A discussion of trend analysis of State of the Environment freshwater biological data of Taranaki 1995-2005

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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, soil, air, and fresh and marine water quality. Monitoring is undertaken to identify pressures upon the regional resources, their state, changes in their state (trends), and the effectiveness of the policies and actions undertaken to maintain and enhance the environment. The Taranaki Regional Council initiated comprehensive state of the environment monitoring programmes (SEM) in 1995 to inform itself and the regional community on the state of the region. The results of the programmes describing Taranaki's environment have been reported twice to date within the Council's omnibus State of the Environment reports.

With the accumulation of ten years' data for four key parameters or indicators, and the development and implementation of appropriate statistical analysis tools, the Council is now in a position to quantitatively determine and assess trends in the quality of the region's freshwater ecological systems, for the first time. The Council therefore commissioned Cawthron Institute to undertake such an analysis. This report is a companion report to the report prepared by Cawthron. It examines the results of the Institute's trend analysis of the macroinvertebrate data of the region's surface freshwater, in the light of the Council's policies, and provides additional comment and interpretation over and above the Cawthron report. The two reports should be read in association with each other.

The results of the first trending of Taranaki's SEM macroinvertebrate show very good news for the region. A number of tests of data and the trends revealed in analysis were applied by Cawthron, together with a discussion of the strength of each level of test ('significance'). It should be noted that the number of sites where a 'significant' trend is determined, depends upon the level of certainty, or 'confidence' that is to be established. The results are discussed in both reports. They show that at all levels of confidence used, there is a clear overall tendency towards maintaining and enhancing the state of the region's surface waters.

At a standard significance test criterion of $p<0.05$, the results show a considerable number of sites (21) with statistically significant improvement in water quality as indicated by MCI. This test also shows that a lot of other sites are maintaining existing water quality, with no significant trends. This is despite increasing pressures on water quality in the region e.g. a doubling in the region's dairy herd. What is equally encouraging is at this significance level there is only one significantly deteriorating site of the 60 trended.

With a more conservative approach, at a significance level of $p<0.05$ with False Discovery Rate (FDR) adjustment, the results remain encouraging. It shows 11 sites with significant improvement with regard to MCI and no sites with significant deterioration.

Even with the most stringent statistical approach examined, a significance level of $p<0.01$ with FDR adjustment, there are sites showing significant improvement and no sites showing deterioration.

This report also examines, in general terms, the data from the sites which do not show a clear statistical significance. Even though the data for each individual site is less certain, the cumulative impression is that on a regional scale, improvement is occurring. While this finding must be treated with some caution, for reasons set out within the report, nevertheless the overall pattern is such that there is a place for some encouragement from the data.

Since this is the first time the SEM macroinvertebrate data for the Taranaki region has been trended, and with very little biological work of this type carried out to date in New Zealand, and a number of questions over methodology still to be resolved, there remains work to be done, particularly in regard to interpreting the results. The Council recognises that this is a first step. It is anticipated that closer examination of the results will reveal insightful information which will benefit water management in the region.

The companion report ('An approach to the evaluation of temporal trends in Taranaki state of the environment macroinvertebrate data') presents the data, technical analysis, and methodology used in this study in more detail. It should be noted that while the companion report has been prepared by Cawthron, this report is the work of Council staff.

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1. Monitoring the environment for surface water quality

1.1 Background

1.1.1 The structure of this report

This report has five sections. Section 1 provides a background to the purpose of state of the environment monitoring (SEM). Section 2 describes the macroinvertebrate freshwater quality SEM programme, and Section 3 discusses analysis of trends- whether the quality of our rivers is changing.

Section 4 discusses the trends, and Section 5 provides a summary review and conclusions of the study.

1.1.2 The Regional Freshwater Plan for Taranaki and monitoring

State of the environment monitoring involves on-going programmes that regularly monitor different parts of the environment and enable the Council and the community to ascertain how successful the Council has been in promoting the purpose of the Resource Management Act –namely, the sustainable management of our natural and physical resources. It involves the sampling of air, land, fresh water (including groundwater) and coastal water and may include chemical, physical, bacterial or viral analysis, soil analyses, flow variability, biological surveys of freshwater or marine ecosystems, and the sampling and analysis of ambient air. It may also involve the review of operational monitoring data provided by other sections of the Council, consent holders and other organisations.

State of the environment monitoring puts in place systems and programmes that enable the Council to look back on environmental trends and changes over time. With this information, the Council can continuously assess its own performance in resource management as well as that of resource users.

The Council's objectives in respect of point source discharges to land and water are set out in the Council's Regional Policy Statement (RPS) and Regional Freshwater Plan for Taranaki (RFWP). The relevant sections of the RPS are set out in Appendix I of this report. The Council's objective in respect of point source discharges to land and water as set out in the RFWP is 'to maintain and enhance the quality of the surface water resources of Taranaki by avoiding, remedying or mitigating the adverse effects of contaminants discharged to land and water from point sources' (Objective 6.2.1).

The Council's objective in respect of diffuse source discharges to land and water as set out in the RFWP is 'to maintain and enhance the quality of the surface water resources of Taranaki by avoiding, remedying or mitigating the adverse effects of contaminants discharged to land and water from diffuse sources' (Objective 6.3.1).

In order to monitor the implementation and effectiveness of the Council's policies and methods that support and provide for the objectives set out above, the Council is committed to the following procedures (amongst others) :

1. use of State of the Environment monitoring;
2. continuation of the freshwater monitoring programme, including physicochemical, biological and bathing water quality programmes; and

3. use of monitoring and research programmes carried out by other agencies where appropriate (Section 10.3, *ibid*).

The RPS came into effect in September 1994, and thus effectively co-incides with the period of SEM monitoring reported in this study. The Council is currently preparing a new RPS. The RFWP came into effect in October 2001, and by statue has an effective life of no more than 10 years. In simple terms, this means that the current regulatory and management regime in place in the region for surface water quality has six years or less to run. The Council intends to conduct an interim review of the RFWP next year, half way though its statutory life. Either as a consequence of the review, or in any case at the end of the life of the RFWP, this management regime is subject to change. The present study, and other work of a like nature, will guide the Council in its evaluation and refinement of objectives and policies within the RPS and RFWP.

2. Monitoring activity

2.1 Introduction

The Council commenced the freshwater biological SEM programme in spring 1995. The 2004-2005 monitoring year was therefore the tenth year in which the SEM programme was undertaken. This report presents the results from the sites surveyed from spring 1995 to summer 2005. The methodology for the programme is described in TRC (1997b), and summarised in Section 2.2.

This report is similar in format to the report *Trends in the quality of surface water in Taranaki* (TRC, 2006b), and companion report *Trends in the quality of surface water in Taranaki, Volume II Background Data* (TRC, 2006c), which examined the results of 10 year's evaluation of physicochemical data collected in the region under a separate SEM programme.

This report aims to consider the results of a companion report prepared by the Taranaki Regional Council and the Cawthron Institute, *An approach to the evaluation of temporal trends in Taranaki state of the environment macroinvertebrate data* (Stark & Fowles, 2006), with regard to significant trends (statistical and ecological), and with regard to meeting the aims of the RPS and RFWP.

There are a total of 51 SEM sampling sites, plus an additional eight compliance monitoring sampling sites that have been included in this trending analysis as they have been sampled using the same SEM sampling protocols and the sites are classified as control sites, which are upstream of discharge sites.

One extra sampling site in the Kapuni River has been included for trend analysis. While the samples taken do not meet all the SEM sampling protocols, this data is more frequent (seasonal) and is therefore, worthwhile including in the discussion. This brings the total number of sampling sites trended to 60 for the Taranaki region.

2.2 Monitoring methodology

The standard '400 ml kick-sampling' technique was 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). This 'kick-sampling' technique is very similar to Protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark et al, 2001). Surveys of all sites were performed twice during the monitoring year, once during spring (October and November) and once during summer (late January and March).

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001).

The abundance of each macroinvertebrate taxon found in each sample is recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= estimated 20-99 individuals;
VA (very abundant)	= estimated 100-499 individuals;

XA (extremely abundant) = estimated 500 individuals or more.

Regular quality control procedures, (Protocol QC 1 of NZMWG Protocols (Stark et al. 2001)) were performed by the Council.

2.3 Environmental parameters and indicators

2.3.1 Introduction

There are four categories used in the Council's methods for stream macroinvertebrate monitoring. These are taxonomic richness, macroinvertebrate community index (MCI), semi-quantitative MCI ($SQMCI_s$), and %EPT. Each has its own usefulness (and limitations) but results should be viewed in relation to each other rather than in isolation.

2.3.2 Taxonomic richness

The number of macroinvertebrate taxa found in each sample is used as an indicator of the richness (diversity) of the community at each site. However, an increase in the number of taxa at a site does not alone indicate improved water quality. The type of taxa and their sensitivity to pollution must be known to deduce water quality when considering taxa richness at a site.

2.3.3 Macroinvertebrate Community Index (MCI)

The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities, those with high MCI, generally typify less polluted, or slightly enriched waterways. Macroinvertebrate communities are not only influenced by pollution of the water but can also be affected by natural changes in stream conditions, such as low flow, sedimentation, water temperature, and dissolved oxygen. Changes after major floods can alter the streambed physical composition thus affecting the habitat.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience (see TRC, 1997b). By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value is obtained.

A stream community with a low MCI may still not be 'degraded' i.e. it may be the highest MCI that would be found at such a site given its nature, while a site with a higher MCI could be degraded. Typically, sites throughout Taranaki have lower MCI in summer than in spring, usually due to lower flows and warmer water temperatures, even at 'pristine' sites.

Rates of MCI change have been calculated for various catchments, where many sites have been surveyed, based upon recent updated G.I.S. river / stream length information incorporated into the Council's 'SITES' database system.

2.3.4 Semi Quantitative MCI (SQMCI$_s$)

This parameter gives an indication of the relative abundance of taxa. A semi-quantitative MCI value (SQMCI$_s$) (Stark 1998 & 1999) is calculated for the community present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998, 1999). The loading factors were 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$_s$ is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

2.3.5 %EPT$_{taxa}$

%EPT$_{taxa}$ is another indicator of composition. It represents the proportion of taxa of families that are generally more sensitive to pollution in a given macroinvertebrate community. EPT are the **E**phemeroptera (mayflies), **P**lecoptera (stoneflies), and **T**richoptera (caddisflies).

2.4 Site locations

All sites in the freshwater biological SEM programme for the Taranaki region are illustrated in Figure 1 and described in Table 1 and 2.

The biological programme for the 2004-2005 period included the continuation of a riparian vegetation monitoring component incorporating five sites in the Kaupokonui River and five sites in western Taranaki ring plain streams (Katikara Stream and Kapoaiaia Stream). Further, evaluations of the effects of, and recovery from, extensive erosion in the headwaters of the Waiaua River and Stony River have been included in this programme. These surveys commenced in December 1998 and the two sites on the Waiaua River were incorporated into the SEM biological monitoring programmes since the initial documentation of the effects and recovery was established. Two additional sites in the Waiwhakaiho River catchment were included in 2002-03 in recognition of the importance of this major catchment. Two sites in the Makatawa Stream were also added as a result 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).

Table 1 Summary of biological monitoring sites included in the SEM programme.

Type	Sites			
	River/stream	Location	Site code	River Environment Classification
High conservation1	Hangatahua R (Stony) Maketawa S	Mangatete Road SH45 Denby Rd Tarata Rd	STY000300 STY000400 MKW000200 MKW000300	CX/H/VA/S CX/H/VA/S CX/H/VA/IF CX/H/VA/P

Type	Sites			
	River/stream	Location	Site code	River Environment Classification
Large catchments/Multiple impacts	Waitara R	Mamaku Road	WTR000850	WX/L/SS/P
	Manganui R	SH3 Bristol Road	MGN000195 MGN000427	CX/H/VA/P CX/L/VA/P
	Patea R	Barclay Road Swansea Road Skinner Road	PAT000200 PAT000315 PAT000360	CX/H/VA/IF CX/H/VA/P CW/L/VA/P
	Mangaehu R	Raupuha Road	MGH000950	CW/L/SS/P
	Waiwhakaiho R Mangorei S	National Park SH3 (Egmont Village) Constance St, NP near mouth SH 3	WKH000100 WKH000500 WKH000920 WKH000950 MGE000970	CX/H/VA/IF CX/H/VA/P CX/H/VA/P WW/L/VA/P CX/L/VA/P
Intensive usage	Waingongoro R	Adjacent to N Park boundary Opunake Road Eltham Road Stuart Road SH45 Ohawe Beach	WGG000115 WGG000150 WGG000500 WGG000665 WGG000895 WGG000995	CX/H/VA/IF CX/H/VA/P CW/L/VA/P CW/L/VA/P CW/L/VA/P CW/L/VA/P
Primary Agricultural	Punehu S	Wiremu Road SH45	PNH000200 PNH000900	CX/H/VA/IF CW/L/VA/P
	Mangaoraka S	Corbett Road	MRK000420	WW/L/VA/P
	Timaru S	Carrington Road SH45	TMR000150 TMR000375	CX/H/VA/IF CX/L/VA/P
(& Erosion)3	Waiaua R	Wiremu Road SH45	WAA000200 WAA000447	CX/H/VA/IF CX/H/VA/P

Type		Sites			
		River/stream	Location	Site code	River Environment Classification
Riparian	Western	Waimoku S	Lucy's Gully	**WMK000100**	WW/L/VA/P
			Beach	WMK000298	WW/L/VA/P
		Katikara S	Carrington Road	**KTK000150**	CX/H/VA/IF
			Coast	KTK000248	WX/L/VA/P
		Kapoaiaia S	Wiremu Road	**KPA000250**	CX/H/VA/P
			Wataroa Road	KPA000700	CX/H/VA/P
			Cape Egmont	KPA000950	CX/L/VA/P
	Southern	Kaupokonui R	Opunake Rd	**KPK000250**	CX/H/VA/IF
			u/s Kaponga oxi ponds	KPK000500	CX/H/VA/P
			u/s Lactose Co	KPK000660	CX/H/VA/P
			Upper Glenn Rd	KPK000880	CW/H/VA/P
			near mouth	KPK000990	CW/L/VA/P
Small Degraded ("poor") Catchments		Mangawhero S	u/s Eltham ox. ponds	MWH000380	WW/L/M/P
			d/s Mangawharawhara S	MWH000490	CW/L/VA/P
		Mangati S	d/s railway line	MGT000488	WW/L/VA/U
			Te Rima Pl, Bell Block	MGT000520	WW/L/VA/U
Urbanisation		Huatoki S	Hadley Drive	**HTK000350**	WX/L/VA/P
			Huatoki Domain	HTK000425	WW/L/VA/U
			Near coast	HTK000745	WW/L/VA/U
Northern lowland catchment		Waiau S	Inland North Road	WAI000110	WW/L/VA/P
Major Abstraction		Waiongana S	SH3a	WGA000260	CX/L/VA/P
			Devon Road	WGA000450	WW/L/VA/P

Key: Bold site codes indicate reference sites

Table 2 Selected non-SEM monitoring sites for which time-series biological data are available

Site code	River name	Location	River Environment Classification
KPN000275	Kapuni Stream	d/s Hawera Water Treatment Plant intake	CX/H/VA/P
KPN000360	Kapuni Stream	Kokiri Road	CX/H/VA/P
KRP000300	Kurapete Stream	u/s Inglewood Waste Water Treatment Plant	WX/L/VA/P
KRP000660	Kurapete Stream	6km d/s Inglewood WWTP	WW/L/VA/P
INH000400	Inaha Stream	Kohiti Road	WW/L/VA/P
MGO000050	Mangaone Stream	Egmont Road	WW/L/VA/P
MGO000190	Mangaone Stream	Rifle Range Road	WW/L/VA/P
MHW000060	Mangahewa Stream	u/s McKee Production Station	WW/L/VA/P
WGG000540	Waingongoro River	400m d/s Riverlands meatworks	CW/L/VA/P

The sequence of the REC classification is:-
climate type /nature of source catchment /geology /land cover;
and the categories are:-

WW warm wet	L low elevation	SS soft sedimentary	IF indigenous forest
CW cool wet	H hill	VA volcanic ash	S scrub
CX cool extremely wet			P pastoral

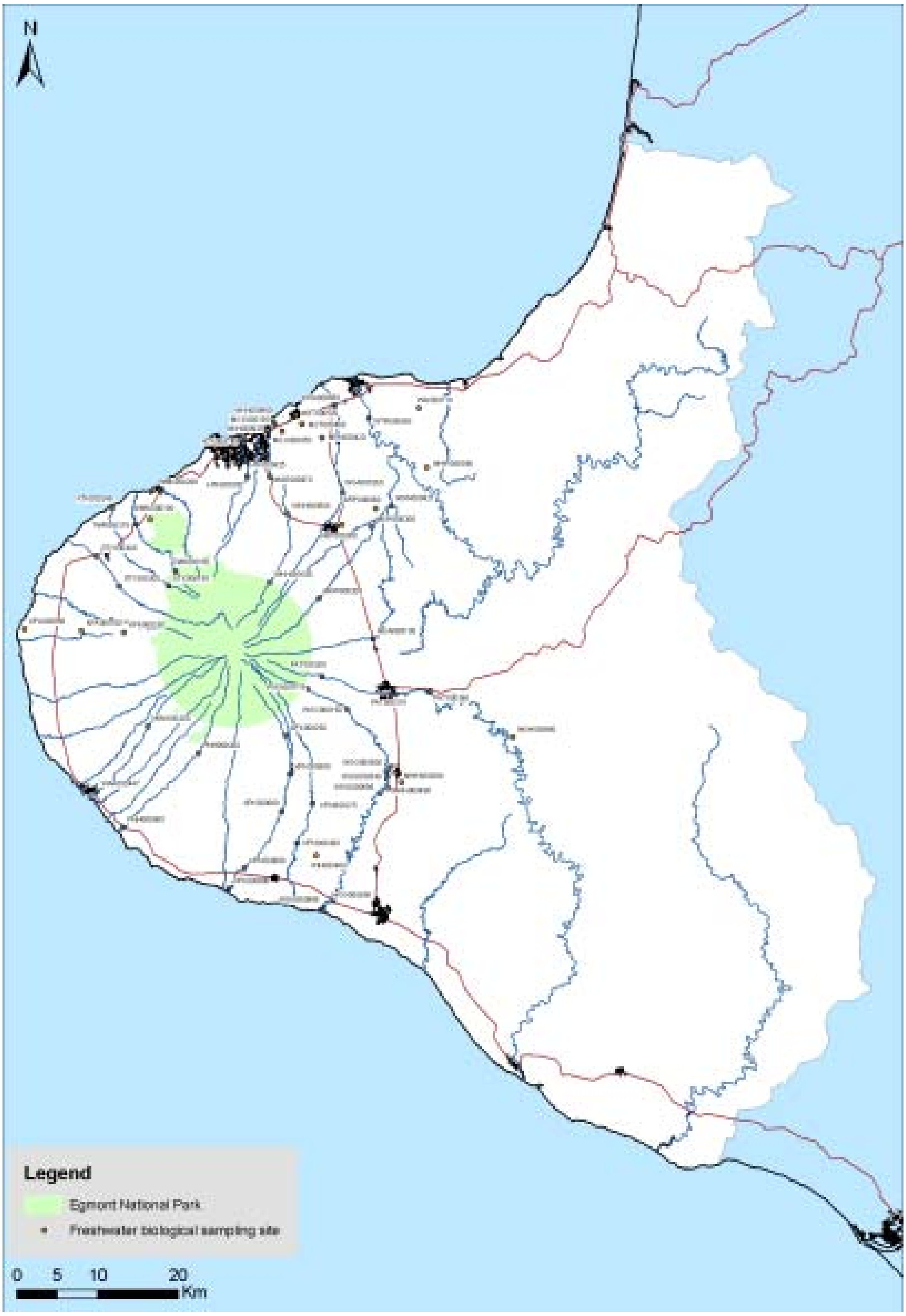

Figure 1 Location of macroinvertebrate fauna sampling sites for the Taranaki SEM programme

2.5 SEM programme sites

The **Hangatahua River** (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. 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 north-east 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.

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 monitoring programme. The site adjacent to Lake Rotomanu has replaced the site immediately downstream of the Mangaone Stream that was used in the 1995-96 State of the Environment monitoring survey. This allows the State of the Environment monitoring programme to better synchronise 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.

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 in the upper and lower reaches of the stream were included in the SEM programme.

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 Mamaku Road site is located six kilometres upstream of the coast above any tidal influence. This site is 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 stream less than one kilometre upstream of the confluence with the Patea River.

The **Mangati Stream** was chosen for the SEM programme as an example of a small, degraded stream arising on the coastal ring plain. 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 on the ring plain near Tikorangi, near the Waitara River. It flows for twelve and a half kilometres 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. No industrial discharges to the stream system are known to occur. Both sites were Taranaki ring plain survey sites 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 2 km below the National Park boundary.

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. The site at Barclay Road is representative of the upper catchment adjacent to the National Park above agricultural impacts. The site at Swansea Road, which is integrated with special order consent 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. The site 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 and is also utilised for water abstraction purposes and receives treated industrial and municipal wastes discharges in mid-catchment at Eltham. The site near the National Park boundary is representative of high water quality conditions with minimal agricultural impacts. The site 6 km further downstream (at Opunake Road) represents agricultural impacts, still in the upper reaches of the river while the site at Eltham Road a further 16 km downstream remains representative of the impacts of farmland drainage and some water abstraction while upstream of the Eltham point source discharges. The Stuart Road site, a further 6 km downstream is located below these discharges, with a further two sites (SH45 and Ohawe Beach) 33 km and 37 km downstream of Stuart Road and located 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 point source discharge from the Eltham municipal wastewater treatment plant, while the lower site is located a further 3 km downstream, below the Mangawharawhara Stream confluence, near the confluence with the Waingongoro River. Apart from the municipal point source discharge, 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 1997-98 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 kilometres to the outskirts of New Plymouth where it enters native forest reserve. The stream flows for 4.5 kilometres alongside walkways and beneath the central business district of New Plymouth before entering the sea next to Pukeariki 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.

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 2.5 km downstream of the National Park boundary and has high water quality, with minor agricultural impacts. Toward the mid-reaches, site 2 (6 km further downstream) is subject to some agricultural impacts, but is a short distance upstream of the Kaponga oxidation ponds' system discharge. A further 6 km 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 current riparian vegetation is poor. 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 but 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.

The remaining nine sites were chosen from compliance monitoring sites as they are all control sites and were considered for trending as they either comply with SEM sampling protocol (eight sites), or have sufficient data sample size to warrant trending. These compliance monitoring sites are shown in Table 2.

2.6 National categorisation of water quality sites

Most sites used by the Council for SEM water quality were selected during the 1994-1995 period, when SEM was being established.

NIWA has subsequently (2001) developed a system of classifying surface waters according to various criteria. The development of the GIS-based River Environment Classification (REC) was supported by the Ministry of the Environment (MfE) with the involvement of a number of regional councils. The REC is an ecosystem-based spatial framework for river management purposes and provides a context for inventories of river resources, and a spatial framework for effects assessment, policy development, developing monitoring programmes and interpretation of monitoring data and state-of-environment reporting. The REC has been used to classify all the rivers of New Zealand at a 1:50,000 mapping scale.

REC uses six different classifications to define the characteristics of a river system. Each classification has a number of classes into which rivers are assigned. The six classifications are: climate, source of flow, geology, land cover, river order, and valley landform. For the purposes of trend analysis, it is considered that the two having the greatest significance are climate and land cover, while source of flow and geology are also used to classify rivers for comparative purposes in NIWA work.

In the REC system these four classes are sub-divided as follows:

Climate: warm extremely wet (WX), warm wet (WW), warm dry (WD), cool extremely wet (CX), cool wet (CW) and cool dry (CD)

Source of flow: low elevation (L), hill (H)

Geology: soft sedimentary (SS), volcanic ash (VA)

Land cover: urban (U), bare (B), indigenous forest (IF), exotic forest (EF), wetland (W), tussock (T), pastoral (P), and scrub (S).

As explained above, SEM sites in the region were chosen particularly for their usefulness at providing information in relation to particular pressures upon the water resources of the region and the state of our rivers in relation to those pressures. They were selected well before the development of the REC system. The sites and their REC are shown in Tables 1 and 2.

3. Trends in the state of our rivers

3.1 Methods of data analysis

Until recently biological sampling of streams in Taranaki, and in other regions, was carried out primarily as part of compliance monitoring. However, in the mid nineties regional councils implemented SEM to assess the environmental health of their regions over time. In Taranaki the SEM programme was initiated in 1995. Therefore, at present a full 10 years' set of data exists for all physicochemical sites and for most macroinvertebrate freshwater sites.

In February 2006 the Taranaki Regional Council trended physicochemical data for its 10 SEM sites. This trending took into account and adjusted for river flow and seasonal variations, and applied a statistical method (seasonal-Kendall), to determine if the changes were significant at a 95% confidence level. This trending procedure was adopted from similar work carried out by Environment Waikato, and the National Institute of Water and Atmospheric Research (NIWA).

The trending of freshwater macroinvertebrate data is a relatively new task being undertaken by regional councils and state agencies in New Zealand. In light of the value of the work done on trend analysis of physicochemical water quality data, the Council commissioned Dr John Stark of Cawthron Institute to analyse biological data. Since the trending of macroinvertebrate data in Taranaki is a new procedure a selection of statistical methods were explored in the study, which ranged from a similar method used to trend the physicochemical data through to more stringent methods. A description of these procedures can be found in the companion report.

A summary of the main statistical analysis methods explored during this initial trending exercise is shown in Table 3. An additional method, Bonferroni correction, was briefly considered but was deemed not suitable for this trending, particularly with increasing sampling size.

Table 3 Main statistical methods considered for trending macroinvertebrate data for Taranaki

Statistical method	p-value	Additional correction factor
1. Mann-Kendall	0.05	-
2. Mann-Kendall	0.01	-
3. Mann-Kendall	0.05	False discovery rate (FDR)
4. Mann-Kendall	0.01	False discovery rate (FDR)

For the methods shown in Table 3, methods 2 and 3 produced almost identical results for MCI, taxa richness, and %EPT_{taxa}, with slight difference for $SQMCI_s$, and therefore, while the results are not reported here they are discussed in the companion report.

Therefore, to keep this report as simple as possible only three of the methods are discussed further in this report:

- Mann-Kendall (at $p<0.05$)
- Mann-Kendall ($p<0.05$) with FDR (False Discovery Rate correction)
- Mann-Kendall ($p<0.01$) with FDR

3.2 Use of statistics

In simple terms, the three tests referred to above apply increasingly stringent criteria to the data to determine whether any trends can be considered ‘significant’ i.e. that they have a very high probability of being ‘real’ trends rather than just be an artefact of random data scatter and natural variability.

The application of the Mann-Kendall test at $p<0.05$, without FDR adjustment, was part of the study and was presented in a first draft of the Cawthron report. Following discussions between recognised experts in ecological statistical analysis, it was decided to concentrate on more stringent criteria only, to reduce the likelihood of false detection. There is an inherent tension in statistical analysis. As increased certainty is sought, fewer datasets will qualify as showing ‘significant’ changes or trends. Yet the resource manager wishes to have information about and to understand what is happening across an entire region i.e. an entire data set, not just at sites where a trend (whether of change or of stable conditions) can be established ‘beyond reasonable doubt’. To be in a situation where ‘you can’t say what’s happening because you can’t be sure what’s happening’ is unhelpful in determining whether objectives, policies, and methods of implementation are effective. Therefore, in this present report, the Mann-Kendall test at $p<0.05$ is re-introduced, as it provides information about trends at more sites than the more rigorous tests, and there is also some examination of the entire dataset to draw some general conclusions, even if tentative in nature. This should not be taken as implying any endorsement by Cawthron or NIWA of such an approach. As noted elsewhere in this report there is on-going discussion and evaluation of the application of statistical methods to biomonitoring data in New Zealand. This discussion may lead to a consensus on methodology, including how to appropriately interpret and draw inferences from ‘non-significant’ results.

It is noted that NIWA have previously used a Mann-Kendall test with criteria $p<0.05$ to examine trends in physicochemical and biological water quality data on a national scale (‘Spatial patterns in state and trends of environmental quality in New Zealand rivers: an analysis for State of Environment reporting’, February 2005, prepared by NIWA for the Ministry for the Environment, and ‘Nationwide and regional state and trends in river water quality’, February 2005, prepared by NIWA for the Ministry for the Environment). However, it should also be noted that the nature of the datasets in those studies, and how data was gathered, is not strictly comparable with the Council’s macroinvertebrate SEM dataset, indicating that a ‘one size fits all’ approach to trend analysis is inappropriate.

It also needs to be borne in mind that the term ‘significant’ carries several different meanings. To a statistician, ‘significance’ is a test of how certain we are of a result- the probability that a proposition or hypothesis is true. A substantial slope apparently representing a strong rate of change may be found when data is plotted and analysed, but there may be considerable uncertainty over where the ‘true’ trend lies if data is highly scattered, to the extent that in the end it may be deemed ‘not significant’- that is, to some extent the slope of the graph as plotted is unreliable. In common parlance, people may refer to tests of likelihood such as ‘the balance of probabilities’, or as another example the extent to which they are sure may be described as ‘more likely than not’. This level of confidence falls well short of what a statistician would accept as ‘significant’. Environment Waikato have used additional categories of ‘probable’ and ‘possible’ trends to further sort analytical results when the sample size was small, and such an approach could be examined further for usefulness for resource managers.

To the ecologist, a ‘significant’ change is one where there is a quantum change in the state of a habitat- that is, there are clear differences between one ecological community and another, to the extent that one is clearly better. There may well be a statistically significant change at a site, that does not represent a clear transformation of the state of the site but rather a subtle shift in population or composition that might still remain within the variability found naturally.

To the resource manager concerned to see whether a Council objective such as ‘maintain and enhance surface water quality’ is being delivered through particular methods, then even a subtle change or trend with a relatively low reliability could still be highly significant, as an indication of success or failure.

4. Results

4.1 Graphed results

Results have been converted to image form to provide easier conception of a significant amount of data and graphs are provided to condense information.

4.1.1 Significant results at $p<0.05$

Table 4 shows significant trends using the Mann-Kendall method with $p<0.05$.

Table 4 Summary of Mann-Kendall test results for taxa richness, MCI, $SQMCI_s$, and $\%EPT_{taxa}$ vs time for 60 Taranaki rivers at $p<0.05$

Key 😐 = trend not statistically significant ($P > 0.05$), ☹ = negative trend, ☺= positive trend

Site	Taxa richness	MCI	SQMCIs	$\%EPT_{taxa}$
HTK000350	😐	☺	☺	☺
HTK000425	☹	☺	☺	😐
HTK000745	☺	☺	😐	😐
INH000400	😐	😐	😐	😐
KPA000250	😐	😐	☺	😐
KPA000700	😐	☺	☺	☺
KPA000950	😐	😐	😐	☺
KPK000250	😐	😐	😐	😐
KPK000500	😐	😐	😐	😐
KPK000660	😐	☺	😐	☺
KPK000880	😐	☺	☺	😐
KPK000990	😐	😐	☺	☺
KPN000275	☹	😐	☺	😐
KPN000360	😐	😐	☺	😐
KRP000300	☺	☺	😐	😐
KRP000660	☺	☺	😐	☺
KTK000150	😐	😐	😐	😐
KTK000248	😐	☺	☺	😐
MGE000970	😐	😐	😐	😐
MGH000950	☺	☺	☺	☺
MGN000195	😐	😐	😐	😐
MGN000427	😐	😐	😐	😐
MGO000050	☺	😐	😐	😐
MGO000190	😐	😐	😐	😐
MGT000488	☺	😐	😐	😐
MGT000520	☺	☺	😐	😐
MHW000060	😐	😐	😐	😐
MKW000200	😐	😐	😐	😐

Site	Taxa richness	MCI	SQMCIs	%EPT$_{taxa}$
MKW000300	😐	😐	😐	😐
MRK000420	☺	☺	☺	☺
MWH000380	😐	😐	😐	😐
MWH000490	☺	☺	☹	😐
PAT000200	😐	😐	😐	😐
PAT000315	😐	😐	😐	😐
PAT000360	☺	😐	😐	😐
PNH000200	😐	😐	😐	😐
PNH000900	😐	😐	☺	😐
STY000300	😐	😐	😐	😐
STY000400	😐	😐	😐	😐
TMR000150	😐	😐	😐	😐
TMR000375	☺	☺	☺	☺
WAA000200	😐	😐	☺	😐
WAA000447	😐	☺	😐	😐
WAI000110	😐	☺	☺	😐
WGA000260	😐	😐	😐	☺
WGA000450	☺	☺	😐	☺
WGG000115	😐	☺	😐	☺
WGG000150	😐	☹	😐	😐
WGG000500	😐	😐	☺	😐
WGG000540	😐	😐	😐	😐
WGG000665	😐	😐	☺	😐
WGG000895	😐	😐	😐	😐
WGG000995	☺	😐	😐	😐
WKH000100	☹	😐	😐	😐
WKH000500	😐	😐	☺	😐
WKH000920	😐	☺	😐	☺
WKH000950	😐	☺	😐	☺
WMK000100	😐	😐	😐	😐
WMK000298	☹	😐	😐	😐
WTR000850	☺	☺	☺	☺
Total ☺	14	21	19	15
Total 😐	42	38	40	45
Total ☹	4	1	1	0

4.2 Significant results with FDR applied at p<0.05 and p<0.01

Table 5 shows significant trends using the Mann-Kendall method with p<0.05 and FDR adjustment, and also Mann-Kendall method with p<0.01 and FDR adjustment .

Table 5 Summary of Mann-Kendall test results for taxa richness, MCI, SQMCI, and %EPT$_{taxa}$ vs time for 60 Taranaki rivers with FDR.

😐 = trend not statistically significant (P > Benjamini-Hochberg FDR of 0.05), ☹ = negative trend, ☺ = positive trend. * denotes significant trends with FDR of p<0.01.

Site	Taxa richness	MCI	SQMCIs	%EPT$_{taxa}$
HTK000350	😐	😐	😐	☺
HTK000425	😐	☺	☺	😐
HTK000745	☺	😐	😐	😐
INH000400	😐	😐	😐	😐
KPA000250	😐	😐	😐	😐
KPA000700	😐	☺	😐	☺
KPA000950	😐	😐	😐	😐
KPK000250	😐	😐	😐	😐
KPK000500	😐	😐	😐	😐
KPK000660	😐	☺	😐	😐
KPK000880	😐	😐	😐	😐
KPK000990	😐	😐	☺	😐
KPN000275	☹	😐	☺	😐
KPN000360	😐	😐	☺	😐
KRP000300	😐	☺	😐	😐
KRP000660	☺*	☺*	😐	☺*
KTK000150	😐	😐	😐	😐
KTK000248	😐	☺	☺	😐
MGE000970	😐	😐	😐	😐
MGH000950	☺	☺*	☺	😐
MGN000195	😐	😐	😐	😐
MGN000427	😐	😐	😐	😐
MGO000050	☺	😐	😐	😐
MGO000190	😐	😐	😐	😐
MGT000488	😐	😐	😐	😐
MGT000520	☺*	😐	😐	😐
MHW000060	😐	😐	😐	😐
MKW000200	😐	😐	😐	😐
MKW000300	😐	😐	😐	😐
MRK000420	😐	☺	😐	☺
MWH000380	😐	😐	😐	😐

Site	Taxa richness	MCI	SQMCIs	%EPT$_{taxa}$
MWH000490	😐	😐	😐	😐
PAT000200	😐	😐	😐	😐
PAT000315	😐	😐	😐	😐
PAT000360	😐	😐	😐	😐
PNH000200	😐	😐	😐	😐
PNH000900	😐	😐	😐	😐
STY000300	😐	😐	😐	😐
STY000400	😐	😐	😐	😐
TMR000150	😐	😐	😐	😐
TMR000375	☺	☺	😐	☺
WAA000200	😐	😐	😐	😐
WAA000447	😐	😐	😐	😐
WAI000110	😐	😐	😐	😐
WGA000260	😐	😐	😐	☺
WGA000450	☺	☺*	😐	☺*
WGG000115	😐	😐	😐	☺
WGG000150	😐	😐	😐	😐
WGG000500	😐	😐	😐	😐
WGG000540	😐	😐	😐	😐
WGG000665	😐	😐	😐	😐
WGG000895	😐	😐	😐	😐
WGG000995	☺	😐	😐	😐
WKH000100	☹	😐	😐	😐
WKH000500	😐	😐	😐	😐
WKH000920	😐	😐	😐	☺
WKH000950	😐	😐	😐	☺
WMK000100	😐	😐	😐	😐
WMK000298	😐	😐	😐	😐
WTR000850	☺	☺	😐	☺*
Total ☺	9 (2*)	11 (3*)	6 (0*)	11 (3*)
Total 😐	49 (58*)	49 (58*)	54 (60*)	49 (57*)
Total ☹	2 (0*)	0 (0*)	0 (0*)	0 (0*)

4.3 'Non-significant' data

The distribution of p-values resulting from the Mann-Kendall method, both for increasing and decreasing trends (i.e. improvement and deterioration) in each parameter have been graphed based on various groupings of p-values, as shown in Figures 2, 3, 4 and 5. The purpose of this method is to give an indication and feel for sub-significant tendencies in the data and to see if there is additional information embedded within the data that could assist the Council when considering its plans and policies.

As discussed earlier, as p-values increase above 0.05 there is less certainty attached to each result. The main focus in these figures should be on the overall tendency that is evident, rather than on any specific data point or value.

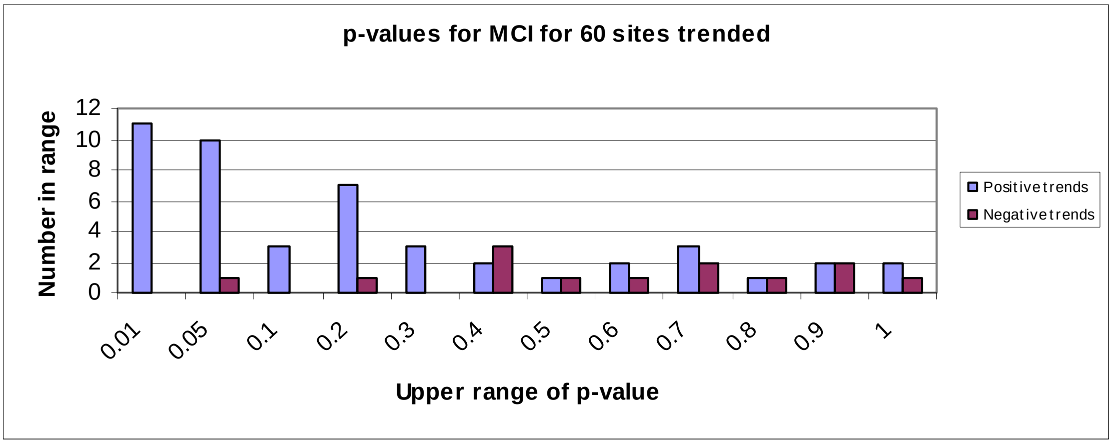

Figure 2 p-values for MCI trended using Mann-Kendall with $p<0.05$

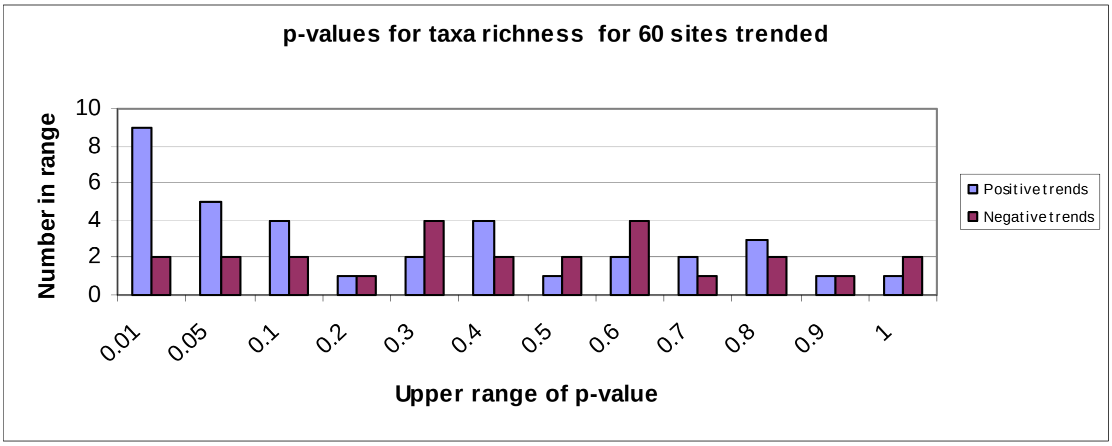

Figure 3 p-values for taxa richness trended using Mann-Kendall with $p<0.05$

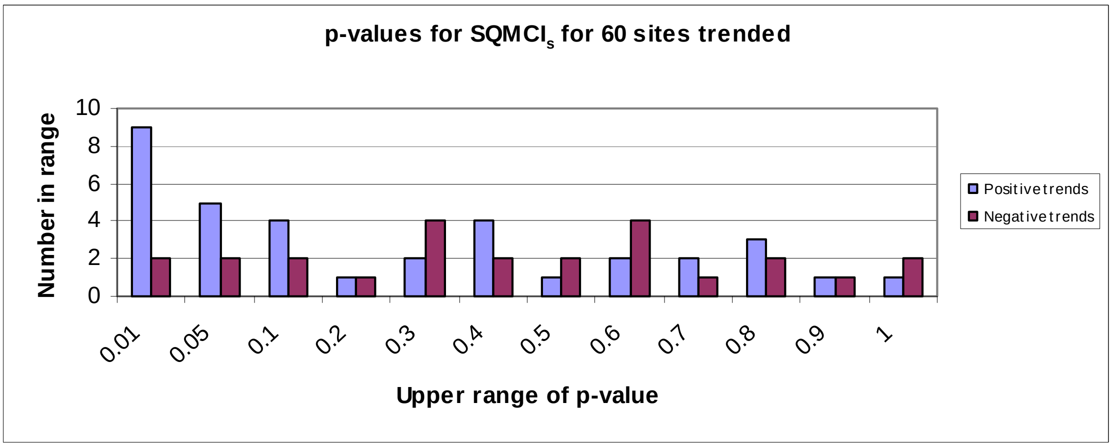

Figure 4 p-values for $SQMCI_s$ trended using Mann-Kendall with $p<0.05$

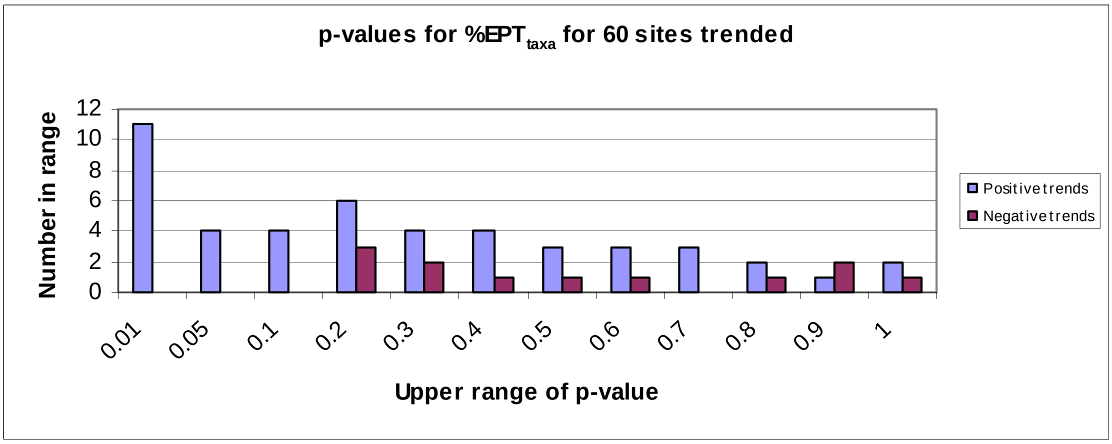

Figure 5 p-values for %EPT$_{taxa}$ trended using Mann-Kendall with $p<0.05$

4.4 Discussion

4.4.1 Mann-Kendall at p<0.05 significance level

As shown in and Table 4 there are a substantial number of statistically significant positive trends in MCI (35%), taxa richness (23%), SQMCI$_s$ (32%), and %EPT$_{taxa}$ (25%). As with all three methods discussed in this section, a majority of sites show no statistically significant evidence of any change, which when combined with the sites where there are significant positive trends, indicates a high level of attainment on a regional basis, of the Council's objective of 'maintain or enhance water quality'.

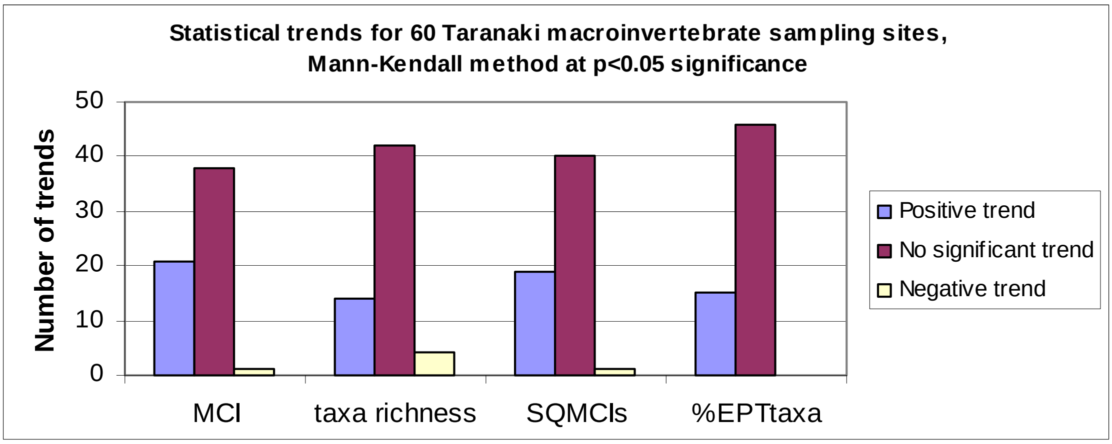

Figure 6 Statistical trends of macroinvertebrate data for Taranaki using Mann-Kendall $p<0.05$ significance level

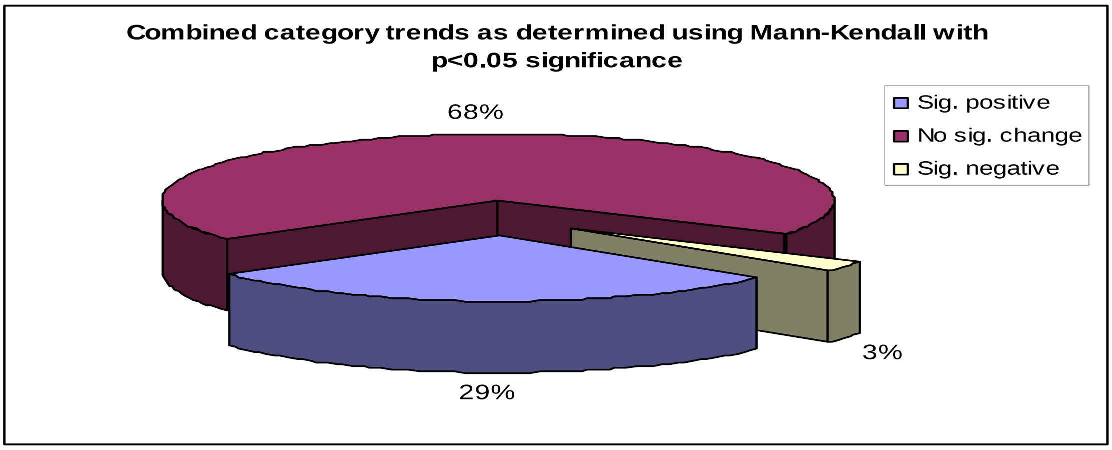

Figure 7 Sum of trends for all categories as determined using Mann-Kendall method with $p<0.05$ significance

A small proportion of sites, 3%, show a statistically significant negative trend for either MCI, taxa richness, or $SQMCI_s$. Overall, at this significance level, there are 97% of sites with no statistically significant deterioration (Figure 7), which is very encouraging.

4.4.2 Mann-Kendall at p<0.05 significance level with FDR adjustment

As shown in Table 5, at this level of certainty there remain quite a number of statistically significant positive trends in MCI (18%), taxa richness (15%), $SQMCI_s$ (10%), and $\%EPT_{taxa}$ (18%). Again, as with all three methods discussed in this section, a majority of sites show no statistically significant change. A small number of sites, (2 of 60), show a statistically significant negative trend for one parameter (taxa richness). Overall, at this significance level, there are 99% of sites with no statistically significant deterioration (Figure 8), which is very encouraging.

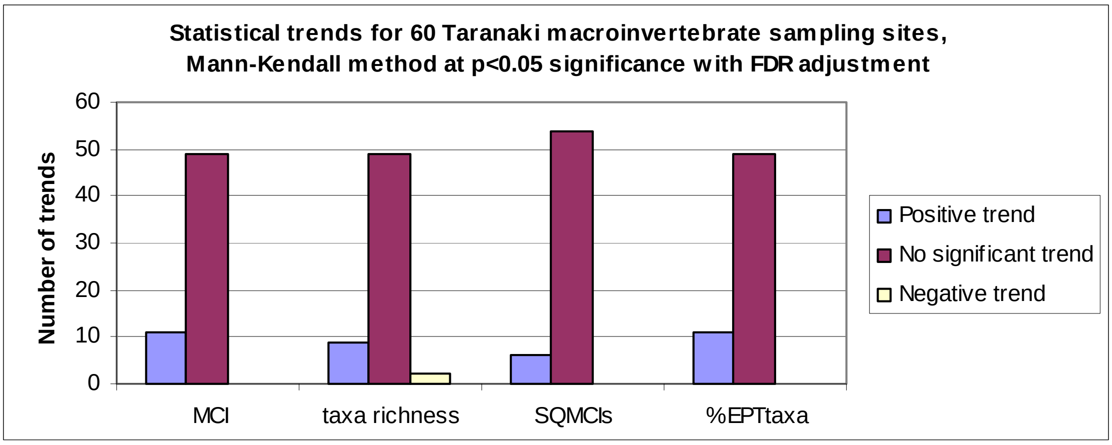

Figure 8 Statistical trends of macroinvertebrate data for Taranaki using Mann-Kendall $p<0.05$ significance level with FDR adjustment

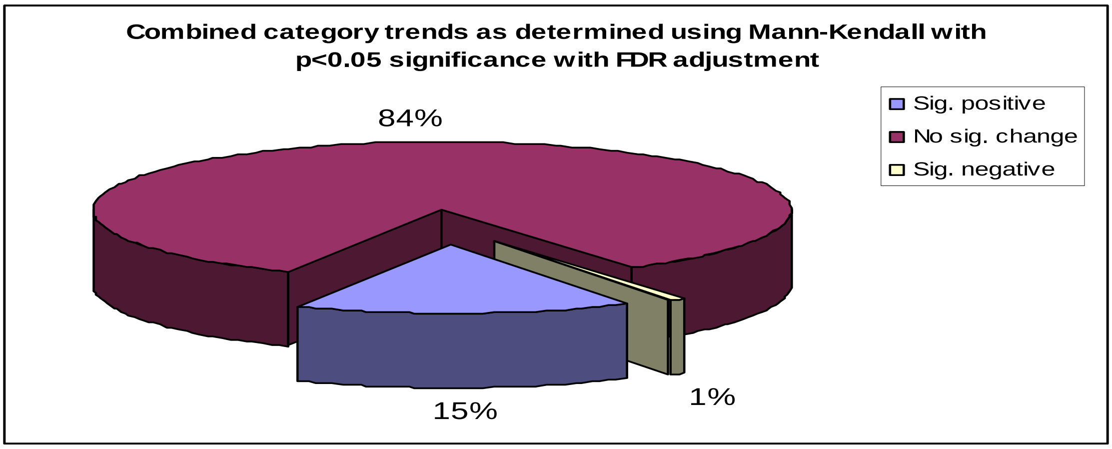

Figure 9 Sum of trends for all categories as determined using Mann-Kendall method with p<0.05 significance and FDR adjustment

4.4.3 Mann-Kendall at p<0.01 significance level with FDR adjustment

As shown in Table 5, at this level of certainty there remain only a few statistically significant positive trends in MCI (5%), taxa richness (3%), and %EPT_{taxa} (5%). As with all three methods discussed in this section, a majority of sites show no statistically significant change. Using this statistical criterion there are no sites showing statistically significant deterioration in either MCI, taxa richness, %EPT_{taxa} or $SQMCI_s$ (Figure 11).

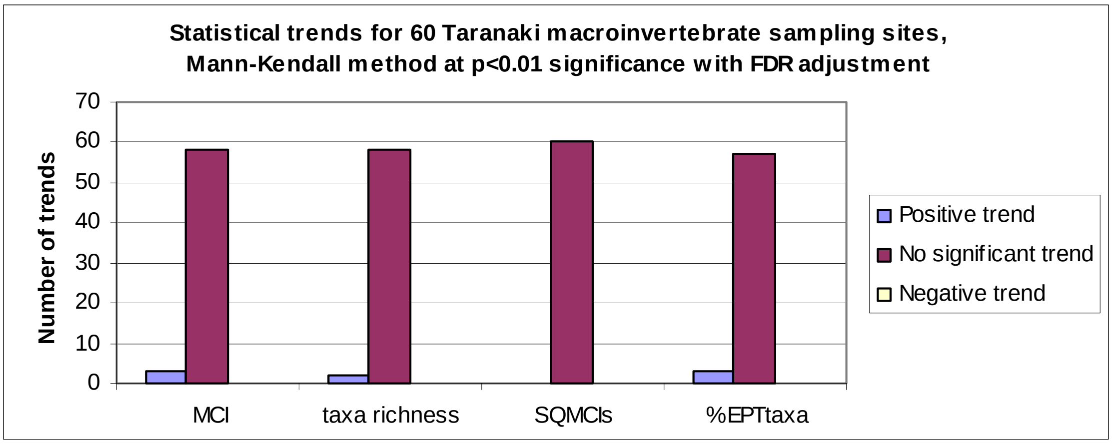

Figure 10 Statistical trends of macroinvertebrate data for Taranaki using Mann-Kendall p<0.01 significance level with FDR adjustment

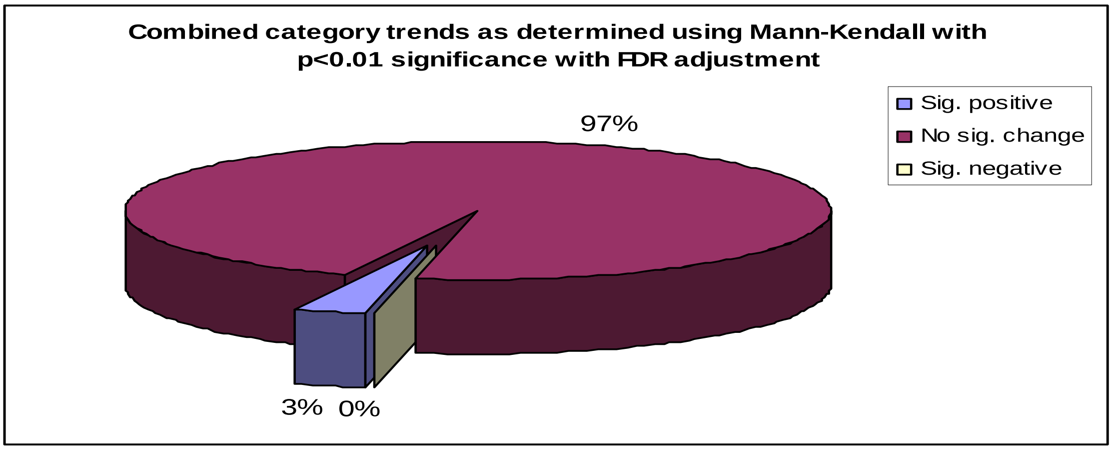

Figure 11 Sum of trends for all categories as determined using Mann-Kendall method with p<0.01 significance and FDR adjustment

4.4.4 Further indications from the data

It is of interest to the Council to examine the spread of significant and non-significant trends. For example if at Mann-Kendall $p<0.05$ there are 21 statistically significant positive trending sites, then the next question is - where do the other sites lie in relation to the statistically significant cut-off level of $p<0.05$?

In the case of MCI, at $p<0.05$, the pattern seen is that there are many more sites with a positive trend than with a negative trend, and that the positive trending sites have probabilities displaced closer to the p-values where significance is recognised than is the case for the sites with negative tendencies. For example, the median of positive trending sites have a p-value below the 0.1 level, with another cluster of sites with p values of 0.2, while the median of negative trending sites does not occur until p-0.6 level, a value denoting very weak probability. Therefore, the indication is that as a general observation across the region, positive trends are stronger than negative and there are more positive trends (see Table 4).

That is, it is not a case of just a handful of sites in Taranaki showing either a positive or a negative significant trend, and the majority of sites showing no indications of a change whatsoever. Rather (acknowledging that there is less certainty underlying any individual result), there is an indication or provisional observation, that there is a widespread pattern beginning to come into focus.

Each of the four parameters is discussed in some more detail below, for interest.

MCI
With regard to positive MCI trends (Figure 2) it can be seen that a further three sites are near the p-0.05 significance level, and a further seven sites lie in the p-0.1 to p-0.2 significance level. While not below the p-0.05 significance level these sites may provide information regarding good environmental practices at these sites, and with further data may become statistically significant in due course.

For MCI it can be seen that 21 sites (35% of sites) lie below the p-0.05 significance level, 24 sites (40% of sites) lie below the p-0.1 significance level, and 31 sites (52% of sites) lie below the p-0.2 significance level when viewing positive trends. If negative trends are viewed in this light, there are only two sites (3% of sites) below the p-0.2 significance level, which is encouraging.

Taxa richness
With regard to positive taxa richness trends (Figure 3) it can be seen that four sites are near the p-0.05 significance level, and one further site lies in the p-0.1 to p-0.2 significance level. While not below the p-0.05 significance level these sites may provide information regarding good environmental practices at these sites.

For taxa richness it can be seen that 14 sites (23% of sites) lie below the p-0.05 significance level, 18 sites (30% of sites) lie below the p-0.1 significance level, and 19 sites (32% of sites) lie below the p-0.2 significance level when viewing positive trends. If negative trends are viewed in this light, there are seven sites (12% of sites) below the p-0.2 significance level, which may in time become statistically significant deteriorating sites.

%EPT_{taxa}
With regard to positive %EPT_{taxa} trends (Figure 5) it can be seen that four sites are near the p-0.05 significance level, and a further six sites lie in the p-0.1 to p-0.2 significance level. While not below the p-0.05 significance level these sites may

provide information regarding good environmental practices. For %EPT_{taxa} it can be seen that 15 sites (25% of sites) lie below the p-0.05 significance level, 19 sites (32% of sites) lie below the p-0.1 significance level, and 25 sites (42% of sites) lie below the p-0.2 significance level when viewing positive trends. If negative trends are viewed in this light, there are three sites (5% of sites) below the p-0.2 significance level, which may in time become statistically significant deteriorating sites.

$SQMCI_s$

With regard to positive $SQMCI_s$ trends (Figure 4) it can be seen that five sites are near the p-0.05 significance level, and a further five sites lie in the p-0.1 to p-0.2 significance level. While not below the p-0.05 significance level, these sites may provide information regarding good environmental practices.

For $SQMCI_s$ it can be seen that 19 sites (32% of sites) lie below the p-0.05 significance level, 24 sites (40% of sites) lie below the p-0.1 significance level, and 29 sites (48% of sites) lie below the p-0.2 significance level when viewing positive trends. If negative trends are viewed in this light, there are seven sites (12% of sites) below the p-0.2 significance level, which may in time become statistically significant deteriorating sites.

From Table 6 it can be seen that the same is true for taxa richness, $SQMCI_s$ and %EPT_{taxa}, i.e. that positive trends are stronger than negative, which is good news for the region.

Table 6 Spread of positive and negative trends for Mann-Kendall $p<0.05$

Category	50% of positive trending sites are below	50% of negative trending sites are below
MCI	$p<0.1$	$p<0.6$
Taxa richness	$p<0.1$	$p<0.4$
%EPT_{taxa}	$p<0.2$	$p<0.5$
SQMCI	$p<0.1$	$p<0.5$

5. Conclusion

The results of the first trending of Taranaki's SEM macroinvertebrate show very good news indeed for the region, with regard to the Council's objectives and policies to maintain and enhance the quality of surface water in the region. A standard significance test of p<0.05 shows a considerable number of sites (21) with statistically significant improvement in water quality as indicated by MCI. This test also shows that a lot of sites are maintaining water quality,(i.e. no significant trends found), despite increasing pressures on water quality in the region. What is equally encouraging is at this significance level there is only one significantly deteriorating site of the 60 trended.

With a more rigorous approach, at a significance level of p<0.05 with FDR adjustment, the results are just as encouraging and show 11 sites with significant improvement with regard to MCI and no sites with significant deterioration. Again, on this analysis water quality in the region is improving or holding its own for the period trended.

Even with a very stringent statistical approach, based on a significance level of p<0.01 with FDR adjustment, there are sites showing significant improvement and no sites showing deterioration.

Since this is the first time the SEM macroinvertebrate data for the Taranaki region has been trended, and with very little work of this type carried out on this in New Zealand, there remains work to be done, particularly in regard to understanding the results. The Council recognises that this is a first step and closer examination of the results will reveal insightful information which will benefit water management in the region.

Several matters are raised by this study.

Cawthron were commissioned to explore trends in the Council's macroinvertebrate data as supplied to the institute. The study has not examined the underlying causes and reasons for trends. In plain language, we do not yet know for sure why we are seeing the encouraging results identified in this study. The next step is to undertake that research, for example correlating biological trends with factors such as trends in physicochemical water quality, surrounding land use, and the state of riparian margins.

The Council will continue to work with experts in the field of statistical analysis of biometric data, to fully appreciate the strengths and shortcomings of the various approaches currently being utilised and to advocate a consensus on methodology.

The Council will work with the same group to identify and advocate the information needs of resource managers, in particular determining methods of gleaning information from 'non-significant ' results and methods for providing results within a range of specified probabilities (such as 'on the balance of probability').

The Council will examine the nature of its freshwater biological monitoring programme. The companion report makes recommendations concerning the respective value of the four parameters used (number of taxa, MCI, SQMCI, and %EPT). Council staff will consider those comments carefully, in the light of the resourcing requirements and the benefit to the Council.

Consideration of the study done by Cawthron, on a site by site basis, may show further patterns that are of value to the Council (for example, is there a geographic pattern in sites showing either improvements or deterioration? Have there been particular changes in some catchments e.g. consent renewal processes that have involved increased scrutiny of farm oxidation pond performance and / or progressive implementation of the Council's pond criteria set out in the RFWP?)

In 1982 the Council undertook a survey of the state of the streams and rivers of the Taranaki ring plain. This survey work included biological surveys. This work can be re-visited to determine whether the earlier data can be utilised in further trend determination work i.e. over a 25 year timeframe instead of a 10 year timeframe.

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Appendix I

RPS Objectives (3.3.6 & 3.3.7)

3.3.6 *ISSUE: Water quality degradation resulting from diffuse source contamination*

OBJECTIVE

To maintain and enhance the quality of the water resources of Taranaki for water supply purposes, contact recreation, shellfish gathering for human consumption, aesthetic purposes, cultural purposes and aquatic ecosystems by avoiding, remedying or mitigating the adverse effects on water quality of diffuse source runoff of sediment, nutrients or other contaminants from land.

POLICIES

Policy One: Land use and management practices

Land use practices which reduce adverse effects on water quality and which maintain and enhance the quality and life-supporting capacity of water will be encouraged and promoted including:

- *the careful application of the correct types and quantity of fertiliser;*
- *the careful use of agrichemicals;*
- *land development and restoration of disturbed land to reduce diffuse source discharge of contaminants to water;*
- *stock control procedures to avoid, remedy or mitigate the effects of stock entry to rivers, trampling and pugging by stock and accelerated erosion from overgrazing; and*
- *land management practices, including the discharge of contaminants to land, that avoid or reduce contamination of groundwater aquifers.*

Policy Two: Management of riparian margins

The vegetation along riparian margins of all Taranaki lakes and rivers will, as far as is practicable, be retained and enhanced and, where appropriate, the retirement and planting of riparian margins will be promoted on all or parts of the following priority ring plain catchments:

*Waingongoro**
*Manganui**
Te Henui
Huatoki
Mangorei
*Patea**
Oakura
Timaru
*Waitara**
*Waiwhakaiho**
*Kapuni**
Hangatahua/Stony
*Waiongana**
*Waiaua**
Taungatara
*Mangatoki**
*Kaupokonui**
Kai Auai
Maketawa
Kahouri
Mangaoraka
Warea
Okahu
*Punehu**
Ngatoro-nui
*Ngatoro**

Tapuae *Pungareere**
Tawhiti
** Waterways which are also community water supply catchments*

In addition, regard shall be had to the following criteria in determining other priority catchments, subcatchments or reaches of rivers and lakes for the promotion of riparian vegetation:

- *existing degraded water quality including high water temperature, suspended solids, nitrate levels and dissolved reactive phosphate levels;*

- *existing degraded habitat quality including instream habitat and the extent or loss of existing vegetation;*

- *the intensity of land uses, their proximity to watercourses and the actual or potential contamination from diffuse sources;*

- *the actual or potential use of water for community, industrial and domestic water supplies;*

- *spiritual and cultural values and customary uses of tangata whenua;*

- *actual or potential scenic, amenity and recreational values including fishery values, indigenous fish and their habitat and the habitat of trout; and*

- *actual or likely conflicts among competing water uses and values and the potential for riparian management to reduce those conflicts.*

In determining what is `practicable' and `appropriate' in relation to the retention or planting of riparian vegetation in all catchments the following criteria will apply:

- *the physical characteristics of the site and catchment;*

- *the riparian management objectives and benefits sought;*

- *the costs of establishing riparian margins relative to the benefits.*

3.3.7 ISSUE: Water quality degradation resulting from the discharge of contaminants from point sources

OBJECTIVE

To maintain and enhance the quality of the water resources of Taranaki for water supply purposes, contact recreation, shellfish gathering for human consumption, aesthetic purposes, cultural purposes and aquatic ecosystems by avoiding, remedying or mitigating the adverse effects of contaminants discharged to water from point sources.

POLICIES

Policy One: Point source discharges of contaminants

Waste reduction and treatment practices which avoid, remedy or mitigate the environmental effects of the direct discharge of contaminants into water will be required. In assessing proposals to discharge contaminants directly to water, matters to be considered will include:

- *the need to maintain or enhance the life-supporting capacity of water and aquatic ecosystems of the receiving environment;*
- *the allowance for reasonable mixing zones;*
- *the potential for cumulative or synergistic effects;*
- *the actual or potential risks to human and animal health from the discharge;*
- *the degree to which the needs of other water users may be compromised;*
- *the actual or potential effects on amenity and heritage values including recreational values of the receiving environment;*
- *the cultural and spiritual values of tangata whenua;*
- *the use of water in its natural state;*
- *measures to reduce the quantity of contaminants to be discharged;*
- *the use of the best practicable option for the treatment and disposal of contaminants including, in the case of human sewage wastewater, the use of land disposal or wetland treatment.*

Policy Two: Contaminated stormwater

The adverse effects on water quality of the discharge of contaminated stormwater will be avoided, remedied and mitigated and management systems, structures or facilities adopted to:

- *separate drainage of areas which are at no risk of being contaminated from those which may be contaminated; and*
- *treat contaminated stormwater at source or before disposal.*

Policy Three: Deepwell injection

The deepwell injection of wastewater or other contaminants to groundwater will only be undertaken at depths and locations and under circumstances in which there is negligible risk of contamination of groundwater resources which may be used for consumptive purposes.

Policy Four: Risk minimisation

Contingency plans and other measures to reduce the risk and effect of any spill event will be adopted at all sites which are subject to the risk of a spill that may have significant actual or potential effects.

<u>Policy Five</u>: Life-supporting capacity

Improvements in the biological health and quality of water ecosystems will be promoted in those water bodies and coastal waters in which the life-supporting capacity of water and aquatic ecosystems is under pressure. For the purposes of this policy, in determining the desired life-supporting capacity, matters to be considered will include:

- *the existing status of water quality according to a selection of chemical parameters;*
- *the existing habitat quality including the need to maintain and enhance aquatic ecosystems and species;*
- *the degree to which cultural and spiritual values or customary uses of tangata whenua are affected by existing water quality; and*
- *the scenic, aesthetic and recreational values including fishery values and the habitat of trout.*