reaches		
	Upper	Middle	Lower
Excellent (≥140)	0	0	0
Very good (120-139)	7	4	0
Good (100-119)	1	12	3
Fair (80-99)	0	11	18
Poor (60-79)	0	1	2
Very poor (<60)	0	0	0
Median ranges (MCI units)	100-138 (38)	74-130 (55)	67-108 (41)

Typically generic 'health' (in terms of median MCI scores) decreases in a downstream direction from 'very good' in the upper reaches of catchments, through predominantly 'good-fair' in the middle reaches, to mainly 'fair' in the lower reaches toward the coast. Each site's 'health' may vary between seasons, but seldom by no more than one category (grading) either side of this median grading in response to preceding stream flow and associated habitat (physical and physicochemical water quality) conditions. In this regard generally there has been a similar level of seasonal variability in scores between middle and lower catchment sites. Upper catchment sites tend to show far less variability. However, there were also far fewer upper reach sites surveyed compared with middle or lower reach sites which limits the usefulness of direct comparisons examining total variability.

The Government's *National Policy Statement for Freshwater Management 2014*, as amended in 2017, does not specify a 'bottom line', or minimum standard, for MCI. However, it does specify that a council must establish '*methods…to respond to a Macroinvertebrate Community Index score below 80*'. The grounds given for this requirement are the more general requirement that councils must establish methods for responding to any monitoring results that indicate freshwater objectives will not be met (one compulsory objective being that ecosystem processes are safeguarded) and/or that values will not be provided for (the relevant compulsory value being ecosystem health). While there are only three sites that have a median MCI value of less than 80, the Council is pursuing methods that are expected to lift MCI values across the ring plain, namely the reduction of dairy effluent discharges to waterways together with the completion of the Council's riparian management programme in association with the farming community.

4.1.5 Comments

The decreasing gradient of stream 'health', from 'very good' in the upper reaches of ringplain streams to 'fair' in the lower reaches, is indicative of a downstream change in macroinvertebrate communities towards those that are comprised of taxa more 'tolerant' of nutrient enrichment and/or physical habitat deterioration in the lower reaches. These communities have become well adapted to the cumulative impacts of upstream point source discharges and diffuse run-off and are particularly resistant to further

impacts (other than toxic discharges). Therefore, in most lower reach communities significant improvement of water quality and habitat would have to occur before changes would be statistically and ecologically significant.

Thus, while maintenance of ('fair') stream 'health' occurs in the lower reaches of ringplain catchments (as these communities are very 'tolerant' of cumulative organic impacts), temporal trends of improvement in stream 'health' are unlikely to be statistically evident until appropriate management initiatives are substantially progressed on a catchment wide basis. However, of the three sites that are graded 'poor', all three have positive trends with one showing very significant improvement (Figure 124). Enhancement of stream health, particularly at the sites in the lower reaches of ringplain streams, is unlikely to be significant and/or important until marked improvements in habitat and water quality occur. These may be implemented for instance by way of a combination of riparian fencing/planting initiatives and re-direction of dairy pond treatment system discharges from direct disposal into surface waters to irrigation to land.

4.2 Macroinvertebrate fauna MCI trends

Temporal trends measured over the monitoring period between 1995 and 2019 (Table 67 and Appendix II) indicated that 46 sites had positive trends, with 25 of those sites having statistically significant (FDR p<5%) improvements (after application of FDR tests[3]), all but two of which have also been of ecological importance. That is, not only is there confidence that the observed trends are real, but the degree of change that has occurred in the state of the in-stream communities is substantial. Only ten sites had negative trends and only one of these was statistically significant. That site, along with two other sites with negative trends, were adversely affected by natural headwater erosion inside the National Park. However, the LOWESS graphs indicate a number of sites have unimodal trendlines, indicating that sites have improved in condition, plateaued, and are now in decline. There were two sites that could not be trended due to the shorter duration of monitoring at these sites and one site with an indeterminate trend.

For the most recent ten-year data set, there were no sites that had a significant trend once FDR adjustment was applied. Prior to FDR adjustment being applied, there were no sites that showed a significant improvement and ten sites that showed a significant decline. In total 20 sites had a positive trend, 36 sites had a negative trend, and one site had no trend.

Trends have plateaued recently at some sites. This could be due to a variety of reasons. In some catchments riparian management initiatives have largely been completed and therefore stream health will likely have stabilised at monitoring sites. Some sites have shown step change improvements due to the removal of point source discharges such as wastewater treatment plant removal, with these improvements now resulting in a new baseline at those sites. There are also other factors that could be counteracting improvements such as increased agricultural inputs or warmer/drier weather. The majority of sites affected by low summer flows in summer 2019 show a negative relationship between days since a significant fresh and MCI scores. Data analysis using regressions indicates that the time between sampling and the last significant fresh has been increasing in recent years. Therefore, the pattern of drier weather might be having a negative influence on long-term trends at some sites.

[3] FDR= False Discovery Rate, one of several tests applied to the results to increase confidence in the results by eliminating apparent trends that are the results of co-incidence and random distributions rather than genuine change.

Table 67 Summary of Mann-Kendall test results for MCI scores trended over time (1995-2019) for 59 Taranaki streams/rivers (p with FDR applied) (significant = p < 0.05 and highly significant = p < 0.01)

River/stream name	Site code	N	FDR[3] p level	+/- (ve)	Significance	Trendline MCI range
Hangatahua (Stony) R	STY000300	47	0.09	-ve	Not significant	15
Hangatahua (Stony) R	STY000400	47	0.95	+ve	Not significant	16
Herekawe S	HRK000085	47	0.02	+ve	Significant	10
Huatoki S	HTK000350	45	<0.01	+ve	Highly significant	16
Huatoki S	HTK000425	45	<0.01	+ve	Highly significant	12
Huatoki S	HTK000745	45	0.95	+ve	Not significant	13
Kapoaiaia S	KPA000250	40	<0.01	+ve	Highly significant	28
Kapoaiaia S	KPA000700	40	<0.01	+ve	Highly significant	28
Kapoaiaia S	KPA000950	40	0.08	+ve	Not significant	13
Katikara S	KTK000150	39	0.04	-ve	Significant	8
Katikara S	KTK000248	37	0.48	-ve	Not significant	11
Kaupokonui R	KPK000250	41	0.14	+ve	Not significant	5
Kaupokonui R	KPK000500	44	<0.01	+ve	Highly significant	20
Kaupokonui R	KPK000660	48	<0.01	+ve	Highly significant	31
Kaupokonui R	KPK000880	48	0.05	+ve	Not significant	15
Kaupokonui R	KPK000990	40	0.09	+ve	Not significant	14
Kurapete S	KRP000300	47	<0.01	+ve	Highly significant	18
Kurapete S	KRP000660	47	<0.01	+ve	Highly significant	24
Maketawa S	MKW000200	38	0.88	+ve	Not significant	9
Maketawa S	MKW000300	37	<0.01	+ve	Highly significant	16
Mangaehu R	MGH000950	48	<0.01	+ve	Highly significant	19
Manganui R	MGN000195	48	0.36	-ve	Not significant	6
Manganui R	MGN000427	48	0.90	+ve	Not significant	10
Mangaoraka S	MRK000420	47	<0.01	+ve	Highly significant	16
Mangati S	MGT000488	47	0.65	+ve	Not significant	8
Mangati S	MGT000520	47	<0.01	+ve	Highly significant	23
Mangawhero S	MWH000380	48	0.01	+ve	Significant	6
Mangawhero S	MWH000490	48	<0.01	+ve	Highly significant	17
Mangorei S	MGE000970	33	0.22	-ve	Not significant	7
Patea R	PAT000200	48	0.18	+ve	Not significant	8
Patea R	PAT000315	48	0.05	+ve	Not significant	8
Patea R	PAT000360	48	0.49	+ve	Not significant	3

River/stream name	Site code	N	FDR[3] p level	+/- (ve)	Significance	Trendline MCI range
Punehu S	PNH000200	48	<0.01	+ve	Highly significant	13
Punehu S	PNH000900	48	<0.01	+ve	Highly significant	18
Tangahoe R	TNH000090	24	0.49	+ve	Not significant	8
Tangahoe R	TNH000200	24	0.88	-ve	Not significant	5
Tangahoe R	TNH000515	24	0.46	-ve	Not significant	10
Timaru S	TMR000150	47	0.64	+ve	Not significant	6
Timaru S	TMR000375	47	<0.01	+ve	Highly significant	18
Waiau S	WAI000110	40	0.02	+ve	Significant	11
Waimoku S	WMK000100	39	0.46	-ve	Not significant	7
Waimoku S	WMK000298	39	<0.01	+ve	Highly significant	12
Waingongoro R	WGG000115	48	0.15	+ve	Not significant	8
Waingongoro R	WGG000150	48	0.31	-ve	Not significant	13
Waingongoro R	WGG000500	48	<0.01	+ve	Highly significant	10
Waingongoro R	WGG000665	48	0.02	+ve	Significant	12
Waingongoro R	WGG000895	48	0.88	+ve	Not significant	5
Waingongoro R	WGG000995	48	0.14	+ve	Not significant	10
Waiokura S	WKR000500	29	<0.01	+ve	Highly significant	13
Waiokura S	WKR000700	24	0.36	+ve	Not significant	8
Waiongana S	WGA000260	47	0.16	+ve	Not significant	8
Waiongana S	WGA000450	47	0.02	+ve	Significant	19
Waitara R	WTR000540	8	N/T	-	-	-
Waitara R	WTR000850	47	0.22	+ve	Not significant	17
Waiwhakaiho R	WKH000100	33	0.28	+ve	Not significant	5
Waiwhakaiho R	WKH000500	47	0.02	+ve	Significant	13
Waiwhakaiho R	WKH000920	47	0.65	-ve	Not significant	16
Waiwhakaiho R	WKH000950	45	1.0	-	Not significant	6
Whenuakura R	WNR000450	8	N/T	-	-	-

[Not significant = ($p \geq 0.05$) after FDR applied, Significant = significant after FDR applied ($p < 0.05$), Highly significant = significant after FDR applied ($p < 0.01$); -ve = negative trend, +ve = positive trend; N/T = not trended, - = no information]

Each of these site's trends is discussed more in the site section of the report. In general, all but two of the sites that had a significant trend exhibited a broad range of MCI scores across the moving average trendline over the monitoring period which suggested trends which were ecologically significant. Those sites with the strongest positive improvement to date, coupled with a large increase in MCI scores have been:

- Kaupokonui Stream upstream of Fonterra, Kapuni factory
- Kapoaiaia Stream at Wiremu Road
- Kapoaiaia Stream at Wataroa Road
- Kurapete Stream downstream of Inglewood WWTP
- Mangati Stream at Bell Block
- Kaupokonui Stream at Kaponga
- Mangaehu River at Raupuha Road
- Punehu Stream at SH45
- Timaru Stream at SH45
- Kurapete Stream upstream of Inglewood WWTP
- Huatoki Stream at Hadley Drive
- Mangawhero Stream upstream of Waingongoro River confluence
- Maketawa Stream at Tarata Road
- Mangaoraka Stream at Corbett Road
- Waiokura Stream at Skeet Road
- Punehu Stream at Wiremu Road
- Waimoku Stream at Oakura Beach
- Huatoki Stream at Huatoki Domain

Generally, the sites with the most statistically significant improvements coupled with the biggest improvements were ones that were in relatively poor health at the start of the monitoring programme. Typically, sites with healthy macroinvertebrate communities at the start of the programme have not shown large improvements which was to be expected.

5 Summary

The 2018-2019 period was the 24th year of the macroinvertebrate state of the environment monitoring (SEM) programme. Sampling was conducted between October to November 2018 for spring samples and February to March 2019 for summer samples. This report describes the macroinvertebrate communities at 59 sites established through the Taranaki region.

Results are discussed in terms of macroinvertebrate taxa richness and MCI scores, which are compared with prior SEM data, and stream 'health' is assessed using generic and predictive methodologies. Trends are identified where possible, and results are discussed in relation to historical data and where applicable also in relation to distance from the National Park (Stark and Fowles, 2009) and the REC system (J Leathwick, pers comm.). Discussion of temporal trends over the 24 years and most recent ten-years of data collection is also provided for each site and causal assessments have been made where trends have been shown to be statistically significant.

6 Recommendations from the 2017-2018 report

In the 2017-2018 report, it was recommended:

1. THAT the freshwater biological macroinvertebrate fauna component of the SEM programme be maintained in the 2018-2019 monitoring year by means of the same programme to that undertaken in 2017-2018;
2. THAT temporal trending of the macroinvertebrate faunal data continues to be updated on an annual basis.

These recommendations have been implemented in the 2018-2019 year under review and per this report.

7 Recommendations for 2019-2020

It is recommended for 2019-2020:

1. THAT the freshwater biological macroinvertebrate fauna component of the SEM programme be maintained in the 2019-2020 monitoring year by means of the same programme as that undertaken in 2018-2019, with some site changes. These changes are namely that five Eastern Hill Country sites be added to the programme to provide improved representation, and that the upper Mangawhero site is removed, as this site has very poor site-specific habitat and is not considered representative of the stream or catchment.
2. THAT temporal trending of the macroinvertebrate faunal data continues to be updated on an annual basis.

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Appendix I

History of Site Selection

Evaluations of the effects of, and recovery from, extensive erosion in the headwaters of the Waiaua River were included in this programme. These surveys commenced in December 1998, with the two sites on the Waiaua River incorporated into the SEM biological monitoring programmes once the initial documentation of the effects and recovery was established. This river has continued to be affected by headwater erosion in more recent years, leading to a review of the programme in 2006, after which the Waiaua River was excluded from the SEM programme. The Kurapete Stream (upstream and 5.5km downstream of the Inglewood oxidation pond system) has been monitored throughout the SEM period, using the appropriate SEM protocols, and thus has been recently included in the programme. Two additional sites in the Waiwhakaiho River catchment were included in 2002-2003 in recognition of the importance of this major catchment. A further two additional eastern hill country sites in the Whenuakura and Waitara Rivers were added to the programme in 2015-2016 to improve the representativeness of the monitoring programme.

Two sites in the Maketawa Stream were also added because of a commitment to continue the documentation of conditions in this catchment following the investigation of baseline water quality conditions during the 2000-2002 period (Stark, 2003). Three sites in the Tangahoe River were established in the 2007-2008 period for the purposes of monitoring land use changes (afforestation) in an eastern hill country catchment. The two sites in the Waiokura Stream were also added in the 2007-2008 period as a long term monitoring commitment to the collaborative best practice dairying catchment project. One site in the Herekawe Stream (a long-term consent monitoring site) was incorporated into the programme in the 2008-2009 period for the purpose of monitoring the local initiatives of walkway establishment and riparian planting of this small catchment on the western outskirts of the New Plymouth urban area.

The Hangatahua (Stony) River was selected for the SEM programme as a waterway of high conservation value. The headwaters of the river are the Ahukawakawa swamp within Egmont National Park, and several tributaries that begin above the tree line on the north-west of Mount Taranaki. Once the river leaves the National Park boundary its catchment becomes very narrow so that it receives little water from surrounding farmland before reaching the sea. This factor and the protection order on the catchment maintains good water quality in the river. However, ecological degradation occurs from time to time after headwater erosion events when sedimentation and scouring of the riverbed may be particularly severe. The sites at Mangatete Road and State Highway 45 are approximately seven kilometres and twelve kilometres downstream of the National Park boundary respectively.

The Timaru and Mangaoraka Streams were chosen for the SEM programme as examples of streams within primary agricultural catchments. The Timaru Stream arises within the National Park boundary, near the peak of Pouakai, in the Pouakai Range. Upon leaving this range, the stream flows along the edge of the Kaitake Range (also part of the National Park) and receives several tributaries that flow through adjacent agricultural land. From the edge of the Kaitake Range, the stream flows north through agricultural land to the sea. Carrington Road crosses the stream within the National Park boundary and State Highway 45 is six kilometres downstream of the confluence with the first farmland tributary. The Mangaoraka Stream rises below the National Park boundary near Egmont Road and flows north through farmland for its entire length before joining the Waiongana Stream near the coast. Corbett Road is 26 kilometres downstream of the source.

The Waiongana Stream was included in the SEM programme as an example of a stream with a major water abstraction. The stream originates within the National Park, near the North Egmont visitor's centre. After crossing the park boundary, it flows northeast through agricultural land to the sea. State Highway 3a crosses the stream fifteen kilometres downstream of the National Park boundary, and the intake for the Waitara industrial water supply is a further five kilometres downstream of that. Devon Road is 30 kilometres downstream of the National Park boundary.

The Waiwhakaiho, Manganui, Waitara, and Mangaehu Rivers were selected for the SEM programme as examples of waterways with large catchments and multiple impacts from human land uses including

plantation forestry, rural, urban and industrial activities. They arise either on Mt Taranaki or in the eastern hill country, before flowing across the ring plain.

The Waiwhakaiho River and its headwater tributaries arise above the tree line on the north face of Mount Taranaki. Upon leaving the National Park, the river flows north through agricultural and industrial land for 27 kilometres to the sea. The river passes under State Highway 3 near Egmont Village, nine kilometres downstream of the National Park boundary. The sites at Constance Street and adjacent to Lake Rotomanu are included in the lower Waiwhakaiho River industrial discharges monitoring programme. The site adjacent to Lake Rotomanu has replaced the site immediately downstream of the Mangaone Stream that was used in the 1995-1996 State of the Environment monitoring survey. This allows the State of the Environment monitoring programme to better integrate with the industrial monitoring programme. The Mangorei Stream is the principal tributary catchment in the lower reaches, downstream of the major abstraction of water for hydroelectric and community supply purposes. Occasional headwater erosion events have been documented in the upper river with an instance of severe (orange) discolouration in spring 2014 due to release of naturally occurring iron oxide from a small headwater tributary.

The source of the Manganui River is situated above the tree line on the eastern slopes of Mount Taranaki. After leaving the National Park, the river flows east and then north through agricultural land for 44 kilometres before joining the Waitara River. State Highway 3 is eight kilometres downstream of the National Park boundary. At Tariki Road, much of the flow of the Manganui River is diverted through the Motukawa hydroelectric power scheme to the Waitara River. Therefore, except when the Tariki weir is overtopping, most of the water in the Manganui River at Bristol Road (14 kilometres downstream of the diversion) comes from tributaries such as the Mangamawhete, Waitepuke, Maketawa, and Ngatoro Streams. Like the Manganui River, these streams originate high on the eastern slopes of Mount Taranaki. They flow through agricultural land before joining the river. The Maketawa Stream provides a valued trout and native fish habitat. Sites were included in the upper and lower reaches of the stream.

The small Kurapete Stream, which rises as seepage to the west of Inglewood, was included to monitor trends in relation to the removal of the discharge from the town's Wastewater Treatment Plant from this tributary of the lower Manganui River in 2000. Sites were included upstream and nearly six km downstream of where the discharge was located.

The Waitara River flows south-west and then north-west out of the eastern hill country through a mix of agricultural land and native forest before passing through the town of Waitara and out to sea. It has a different character from the steep ring plain rivers and carries a high silt load. The Autawa Road site is located 46 km from the coast. This site was added only during the 2015-2016 reporting period, to increase the number of eastern hill country sites being monitored. The Mamaku Road site is located six km upstream of the coast above any tidal influence. This site is also part of the monitoring programme for the stormwater discharge from the Waitara Valley Methanex plant to the Waitara River.

The Mangaehu River originates in the eastern hill country and flows south-west through agricultural land for most of its length before joining the Patea River, ten kilometres upstream of Lake Rotorangi. Raupuha Road crosses the river less than one kilometre upstream of the confluence with the Patea River.

The Tangahoe River is a smaller eastern hill country catchment which flows through agricultural land, some of which has undergone afforestation in the upper reaches. Fonterra extracts dairy company processing waters in the lower reaches near the coast, south of Hawera township.

The Whenuakura River is an eastern hill country river which primarily flows through agricultural land. It has a high silt load and is consequently highly turbid. The only site located on the Whenuakura River was at Nicholson Road. This was included from 2015-2016 onwards to increase the number of eastern hill country rivers being monitored.

The Mangati Stream was chosen for the SEM programme as an example of a small, degraded stream. Only five kilometres in length, the stream rises in farmland and flows north through the Bell Block industrial area and suburbs to the sea. The site downstream of the railway line is upstream of all industrial discharges to the stream. The site at Te Rima Place is located within a suburban park, downstream of all Bell Block industrial discharges. Both sites are part of the Mangati Stream industrial monitoring programme.

The Waimoku Stream originates in Egmont National Park where it flows down Lucy's Gully in the Kaitake Ranges. Once the stream leaves the park it flows through farmland for three and a half kilometres, and through the coastal township of Oakura for about 200 metres, before entering the sea. It was included in the SEM programme in the 1999-2000 monitoring year to monitor the effects of a riparian planting programme in the catchment. Sampling sites are located in Lucy's Gully under native forest, and in Oakura township, about 100 metres upstream of the sea.

The Waiau Stream originates in farmland near Tikorangi, and is a small catchment to the north of the Waitara River. It flows for 12.5 km to the sea. The stream was included in the SEM programme in the 1999-2000 monitoring year as an example of a northern lowland catchment. The sampling site at Inland North Road is located in a pasture setting.

The Punehu Stream is representative of a south-western Taranaki catchment subject primarily to intensive agricultural land use with water quality affected by diffuse source run-off and point source discharges from dairy shed treatment pond effluents particularly in the Mangatawa Stream, a small lower reach tributary. No industrial discharges to the stream system are known to occur. Both sites were Taranaki ring plain survey sites (TCC, 1984) and the lower site near the coast remains a NIWA hydrological recording station as a representative basin. The upstream site is representative of relatively unimpacted stream water quality although it lies approximately two km below the National Park boundary.

The small seepage fed, ringplain Waiokura Stream drains an intensively dairy-farmed catchment. The Fonterra, Kapuni factory irrigates wastewater within the mid reaches of this catchment. The catchment is the subject of a collaborative long term study of best practice dairying in five New Zealand catchments (Wilcock et al, 2009).

The Patea River rises on the eastern slopes of Mt Taranaki, within the National Park and is a trout fishery of regional significance, particularly upstream of Lake Rotorangi (formed by the Patea dam) in its mid reaches. Site 1 (at Barclay Road) is representative of the upper catchment adjacent to the National Park above agricultural impacts. Site 2 (at Swansea Road), which is integrated with consent compliance monitoring programmes, was also a ring plain survey site, and is representative of developed farmland drainage and is downstream of Stratford township (urban run-off, but upstream of the rubbish tip and oxidation pond discharges and the combined cycle power station discharge). Site 3 (at Skinner Road) is an established hydrological recorder station downstream of these discharges and the partly industrialised Kahouri Stream catchment.

The Waingongoro River rises on the south-eastern slopes of Mount Taranaki within the National Park and is one of the longest of the ring plain rivers, with a meandering 67 km of river length from the National Park boundary prior to entering the Tasman Sea at Ohawe Beach. The river is the principal trout fishery in Taranaki, is also utilised for water abstraction purposes, and up until mid 2010, received treated industrial and municipal wastes discharges in mid-catchment at Eltham. Site 1 (near the National Park boundary) is representative of high water quality conditions with minimal agricultural impacts. Site 2, six km further downstream (at Opunake Road) represents agricultural impacts, still in the upper reaches of the river. Site 3, (at Eltham Road) a further 16 km downstream remains representative of the impacts of farmland drainage and some water abstraction while upstream of the former major Eltham point source discharges from a meatworks and the municipal wastewater treatment plant. The meatworks wastewaters were diverted to spring and summer land irrigation in the mid 2000s and treated plant wastewater subsequently has been irrigated onto farmland in this manner. The Eltham municipal wastes were permanently diverted by pipeline

to Hawera in June 2010. The Stuart Road site, a further six km downstream is located below these former discharges. A further two sites (SH45 and Ohawe Beach) are located 33 km and 37 km downstream of Stuart Road in the intensively developed farmland lower reaches of the catchment. River flow recording sites are located at Eltham Road and SH45.

The Mangawhero Stream is a relatively small, swamp-fed catchment rising to the east of Eltham in the Ngaere Swamp and draining developed farmland. The upper site is located in the mid reaches of the stream upstream of the former point source discharge from the Eltham municipal wastewater treatment plant while the lower site is located a further three km downstream, below the Mangawharawhara Stream confluence, near the confluence with the Waingongoro River. Apart from the municipal point source discharge, which was diverted out of the stream in July 2010 (see above), the catchment is predominantly developed farmland.

The Huatoki Stream was sampled as part of the State of the Environment monitoring programme for the first time in the 1997-1998 monitoring year. The stream rises one kilometre outside the National Park boundary on the foothills of the Pouakai Range. It flows through agricultural land for 12.5 km to the outskirts of New Plymouth where it enters native forest reserve. The stream flows for four and a half kilometres alongside walkways and beneath the central business district of New Plymouth before entering the sea next to Puke Ariki Landing. Within New Plymouth it flows through a culvert in a flood retention dam and over a small weir in the Huatoki Reserve prior to the business section of the city. Beautification works adjacent to 'Centre City' near the stream mouth (in 2010) involved the creation of a weir and fish pass immediately upstream of the lowest site which subsequently has altered the flow regime at this site and created a run-like habitat with intermittent flow variability rather than the previous riffle habitat.

The Herekawe Stream is a small seepage stream on the western boundary of New Plymouth. It drains a mainly urban catchment and receives stormwater discharges particularly in its lower reaches. Completion of a walkway and riparian planting community project now warrants the inclusion of the consent monitoring 'control' site at Centennial Drive for monitoring the effectiveness of these initiatives.

The Kaupokonui River rises on the southern slopes of Mt Taranaki within the National Park. It drains an intensively farmed dairy catchment. The principal point source discharges to the river occur in the mid-reaches from the Kaponga oxidation pond system, and cooling water from NZMP (Kapuni) Ltd. The river has patchy riparian vegetation cover and has been targeted for intensive riparian management initiatives. Site 1 is two and a half kilometres downstream of the National Park boundary and has high water quality, with minor agricultural impacts. Toward the mid-reaches, site 2 (six kilometres further downstream) is subject to some agricultural impacts, but is a short distance upstream of the Kaponga oxidation ponds' system discharge. A further six kilometres downstream, site 3 is upstream of wastes irrigation, cooling water discharges and factory abstraction. The Upper Glenn Road (site 4) is a further 10 km downstream, below all of the factory's activities and is a river flow hydrological recording site. The final site 5, is located near the mouth of the river, 5 km below site 4, upstream of any tidal influence at Kaupokonui beach domain camping ground.

Two western catchments, the Katikara Stream and Kapoaiaia Stream, were included in the programme to monitor trends in relation to riparian planting. Such riparian planting initiatives have been concentrated in certain catchments where past riparian vegetation has been sparce. The Katikara Stream rises on the western slopes of Mt Taranaki, passing through primarily agricultural land in the relatively short distance to the sea. The Kapoaiaia Stream also rises from Mt Taranaki on the western side and south of the Katikara Stream. The Kapoaiaia Stream drains agricultural land throughout its entire catchment below the National Park boundary, passing through Pungarehu township at SH45 before entering the sea at Cape Egmont. A hydrological telemetry recorder is located at Cape Egmont

Appendix II

Summary of SEM sites' information 2018-2019, historical median MCI scores, predicted scores and 1995-2019 trends

Summary of MCI scores at all SEM sites: significance in relation to various predictive methodologies (Stark and Fowles, 2009; Leathwick, 2008), and trends over the SEM period 1995 to 2019

Site code	River Environment Classification (REC)	Altitude (masl)	Distance from National Park (km)	MCI values							Median 'health' category	Predictive MCI values		Time Trends (1995-2019)		
				Spring 2018	Summer 2019	Historic Range	5 year mean	Historic Medians				Distance[1]	REC[2]	P value	FDR p value	+ / -
								Spring	Summer	Overall						
STY000300	CX/H/VA/S/MO/MG	160	7.3	109	108	64-140	109	111	113	112	Good	109[0]	128[-]	0.05	0.09	-ve
STY000400	CX/H/VA/S/MO/MG	70	12.5	118	110	0-150	109	107	109	108	Good	103[0]	115[0]	0.95	0.95	+ve
HRK000085	WW/L/VA/U/MO/MG	5	N/A	92	96	68-100	90	89	88	89	Fair	N/A	89[0]	<0.01	0.02	+ve
HTK000350	WX/L/VA/P/MO/LG	60	N/A	109	89	79-115	104	101	96	97	Fair	N/A	95[0]	<0.01	<0.01	+ve
HTK000425	WW/L/VA/P/MO/LG	30	N/A	106	103	91-117	107	106	103	104	Good	N/A	92[+]	<0.01	<0.01	+ve
HTK000745	WW/L/VA/U/MO/MG	5	N/A	98	56*	62-102	83	86	85	86	Fair	N/A	93[0]	0.95	0.95	+ve
KPA000250	CX/H/VA/P/MO/MG	240	5.7	127	107	83-131	120	121	114	117	Good	112[0]	111[0]	<0.01	<0.01	+ve
KPA000700	CX/H/VA/P/MO/MG	140	13.5	105	94	78-118	102	98	94	96	Fair	103[0]	105[0]	<0.01	<0.01	+ve
KPA000950	CX/L/VA/P/MO/LG	20	25.2	86	89	76-101	88	90	81	87	Fair	96[0]	99[-]	0.04	0.08	+ve
KTK000150	CX/H/VA/IF/LO/HG	420	0	135	125	112-148	132	137	135	135	Very good	132[0]	131[0]	0.02	0.04	-ve
KTK000248	WX/L/VA/P/MO/LG	5	18.1	102	80*	87-118	95	102	102	102	Good	99[0]	96[0]	0.39	0.48	-ve
KPK000250	CX/H/VA/IF/MO/MG	380	3.3	135	127	124-139	134	130	128	130	Very good	118[+]	137[0]	0.08	0.14	+ve
KPK000500	CX/H/VA/P/MO/MG	260	9.2	138^	104	98-133	118	121	113	117	Good	107[0]	127[0]	<0.01	<0.01	+ve
KPK000660	CX/H/VA/P/MO/LG	170	15.5	118	110	71-128	108	107	102	103	Good	101[0]	122[-]	<0.01	<0.01	+ve
KPK000880	CW/H/VA/P/MO/LG	60	25.7	92	81	66-110	92	94	88	91	Fair	95[0]	106[-]	0.03	0.05	+ve
KPK000990	CW/L/VA/P/HO/LG	5	31.1	93	80	69-103	91	94	87	91	Fair	93[0]	96[0]	0.05	0.09	+ve
KRP000300	WX/L/VA/P/LO/LG	180	N/A	98	98	80-107	102	94	96	95	Fair	N/A	92[0]	<0.01	<0.01	+ve
KRP000660	WW/L/VA/P/LO/LG	120	N/A	98	93	74-112	99	96	91	94	Fair	N/A	102[0]	<0.01	<0.01	+ve
MKW000200	CX/H/VA/IF/MO/MG	380	2.3	133	126	100-142	129	131	124	129	Very good	121[0]	130[0]	0.83	0.88	+ve
MKW000300	CX/H/VA/P/MO/LG	150	15.5	109	105	90-127	114	110	105	108	Good	101[0]	111[0]	<0.01	<0.01	+ve
MGH000950	CW/L/SS/P/HO/LG	120	N/A	99	96	77-104	97	94	91	92	Fair	N/A	117[-]	<0.01	<0.01	+ve
MGN000195	CX/H/VA/P/MO/LG	330	8.7	133	123	106-143	124	129	123	126	Very good	107[+]	124[0]	0.26	0.36	-ve
MGN000427	CX/L/VA/P/HO/MG	140	37.9	89	93	77-117	99	102	96	98	Fair	91[0]	103[0]	0.87	0.9	+ve
MRK000420	WW/L/VA/P/MO/LG	60	N/A	94	81	75-105	90	93	89	90	Fair	N/A	92[0]	<0.01	<0.01	+ve
MGT000488	WN/L/VA/P/LO/LG	30	N/A	79	74	56-91	75	78	78	78	Poor	N/A	80[0]	0.58	0.65	+ve
MGT000520	WW/L/VA/U/LO/LG	20	N/A	74	73	44-79	71	65	70	67	Poor	N/A	88[-]	<0.01	<0.01	+ve

Site code	River Environment Classification (REC)	Altitude (masl)	Distance from National Park (km)	MCI values							Median 'health' category	Predictive MCI values		Time Trends (1995-2019)		
				Spring 2018	Summer 2019	Historic Range	5 year mean	Historic Medians				Distance[1]	REC[2]	P value	FDR p value	+ / -
								Spring	Summer	Overall						
MWH000380	WW/L/M/P/MO/LG	200	N/A	88^	83	58-85	76	74	73	74	Poor	N/A	92[-]	<0.01	0.01	+ve
MWH000490	CN/L/VA/P/MO/LG	190	N/A	96	88	63-102	89	82	79	80	Fair	N/A	93[-]	<0.01	<0.01	+ve
MGE000970	CX/L/VA/P/MO/LG	90	15.6	107	84*	86-113	98	104	99	102	Good	101(0)	101[0]	0.15	0.22	-ve
PAT000200	CX/H/VA/IF/MO/MG	500	1.9	135	148	127-150	140	138	138	138	Very good	125[+]	129[0]	0.12	0.18	+ve
PAT000315	CX/H/VA/P/MO/LG	300	12.4	110	113	99-130	116	116	109	111	Good	103[0]	112[0]	0.03	0.05	+ve
PAT000360	CW/L/VA/P/HO/LG	240	19.2	98	90	86-112	99	99	96	98	Fair	99[0]	109[-]	0.41	0.49	+ve
PNH000200	CX/H/YA/IF/MO/MG	270	4.4	135	122	104-137	127	127	122	124	Very good	115[0]	121[0]	<0.01	<0.01	+ve
PNH000900	CW/L/VA/P/MO/LG	20	20.9	98	88	70-114	97	96	85	90	Fair	98[0]	100[0]	<0.01	<0.01	+ve
TNH000090	WW/L/SS/P/MO/LG	85	N/A	96	93	90-107	101	98	101	100	Good	N/A	110[0]	0.40	0.49	+ve
TNH000200	WW/L/SS/P/HO/LG	65	N/A	101	99	92-111	102	104	102	103	Good	N/A	108[0]	0.80	0.88	-ve
TNH000515	WW/L/SS/P/HO/LG	15	N/A	94	79	78-104	90	96	87	94	Fair	N/A	95[0]	0.35	0.46	-ve
TMR000150	CX/H/VA/IF/LO/HG	420	0	131	130	119-152	140	137	139	138	Very good	132[0]	141[0]	0.55	0.64	+ve
TMR000375	CX/L/VA/P/MO/MG	100	10.9	110	88*	89-120	103	107	103	103	Good	105[0]	117[-]	<0.01	<0.01	+ve
WAI000110	WW/L/VA/P/MO/LG	50	N/A	94	84	79-101	92	93	88	91	Fair	N/A	91[0]	<0.01	0.02	+ve
WMK000100	WW/L/VA/P/LO/HG	160	0	127	119*	121-141	129	132	130	131	Very good	132[0]	128[0]	0.36	0.46	-ve
WMK000298	WW/L/VA/P/MO/MG	1	4	98	97	75-105	97	94	90	92	Fair	116[-]	103[-]	<0.01	<0.01	+ve
WGG000115	CX/H/VA/IF/LO/MG	540	0.7	136	133	122-144	134	132	134	133	Very good	132[0]	131[0]	0.09	0.15	+ve
WGG000150	CX/H/VA/P/LO/MG	380	7.2	128	119	119-139	125	131	126	129	Very good	110[+]	124[0]	0.22	0.31	-ve
WGG000500	CW/L/VA/P/MO/LG	200	23	112	109	93-125	109	103	102	103	Good	97[0]	110[0]	<0.01	<0.01	+ve
WGG000665	CW/L/VA/P/HO/MG	180	29.6	108	88	77-111	97	100	93	96	Fair	94[0]	102[0]	<0.01	0.02	+ve
WGG000895	CW/L/VA/P/HO/LG	40	63	88	96	73-106	93	96	94	95	Fair	85[0]	92[0]	0.83	0.88	+ve
WGG000995	CW/L/VA/P/HO/MG	5	66.6	97	79	69-100	88	93	86	91	Fair	85[0]	95[0]	0.08	0.14	+ve
WKR000500	WW/L/VA/P/MO/LG	150	N/A	112	104	88-114	105	102	98	100	Good	N/A	97[0]	<0.01	<0.01	+ve
WKR000700	WW/L/VA/P/MO/LG	70	N/A	102	100	92-109	100	99	98	98	Fair	N/A	95[0]	0.27	0.36	+ve
WGA000260	CX/L/VA/P/MO/LG	140	16.1	99	90	82-112	98	99	96	97	Fair	100[0]	99[0]	0.10	0.16	+ve
WGA000450	WW/L/VA/P/MO/LG	20	31.2	90	82	72-102	89	92	87	89	Fair	93[0]	88[0]	<0.01	0.02	+ve
WTR000540	WX/L/SS/P/HO/LG	100	N/A	108	93*	95-110	N/T	99	98	99	Fair	N/A	110[-]	N/T	N/T	-
WTR000850	WX/L/SS/P/HO/LG	15	N/A	93	64	64-107	85	91	80	86	Fair	N/A	98[-]	0.14	0.22	+ve

Site code	River Environment Classification (REC)	Altitude (masl)	Distance from National Park (km)	MCI values							Median 'health' category	Predictive MCI values		Time Trends (1995-2019)		
				Spring 2018	Summer 2019	Historic Range	5 year mean	Historic Medians				Distance[1]	REC[2]	P value	FDR p value	+ / -
								Spring	Summer	Overall						
WKH000100	CX/H/VA/IF/LO/HG	460	0	139	126	115-147	131	131	128	130	Very good	132[0]	137[0]	0.20	0.28	+ve
WKH000500	CX/H/VA/P/MO/MG	175	10.6	103	96	87-125	110	112	108	111	Good	105[0]	115[0]	<0.01	0.02	+ve
WKH000920	CX/H/VA/P/HO/LG	20	26.6	89	60*	71-110	86	99	92	94	Fair	95[0]	97[0]	0.57	0.65	-ve
WKH000950	CX/H/VA/P/HO/LG	2	28.4	84	80	70-111	88	92	84	89	Fair	94[0]	97[0]	1.00	1.0	-
WNR000450	WW/L/SS/P/HO/LG	20	N/A	99^	71*	81-94	N/T	87	88	87	Fair	N/A	109[-]	N/T	N/T	-

Notes: ( ) = affected by headwater erosion events; Time trend - highly significant (p <0.01), significant (p <0.05) and not significant (p ≥ 0.05), [+ve/-ve/-] = whether a trend was positive, negative or absent; Predictive MCI values – significant (>10), and not significant (≤10), [+/-/0] = whether a value was significantly higher, significantly lower or not significant, N/A = non-ringplain source inside NP sites; N/A^{s} = soft-bedded sites;^ = highest recorded MCI score for that site; * = lowest recorded MCI score for that site, 1 = Stark and Fowles, 2009' 2 = Leathwick, 2009; N/T = not trended (insufficient data at present).